Denton County
Planning Department
Subdivision Process

1. Owner or applicant submits a Preliminary Plat, except where the provisions of a Minor Plat apply, along with all required fees, application forms, and associated information, and, if interior roadways and/or drainage improvements are associated with the development, engineering plans to the Planning Department and Engineering Department for review. Plats and plans will be prepared in conformance to the Denton County Subdivisions and Regulations.

2. By special permission of the Commissioners Court, an Owner, whose lot or parcel has not been platted, may secure a development permit under the procedures stated in Section VI, Subsections 19 and 20.

3. Development Support Committee reviews identifies any deficiencies, and makes recommendations to Commissioners Court for approval of the plat and plans, after all corrections are addressed and required information is submitted.

4. Preliminary Plat and plans are submitted to the Development Support Committee for their action.

5. Upon Commissioners Court approval of the Preliminary Plat and engineering plans, the applicant is authorized to begin construction of perimeter and interior improvements. Twelve months after approval of a Preliminary Plat, the approval will expire if Owner or Applicant fails to proceed with platting or development process.

6. Improvements are constructed. County makes inspection during the construction and as each phase is complete. After any deficiencies are corrected, preliminary acceptance of the improvements is issued. The Owner or Applicant maintenance period begins.

7. Applicant submits a Final Plat to the Planning Department for review.

8. Development Support Committee reviews the Final Plat, identifies any deficiencies and after all corrections are addressed, makes recommendations to the Commissioners Court for approval of the Final Plat

9. Final Plat is submitted directly to the formal agenda for Commissioners Court action.

10. Once the Final Plat is approved by Commissioners Court, it is recorded by the Owner or Applicant and copies are distributed.

11. Applicant begins lot sales, unless the Owner is approved to proceed under Section VI, Subsections 19 and 20 of these Rules and Regulations.

12. Prior to actual construction lot owner submits application with all information required under Regulations for Floodplain Management for a development permit for each structure to be built.

13. If the proposed structure complies with Denton County Regulations for Flood Plain Management, the proposed structure is platted in County Floodplain book and development permit is issued to the applicant, along with copies of floodplain maps, abstract maps and plat maps.

14. After construction/establishment of the finished floor is completed, (if in a FEMA Flood Zone A) and prior to the construction of the finished structure and/or the construction of a private sewage facility applicant must submit a post-construction finished floor elevation certification. This Certification must be made by a Texas Registered Professional Surveyor, Engineer or Architect and must confirm that the finished floor of the actual construction is at or above elevation established in the Elevation Certificate.

15. Lot owner submits application for a permit to construct a private sewage facility with all the information required in the Rules and Regulations covering private sewage facilities. Applicants will also be required to submit a copy of the development permit application, the development permit, plat map, abstract map, floodplain map, elevation certificate, and post-construction finished floor certification.

16. The permit, including specifications for construction will be issued to the lot owner.

17. Construction of the private sewage facility is substantially completed.

18. Lot owner requests a County inspection of the sewage facilities.

19. Once construction of the sewage facility is satisfactory, inspection sheet and license to operate is issued to the owner.

Denton County
Planning Department
Development Process

1. The Owner or Applicant shall comply with all the requirements set forth in the Denton County Flood Damage Prevention Ordinance and the Denton County Rules and Regulations for Private Sewage Facilities.

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SECTION I

INTRODUCTION

1. **LEGAL AUTHORITY**:

These regulations have been adopted to provide minimum standards by which land may be subdivided and developed for the benefit of the citizens of Denton County. Authority for these regulations is given in V.T.C.A. Local Government code Chapter 232. The subdivision process outlined in this document applies to those that meet the following requirements:

(a) "The owner of a tract of land located outside the limits of a Municipality must have a plat of the subdivision prepared if the owner divides the tract into two or more parts to lay out:

(1) A subdivision of the tract, including an addition;
(2) lots;
Or
(3) streets, alleys, squares, parks, or other parts of the tract intended to be dedicated to the public use or for the use of purchasers or owners of lots fronting on or adjacent to the streets, alleys, squares, parks, or other parts.

(a-1) A division of a tract under Subsection (a) including a division regardless of whether it is made by using metes and bounds description in deed of conveyance or in a contract for a deed, by using a contract of sales or convey, or by using any other method." V.T.C.A. local government Code § 232.001.

2. **DEVELOPMENT SUPPORT COMMITTEE:**

In order to foster a greater understanding of the regulations set forth herein, a Development Support Committee (Committee) shall be established to schedule meetings with Owners, Applicants, Developers or other interested persons. The Committee shall be composed of representatives from the Planning Department, Engineering Department, the Denton County Environmental Health Officer, and the Denton County Fire Marshall. The Planning Representative shall act as the presiding officer at all meetings of the Committee. Any other County official or employee who may be requested to participate by the Planning Representative shall be Ex-official members.

SECTION II

DEFINITIONS

1. **APPLICANT**: A natural person or other legal entity who is authorized in writing to present matters to the County Commissioners Court, or Planning Department regarding any plat, plan or study submitted pursuant to these Rules and Regulations.

2. **ARCHITECT**: A person duly registered, licensed and authorized under the provisions of the Texas Regulation of Practice of Architecture Act to practice the profession of architecture.

3. **BENCH MARKS**: A surveyor's mark made on a stationary object of a previous determined position and elevation.

4. **BUSINESS DAY**: A day other than Saturday, Sunday, or a holiday recognized by this state.

5. **ENGINEERING DEPARTMENT**: The Denton County Engineering Department.

6. **COMMISSIONERS COURT**: Commissioners Court of Denton County, Texas.

7. **COUNTY or DENTON COUNTY**: Denton County, Texas a political subdivision of the State of Texas.

8. **COUNTY JUDGE**: County Judge of Denton County, or in his/her absence, his/her authorized designee.

9. **COUNTY ROAD (STREET)**: A public road or street which has been accepted by the County, through prescription, dedication or statutory means for maintenance purposes, or is a road or street that was constructed and maintained by the County. The term "road" and "street" are used interchangeably for the purpose of these regulations.

10. **DEVELOPMENT SUPPORT COMMITTEE:** Development Support Committee (Committee) established by the Commissioners Court to schedule meetings with Owners, Applicants, Developers or other interested persons. The Committee shall be composed of representatives from the Planning Department, Engineering Department, the Denton County Environmental Health Officer, and the Denton County Fire Marshall. The Planning Representative shall act as the presiding officer at all meetings of the Committee. Any other County official or employee who may be requested to participate by the Planning Representative shall be Ex-official members.

11. **EASEMENT:** A grant by the property owner to the public, a corporation or persons, for the used of land for specific purposes.

12. **ENGINEER:** A person duly licensed and authorized under the provisions of the Texas Engineering Practice Act to practice the profession of engineering.

13. **EXTRA TERRITORIAL JURISDICTION (ETJ):** That area outside a City's limits so designated to fall in the City's "sphere of influence".

14. **FINAL PLAT:** A map of a land subdivision or resubdivision prepared in a form suitable for filing or recording with the necessary affidavits, dedications and acceptances and with complete bearings and dimensions of all lines defining lots and blocks, streets, public areas and dimensions of all lines and other dimensions of land and subdivision requirements of Denton County, Texas.

15. **FLOODWAY:** The channel of a stream, plus any adjacent flood plain areas, within which no obstruction to flow would be allowed so that 100 year flood may pass without cumulatively increasing the 100 year flood elevation more then one (1) foot, provided that hazardous velocities are not produced. The floodway limits are to be defined based on standard engineering practices or as determined by the Planning Department, the Federal Emergency Management Agency and the Federal Insurance Administration.

16. **GEOMETRIC DESIGN STANDARDS:** Minimum allowable engineering geometry standards adopted by Denton County affecting the functional traffic level operations, service and safety of highway, roads and streets in Denton County.

17. **INFRASTRUCTURE DEVELOPMENT PLAN:** A set of plans, drawings, sketches, or blueprints which describe, show, locate and define the improvements to be constructed which will provide for adequate drainage, culverts, any Special Flood Hazard Area (SFHA), public or community water supply, water supply lines, sanitary sewer lines facilities, roads, streets, alleys, parks and any other significant improvements.

18. **LOT LINES:** The property lines of any given tract or parcel of land which circumscribe the area divided by any plat of record in the plat records of Denton County, Texas or in the absence of such a plat, the lot lines shall mean those property lines circumscribing the lot independently isolated on the official plat on the file in the Denton County records.

19. **MANUFACTURED HOME RENTAL COMMUNITY (MHRC):** A plot or tract of land that is separated into two or more spaces or lots that are rented, leased, or offered for rent or lease. For a term of less then 60 months without a purchase option, for the installation of manufactured homes for use and occupancy as residences.

20. **MINOR PLAT:** A map of a land subdivision prepared in a form suitable for recording or filing with complete metes and bounds descriptions of all lines defining the lot(s) and other dimensions of land and subdivision requirements of Denton County, Texas.

21. **ORIGINAL TRACT:** An area of land including all contiguous and adjacent tracts, title to which is held under common ownership.

22. **OWNER:** The person, corporation, partnership or other legal entity holding fee simple title to the tract of land or property subject to regulation under these Subdivision Rules & Regulations.

23. **PLANNING DEPARTMENT:** The Denton County Planning Department.

24. **PRELIMINARY PLAT:** A map of a proposed land tract showing the character and proposed layout of the tract in sufficient detail to indicate the suitability of the proposed subdivision of land.

25. **PRESCRIPTIVE EASEMENT:** Any area, parcel or strip of land which provides vehicular access to adjacent property or land whether designated as a street, highway, freeway, thoroughfare, avenue, lane, boulevard, road, place, drive or however otherwise designated which has been used by the general public over a ten year period. This area is typically defined as that portion lying between fence lines including all roadways, shoulders, and drainage ditches. In the absence of fences, this area will be that portion lying between five feet outside of ditches on each side.

26. **PRIVATE SEWAGE FACILITY:** All systems and methods used for the disposal of sewage, other than organized disposal systems operated under a valid permit issued by the Texas Commission On Environmental Quality and /or Texas Department of Health.

27. **PUBLIC STREET/ROADWAY:** Any area, parcel or strip of land which provides vehicular access to adjacent property or land whether designated as a street, highway, freeway, and which is either dedicated or granted for purpose or acquired for public use by prescription.

28. **RESUBDIVISION/REPLAT:** The alteration of an existing subdivision, including but not limited to any changes of lot size therein, or the relocation of any street lines or lots.

29. **SPECIAL FLOOD HAZARD AREA (SFHA):** The land in the floodplain within a community subject to a one percent or greater chance of flooding in any given year according to the FEMA Flood Insurance Rate Map (FIRM).

30. **SUBDIVIDER OR DEVELOPER:** Any person, partnership, firm association corporation (combination thereof), or any officer, agent employee, servant or trustee thereof, who performs or participates in the performing of any act toward subdivision of the land within the intent, scope and purview of these regulations.

31. **SUBDIVISION:** The division of any tract or parcel of land into two or more parts for the purpose of laying a subdivision of the tract, including an addition, or for laying out suburban lots or building or lots and streets, alleys, squares, parks, or other portions intended for public use or the use of purchasers or owner of lots fronting thereon or adjacent thereto.

32. **SUBSTANDARD COUNTY ROAD OR STREET:** A County maintained road or street which was not constructed according to the specifications set forth in these Rules and Regulations or is determined to be substandard by the Director of Public Works/Engineering.

33. **SURVEY:** For the purposes of Section VII, plans, drawings, sketches, or blueprints which identify and /or locate the boundaries of the subdivision, location of lots or spaces, utilities easements, dedications of right of ways and any other significant features of the community.

34. **SURVEYOR:** A person duly license and authorized under the provisions of the Texas Surveyors Registration Act to practice the profession of surveying.

35. **TCEQ:** Texas Commission On Environmental Quality

36. **TxDOT:** Texas Department of Transportation

SECTION III

SUBDIVISIONS EXCLUDING FROM PLATTING

1. **EXCLUDED SUBDIVISION:** Owners of a tract of land who subdivided the tact under the following circumstances, shall not be required comply with these Rules and Regulations.

   a) Agriculture Exclusion: The land is to be used primarily for agriculture use, as defined by, Art. VIII, Section 1d, Texas Constitution, or for farm, ranch, wildlife management, or timber production use within the meaning of Section 1-d-1, Art. VIII, Texas constitution; and the Owner does not lay out any part of the tract for the purposes set forth in § 232.001(a) (3), Local Government Code. If a tract of land ceases to be used primarily for agriculture use or farm, ranch, wildlife management, or timber production use, the Owner will be required to comply with these Rules and Regulations.

   b) Family Exclusion: The land is to be divided into four or fewer lots or tracts; the Owner does not lay out any part of the tact for the purposes set forth in § 232.001(a) (3); and each of the lots or tracts are sold, conveyed, gifted, or otherwise transferred to a person who is related to the Owner within the third degree of consanguinity or affinity.

   c) Large Lots Exclusion: The land is subdivided into lots which are ten acres or more in size and the Owner does not lay any part of the purposes set forth in § 232.001 (a) (3).

   d) Sale to Veterans' Land Board Program: All lots are sold to veterans through the Veterans' Land Board Program and the Owner does not lay out any part of the tact for the purposes set forth in § 232.001 (a) (3).

   e) Government Exclusion: The Owner of the land is the State of Texas, an agency, board or commission of the State of Texas or a permanent school fund or any other dedicated fund of the State and the Owner does not lay out any part of the tract for the purposes set forth in § 232.001 (a) (3).

   f) Retained Ownership Exclusion: The Owner retains title to a lot portion of the land; the other lot or portion is transferred to another person who will further subdivide the tract subject to the plat approval requirements of local Government Code Chapter 232; and the Owner does not lay out any part of the tract for the purposes set forth in § 232.001 (a) (3).

   g) Common Ownership Exclusion: All parts of the tract are transferred to persons who own an undivided portion in the original tract; the requirements of these Rules and Regulations are met before any further development of any part of the tract; and Owner does not lay out any part of the tract for the purposes set forth in § 232.001 (a) (3).

   h) City/Floodplain Exclusion: The Owner is a political subdivision of the State of Texas; the land is situated in a floodplain; and the lots are sold to adjoining landowners.

2. **OWNER REQUIREMENTS**: An Owner who claims to be entitled to any exclusion to platting set forth in Subdivision 1 of this Section must provide the following prior to the issuance of any development permits by the County:

   a) Agriculture Exclusion: The Planning Department shall be provided an affidavit, in a form provided by the Planning Department in which the Owner and any person to whom the Owner is to transfer an ownership interest, affirming the use of the tract of land as defined by section 1-d. Art. VIII., Texas Constitution or within the meaning of section1-a-1, Art. VIII, Texas Constitution.

   b) Family Exclusion: The Planning shall be provided an affidavit in the form provided by the Planning Department or certified copies of birth certificates, marriage licenses or other governmental or family records which establish relationship between the Owner and the persons to whom an Ownership interest has transferred.

   c) Large Lots Exclusion: The Planning Department shall be provided a survey or deed describing the lot transferred.

   d) Sale to Veterans Though Veterans' Land Board Program: The Planning Department shall be provided a statement from an official of the Texas Veterans' Land Board that the lots have been sold through a Veterans' Land Board Program and the persons to whom the lots were sold are veterans, an affidavit by the Owner to the effect or other reliable documentation which establishes the exclusion.

   e) Governmental Exclusion: The Planning Department shall be provided certified copies of the deeds and certified copies of the minutes of the meeting at which the agency, board, commission or fund authorized the transfer of the lot.

   f) Retained Ownership Exclusion: The Planning Department shall be provided copies of the deeds and an affidavit from the person to whom the other lot was transferred which affirms the intent to further subdivide the tract subject to the plat approval requirements of Local Government Code Chapter 232.

   g) Common Ownership Exclusion: The Owner shall provide a certified copy to the deed by which the common Owner acquired their common ownership interests.

   h) City/Floodplain Exclusion: The Planning Department shall be provided certified copies of the ordinance, resolution or minutes of the meeting establishing the approval of the transfer by the City.

SECTION IV

PRELIMINARY PLAT

1. **PRELIMINARY PLATS AND PLANS REQUIRED**: Preliminary Plats shall be required for all subdivisions or resubdivisions, except those submitted as Minor Plats, if the development involves interior roads and/or drainage improvements associated with the development. Engineering plans will be required for all improvements at time of Preliminary Plat submittal. See Section VIII, Engineering Plans for details. When the Director of Public Works/Engineering determines that no improvements are to be constructed and no engineering plans are required, the Owner or Applicant may proceed to submit a Final Plat. The developer shall prepare a Preliminary Plat and submit two (2) prints of a Preliminary Plat along with all forms of a proposed subdivision to the Planning Department for presentation to the committee. Any revisions /changes required by the Planning Department of the Preliminary Plat may delay submittal to the committee. The Preliminary Plat shall show or be accompanied by the following information:

2. **SUBDIVISION NAME:** The proposed name of the subdivision, which shall not conflict with the name of any other subdivision in the County, and the names of adjacent subdivisions.

3 **OWNER IDENTIFICATION:** The names, addresses and telephone numbers of the Owner and / or Owners of the proposed subdivision and the names, addresses and telephone numbers of the Engineer, Architect or Surveyor, responsible for the preparation of the plat or engineering plans. If the Owner is a corporation, partnership or joint venture, the name and address of the corporate officers, partners or joint ventures shall be provided.

4**. BOUNDARY LINES:** The location of boundary lines and their relation to a corner of the original survey, a corner of a platted subdivision, or other known and locally recognized reference point, together with a vicinity map. The Point of Beginning (POB) shall be shown in state plane coordinates (NAD 83).

5. **LOTS AND STREETS LAYOUT:** The location and width of existing and proposed streets, roads, lots (accurate dimensions and acreage) and alleys, building lines, easements, parks, school sites, and any other feature relating to the proposed subdivisions shall be shown. The plat shall show the outline of adjacent properties for a distance of at lease one hundred (100) feet and how the streets, alleys, or highways in the proposed subdivisions may connect with adjacent land or with adjacent subdivision which are of record. No streets or roads will be accepted by the County for maintenance that do not connect or intersect an existing county road or state highway.

   a) The acreage of the proposed subdivision shall be indicated on the plat. All lots shall be one acre minimum, net of all easements for streets or roads and flood hazards areas shall have a minimum width of sixty (60) feet adjacent to the road. Lot numbers and block designations shall be shown on the Preliminary Plat. Proposed street

names shall be clearly printed on the Preliminary Plat. Such names shall not conflict with existing county roads or streets.

6. **DRAINAGE AND TOPOGRAPHY**: The Preliminary Plat must show the preliminary drainage plan, the physical features of the property including water courses, the 100 year flood plain boundaries, and structures, bench marks, and other features of importance of lot and street layout, prepared by a Texas Licensed Professional Engineer or Surveyor. Topography of the tract shall be shown on the Preliminary Plat by means of contours of two (2) foot intervals tied to United States Geological Survey (USGS) datum. Contours of lesser intervals may be required to better determine topographical drainage.

   a) Where drainage within the subdivision forms a part of or is within a SFHA or where drainage must be conveyed on private and not within a dedicated public right-of-way, provisions shall be made for drainage easement(s) to allow for proper control of drainage and, if specifically approved by the Commissioners Court, for maintenance by the County within the easement area. See Section VI, Subsection 13. No drainage will be allowed to be conveyed to property downstream without the written consent of the owner of said down stream property.

7. **LAND USE/LAKE RAY ROBERTS ZONING DISTRICT:** Designation of the proposed uses of land within the subdivision whether for residential, commercial, industrial, or public use, such as parks and churches, shall be shown on the Preliminary Plat. All Preliminary Plats of subdivisions which lie within the jurisdiction of the Lake Ray Roberts Planning and Zoning Commission shall indicate on the face of the plat the zoning district(s) in which the subdivision or any portion thereof, is located.

8. **DRAWING REQUIREMENTS:** The north arrows shall be shown with scale (in figures and with a bar) and date. The Preliminary Plat shall be drawn to a scale not exceeding one (1) inch equals two hundred (200) feet. Preliminary Plats shall be presented on standard size sheets of 24″x 36″. If the proposed subdivision is too large to be accommodated by a single standard size sheet, two or more sheets may be used, with match lines clearly shown.

9. **UTILITY SERVICE:** The owner must submit copies of letters and/or plans, signed by each utility company, along with the Preliminary Plat, stating their plans for providing utility service within the proposed subdivision, i.e., electric, telephone, water and sewer service. The owner may, in the alternative, submit copies of the letters sent to the utility companies stating that copies of the Preliminary Plat were provided to the Utility Company requesting the utility company review and respond within thirty (30) days with any objections the company may have. The owner shall provide proof that the letter was delivered by Certified U.S. Mail return receipt requested. Failure of the utility company to timely respond shall be deemed acceptance of the easements and service plans set forth in the plat. A form of such utility letter is shown as an attachment to these Rules and Regulations.

   Utility easements of not less than sixteen (16) feet shall be provided as needed. The proposed water supply should be clearly indicated, i.e., municipal water, rural water supply corporation, privately owned water system, individual wells, etc. Also, the plan for sewage

disposal should be clearly indicated, i.e., municipal sewer service, privately owned sewage disposal system, individual septic tanks, etc.

10. **DEVELOPMENT IN SFHA**: The Owner or Developer of a tract of land that contains SFHA shall comply with all applicable provisions of Denton County Flood Damage Prevention Ordinance.

11. **SUBDIVISION WITHIN EXTRATERRITORIAL JURISDICTION (ETJ):** If the location of the subdivision is within the ETJ of any city or town within Denton County, Texas, review of the Preliminary Plat shall be conducted concurrently with said city or town. Approval by that governing body shall precede but not preclude the necessity of conforming to all rules and regulations of Denton County. The more stringent regulations of two governing bodies shall apply. If the city or town, in whose ETJ the subdivision lies, does not require the filing of a plat, a written certification to said fact executed by the authority responsible for approving plats in said city or town, shall be attached to the plat when submitted to the Planning Department.

12. **APPROVAL BY DENTON COUNTY COMMISSIONERS COURT:** After examination of the Preliminary Plat and engineering plans (if required), the Development Support Committee shall make a recommendation to Court to approve or disapprove the Preliminary Plat and engineering plans. If the Preliminary Plat and engineering plans are disapproved they will be returned to the Owner with the reason(s) for the disapproval. If the plat and plans are approved by the Commissioners Court, the Owner shall be authorized to begin construction on the project following a Pre-construction meeting with the Engineering Department.

13. The Preliminary Plat and engineering plans shall be approved by the Commissioners Court prior to submittal of the Final Plat and prior to any construction activities. Interior/perimeter roadway and damage improvements must be completed, inspected and approved by the County prior to submittal of the Final Plat. No lots shall be sold prior to Final Plat approval as in Section VI, Subsection 14 unless Commissioners Court approval is granted under Section VI, Subsections 19 and 20.

14. Any field modifications due to construction activities that modify the information provided with the drainage study or engineering plans shall be brought to the attention of the Director of Public Works/Engineering, in writing within a reasonable time after completion of the field modifications.

15. **EXPIRATION OF PRELIMINARY PLAT APPROVAL:** The approval of a Preliminary Plat shall continue for twelve (12) months following the date of approval by the Commissioners Court and will expired after that time if Owner or Applicants have taken no action to proceed with the platting and development process. If Preliminary Plat approval expires, Owner or Applicant will be required to resubmit the Preliminary Plat and pay all applicable fees.

16. **PLAN/PLAT FEES:** Each applicant will pay a fee according to the Fee Schedule which is attached to these Rules and Regulations and which may be amended, adjusted or changed by the Commissioners Court from time to time.

SECTION V

MINOR PLAT

1. **MINOR PLATS ALLOWED:** A Minor Plat will be allowed for any subdivision in which only one lot (1) is being platted (One Lot Minor Plat) or in which no road or drainage improvements are required and each lot contains ten (10) acres or more (Ten Acre Minor Plat). The signature of the owner is required on all Minor Plats. An owner and the owner's successors in title shall not be allowed more than three One Lot Minor Plats in any original tract. The lots of three One Lot Minor Plats shall not exceed twenty-five percent (25%) of the total area of the original tract. Minor plats shall not be accepted for a subdivision in which any portions of the platted lots are located within a SFHA. No Preliminary or Final Plats shall be required where the provisions of this section apply. The provisions of this section shall not apply to any subdivision in which a portion of the original tract is to be dedicated to public streets or roads and the development involves the construction of public improvements, including roads and/ or drainage improvements.

2. **MINOR PLAT REQUIREMENTS:** All of the requirements of Section VI, Subsections 2, 3, 6, 7, 8, 9, 10, 11, 12, and 16 shall apply to all Minor Plats.

3. **OWNERSHIP IDENTIFICATION:** The names, addresses and telephone numbers of the Owner and /or Owners of the proposed subdivision and the name address and telephone number of the Engineer or Surveyor responsible for the preparation of the Minor Plat. If the owner is a corporation, partnership or joint venture, the name and address of the corporate officers, partners or joint ventures shall be provided.

4. **BOUNDARY LINES:** The location of boundary lines and their relation to a corner of the original survey, a corner of a platted subdivision, or other known and locally recognized reference points or monuments, described by metes and bounds, shall be included in the plat, together with a vicinity map. The Point of Beginning (POB) shall be shown in state plane coordinates (NAD 83).

5. **LOT STREETS LAYOUT:** The location and width of existing streets, roads, lots (accurate dimensions and acreage), the original tract (accurate dimensions and acreage), alleys, building lines, easements, and other features relating to the proposed subdivision shall be shown. The Minor Plat shall show the outline of adjacent of properties for a distance of at least one hundred (100) feet. A lot number shall be shown on the Minor Plat.

6. **PLAT FEES AND MISCELLANEOUS:** See Section IV; Subsection 14 of these Rules and Regulations.

7. **APPROVAL BY COMMISSIONERS COURT:** A Minor Plat shall be submitted by the Planning Department to the Commissioners Court within fourteen (14) business days of its submission to the Planning Department. If the Owner or Applicant has failed to provide additional information or make corrections requested in writing by the Planning Department, submission to the Commissioners Court shall be held in abeyance until the information or

corrections are received and approved by the Planning Department. Submission to the Commissioners Court shall be made within five (5) business days after the review of a Minor Plat, and/or corrections are received by the Planning Department. After review of a Minor Plat, the Commissioners Court shall approve or disapprove the Minor Plat. If the Minor Plat is approved, the Minor Plat is recorded; the owner may sell the lots. The Commissioners Court shall advise the owners in writing of the reasons for the disapproval of a Minor Plat. A space shall be provided in the lower right hand corner on a Minor Plat for the approval by the County Judge.

8. **RECORDATION:** After final approval and prior to any sale of the lots, a Minor Plat will be recorded by the owner pursuant to the provisions of Section VI, Final Plats, Subsection 15.

9. **ZONING REQUIREMENTS**: All subdivisions lying within the jurisdiction of the Lake Ray Roberts Land Use Ordinance, shall comply with the land use restrictions, setbacks and all other regulations set forth therein. Final Plats shall contain a note that use of lots in the subdivision is regulated by said Ordinance.

10. **STATUS OF AD-VALOREM TAXES**: Each Owner or Applicant will provide a tax certificate for the subdivision as furnished through the Denton County Tax Assessor-Collector office demonstrating there are no delinquent taxes owed and that taxes imposed for the current year have been paid.

SECTION VI

FINAL PLAT

1. **PLAT AND PLANS REQUIRED**: After the Preliminary Plat (and engineering plans if appropriate) has been approved by the Commissioners Court, and after preliminary acceptance of the construction of perimeter and interior improvements, or after a Final Plat has been approved and a resubdivision is proposed, two copies of a Final Plat for review, without signatures, shall be prepared and submitted to the Planning Department. Upon approval by the Planning Department, a Final Plat for recording shall be submitted and shall consist of one (1) 24" x 36" blackline with original seals and signatures. The Final Plat shall show or be accompanied by the following information.

2. **DRAWING REQUIREMENTS:** The North arrow shall be shown with scale (in figures and with a bar) and date. The Final Plat shall be drawn on 24″x 36" sheets to a scale not exceeding one (1) inch equals two hundred (200) feet. The drawing shall contain a 2″ x 3″ block in the lower right hand corner for recording information.

3. **SUBDIVISION NAME**: The name of the subdivision, scale, date and North arrow; name or numbers of streets, and lot, block and section numbers within the subdivision shall be shown. Adjacent subdivisions shall also be shown and identified.

4. **OWNER IDENTIFICATION**: The names, addresses, and telephone numbers of the owner or owners of the proposed subdivision and the name, address and telephone number of the Surveyor responsible for the preparation of the Final Plat shall be shown. If the Owner is a corporation, partnership or joint venture, the name and address of the corporation officers, partners or joint ventures shall be provided.

5. **BOUNDARY LINES:** The perimeter boundary of the subdivision shall be shown with bearings and distances, references to a corner of the original survey, and shall be described by metes and bounds. The area of each lot and the total project area must be shown in each survey. A vicinity map must be shown. The Point of Beginning (POB) shall be shown in state plane coordinates (NAD 83).

6. **UTILITIES SERVICE:** See Section IV, Subsection 9.

7. **LOTS, STREETS, EASEMENTS, AND SET BACK LINE LAYOUT AND DRAINAGE:** Location of lots, streets, roads, public highways, utility easements, parks, bench marks, 100-year flood plain boundaries and other pertinent features, shall be shown with accurate dimensions in feet and decimals of feet and bearing, with length, radii and central angle of all curves, and with all other information necessary to duplicate the plat on the ground. The location of drainage easements, and other public right-of-way or future right-of-way shall be shown. The names and locations of all streets and roads, as approved in the Preliminary Plat, shall be clearly shown. All lots shall be 1 acre minimum net of all right-of-

way and SFHA. Lot numbers and block designation shall be shown on the Final Plat. A minimum of thirty (30) foot set back line shall be provided for each lot which shall have a minimum sixty (60) foot frontage.

8. **CERTIFICATION AND DEDICATION BY OWNER:** Certification by the Owner of his dedication of all street, highways, alleys, utility and drainage easements, parks, if any, any other land dedicated for public use forever, signed and acknowledged before a notary public by said Owner shall be placed on the face of the Final Plat.

9. **CERTIFICATION BY REGISTERED PROFESSIONAL LAND SURVEYOR:** Certifications to the effect that the plat correctly represents a survey made by him, and that all the lot corner makers and boundary markers are correctly placed as shown thereon and all markers shall be shown on the face of the Final Plat. Markers shall be at least one half (1/2) inch iron rods at lease eighteen (18) inches in length, with caps, firmly placed in the ground on the corners of each lot so as to be permanent. The dimensions, bearing, acreage and other technical information needed for platting each lot shall be shown on the subdivision plat. A Final Plat shall not be approved until all pins and benchmarks are placed and placement of same is certified by the Surveyor.

10. **CERTIFICATION AND APPROVAL BY CITY**: Certification of approval signed by the appropriate representatives of any city having extraterritorial jurisdiction over the area in which the subdivision is located shall be placed on the face of the Final Plat. All cities required information, i.e. plans and specifications, that was necessary for the city's approval, shall also be submitted to Denton County along with the Final Plat.

11. **RESTRICTIONS OF SUBDIVISION:** A copy of the restrictions, if any, within the subdivision shall accompany the Final Plat, shall be properly signed and notarized, and filed for record in the office of the County Clerk.

12. **ZONING REQUIREMENTS:** All subdivisions lying within the jurisdiction of the Lake Ray Roberts Land Use Ordinance, shall comply with the land use restrictions, setbacks and all other regulations and requirements set forth therein. All required setbacks shall be shown on the plat. Final Plats shall contain a note that use of lots in the subdivision is regulated by said ordinance.

13. **DEVELOPMENT IN SFHA:** The owner or developer of tract of land that contains SFHA must comply with all provisions of the Denton County Regulations for Flood Plain Management and supply sufficient hydrological/hydraulic data suitable to determine flood plain and flood way limits and to determine base flood elevations. Lots that extend into the floodway must be adequately sized to insure that no encroachments will occur in the floodway.

14. **APPROVAL BY COMMISSIONERS COURT:** After examination of the Final Plat, the Planning Representative shall submit same to the Commissioners Court, directly to the Formal Agenda. The Commissioners Court shall approve or disapprove the Final Plat. If the plat is disapproved it shall be returned to the Owner with reasons for the disapproval. Lots

may not be sold prior to Final Plat approval and recording or the owners complying with Section VI, Subsections 19 and 20. Final Plat approval does not constitute acceptance of any maintenance obligations of any improvements by Denton County. A space shall be provided on the Final Plat, in the lower right hand corner, for the approval by the County Judge of Denton County, Texas.

15. **RECORDATION:** With ten (10) business days after Final Plat approval, the owner or applicant shall file the Final Plat and deed restrictions, if any, with the County Clerk and pay all fees therefore, Failure to comply with this section shall void the approval granted under Section VI, Subsection 14 as provided in Section XIII, Subsection A in addition to being punishable under Section XIII, Subsection B.

16. **STATUS OF AD-VALOREM TAXES:** Each Owner or Applicant will provide a tax certificate for the subdivision as furnished through the Denton County Tax Assessor-Collector office demonstrating there are no delinquent taxes owed and that taxes imposed for the current year have been paid. An original certificate from each taxing unit with jurisdiction of the real property indicating that no delinquent ad valorem taxes are owned on the real property must be attached to and recorded with the Final Plat.

17. **IMPROVEMENTS STATEMENT:** Each plat shall have the following statement placed on the face.

    "Water service to be provided by XXXX."

    All utility providers' names, addresses and phone numbers.

    "Sanitary sewer to be handled by facilities approved by the Denton County Health Department."

    ″The maintenance of paving, grading and drainage improvements and/or easements shown on this plat are the responsibility of the individual property owners and do not constitute acceptance of same for maintenance purposes by Denton County.″

    "All surface drainage easements shall be kept clear of fences, buildings, foundations, plantings, and other obstructions to the operation and maintenance of the drainage facility."

    "Blocking the flow of water or constructing improvements in surface drainage easements, and filling or obstructing the floodway is prohibited."

    "Denton County will not be responsible for any damage, personal injury or loss of life or property occasioned by flooding or flooding conditions."

    "The existing creeks or drainage channels traversing along or across the addition will remain as open channels and will be maintained by the individual property owners of the

lot or lots that are traversed by or adjacent to the drainage courses along or across the lots."

"Construction not complete within two years of the Commissioners Court approval shall be subject to current County Subdivision Rules and Regulations."

"A driveway culvert must be obtained from Road and Bridge Departments by the owner of each lot prior to the construction, installation or placement of any driveway access improvements within the dedicated right-of-way."

"No construction, without written approval from Denton County shall be allowed within an identified "FIRM" floodplain area, and then only after a detailed floodplain development permit including engineering plans and studies show that no rise in the Base Flood Elevation (BFE) will result, that no flooding will result, that no obstruction to the natural flow of water will result; and subject to all owners of the property affected by such construction becoming a party to the request. Where construction is permitted, all finished floor elevations shall be a minimum of one foot above the 100-year flood elevation."

When engineering plans are provided, the engineer shall execute on the face of the plat the following statement:

"I, _____, a Texas Licensed Engineer, do hereby affirm that to the best of my knowledge, information, and belief and based upon the information provided, the drainage improvements shown on this plat will have no adverse effect on any property adjacent to the property shown. I further declare that I will accept full responsibility for the drainage design and will defend and hold harmless Denton County from any claim or litigation arising out of any errors, omissions or other acts of negligence in the preparation of same."

For those properties located within the Lake Ray Roberts Planning and Zoning Jurisdiction, the following note must be added: "These properties are located within the Lake Ray Roberts Land Use Ordinance jurisdiction and are subject to the ordinance. This property is zoned ____." All setback lines must be shown on the plat.

The following statement shall appear on any Plat containing private streets, drives, emergency access easements, recreation areas and open spaces.

"Denton County shall not be responsible for maintenance of private streets, drives, emergency access easements, recreation areas and open spaces; and the owners shall be responsible for the maintenance of private streets, drives, emergency access easements, recreation areas and open spaces, and said owners agree to indemnify and hold harmless Denton County, from all claims, damages and losses arising out of or resulting from performance of the obligations of said owners set forth in this paragraph."

18. **CITY EXTRA-TERRITORIAL JURISDICTION**: The owner will be required to submit an affidavit regarding the subdivision's location within a municipality ETJ. A re-plat of a subdivision located within the ETJ of a municipality whose population exceeds fifty thousand and approved by said municipality has approved the re-plat under Local Government Code §212.016, shall not be required to submit said re-plat for review and approval under these Subdivision Rules and Regulations. Qualifying plats shall be approved on the face of the plat by the Development Support Committee.

19. **POSTING BOND:** A Corporate Surety Bond in the amount of not less than the estimated construction cost and as approval by the Commissioners Court of Denton County may be posted with the Commissioners Court in lieu of completing construction of all interior and perimeter improvements. The estimated construction costs shall include a contingency factor in the amount of twenty percent (20%). The bond shall be executed by a surety company authorized to conduct business in the State of Texas, preferably in Denton County, and shall be made payable to the County Judge, or his/her designee or successors in office, Denton County, Texas. The conditions of said bond shall be that the developer(s) of such proposed subdivision shall (1) provide to Denton County a certified copy of the contract for construction of the said improvements, (2) complete construction within the time as noted in a schedule provided by the developer's constructor at the pre-construction meeting and (3) not be released until and unless all construction and drainage improvements have been accepted for maintenance by Denton County.

20. **DEVELOPMENT PERMIT**: The Commissioners Court may, by special permission after certain requirements are not met, including those set forth in Section 19 above, grant a development permit to an owner whose lot or parcel has not been platted. The requirements, as recommended to the Commissioners Court by the Director of Public Works/Engineering, may include, but are not limited to, the following:

    a) The posting of a performance bond, letter of credit or escrow agreement in an amount to cover the cost of the engineering/surveying process and 20% contingency.

    b) A copy of the professional services agreement between the engineer/surveyor and developer/owner must be provided. The professional service agreement must contain at least the following terms:

        1) A date of completion, if a date of completion was not provided at the preconstruction meeting;

        2) Total cost of construction and cost within the right of way;

        3) A sufficient description of the services to be performed for the Director of Public Works/Engineering to determine that all improvements provided in the engineering plans will be constructed pursuant to said plans.

    a) All platting fees payable to the Planning Department must be paid with all necessary applications completed.

21. **FORFEITURE:** If the Owner, Applicant or Developer fails to complete construction of all interior and perimeter improvements within the time as noted in a schedule provided by the developer's contractor at the pre-construction meeting (The ″Completion Date″), the County shall give written notice to the Owner, Applicant and/or Developer of the failure to timely complete the improvements. The Director of Public Works/Engineering shall send notice by Certified U.S. Mail; return Receipt Requested, to the address provided by the Owner, Applicant and/or Developer. Notice to the Owner, Applicant or Developer shall be deemed sufficient notice to all persons involved in said subdivision. The notice shall be sent no later than ten (10) business days prior to the Completion Date. The notice shall specify the improvements or any portion thereof which remain to be completed. The notice shall also state that if the improvements are not completed by the completion date or an extension thereof, with adequate assurances to the County, and approved by the Commissioners Court, the applicant will forfeit the bond, letter of credit, or escrow agreement, whichever is applicable, and the County will proceed to complete the improvements with the available funds.

22. **AMENDING PLATS:** The Development Support Committee may approve an amending plat which may be recorded and is controlling over the preceding plat without vacation of that plat, amending plat is signed by the applicants only and is solely for one or more of the following purposes:

    a. To correct an error in a course or distance shown on the preceding plat;

    b. To add a course or distance that was omitted on the preceding plat;

    c. To correct an error in a real property description shown on the preceding plat;

    d. To indicate monuments set after the death, disability, or retirement from practice of the engineer or surveyor responsible for setting monuments;

    e. To show the location or character of a monument that has been changed in location or character or that is shown incorrectly as to location or character on the preceding plat;

    f. To correct any other type of scrivener or clerical error or omission previously approved by the Commission Court, including lot numbers, acreage, street names, and identification of adjacent recording plats;

    g. To correct an error in courses and distance of lines between two adjacent lots if:
        i. Both lot owners join in the application for amending the plat;
        ii. Neither lot is abolished;
        iii. The amendment does not attempt to remove recorded covenants or restrictions; and
        iv. The amendment does not have a material adverse effect on the property rights of the other owners in the plat.

h. To relocate a lot, to eliminate encroachment of a building or other improvement on a lot line easement;

i. To relocate one or more lot lines between one or more adjacent lots if:
   i. The owners of all those lots join in the application for amending the plat;
   ii. The amendment does not attempt to remove recorded covenants or restrictions;
   iii. The amendment does not increase the numbers of lots; and
   iv. The amendment does not create or require the creation of a new street or make necessary the extension of utility easements.

j. To replat one or more lots fronting on an existing street if:
   i. The owners of all those lots join in the application for amending the plat;
   ii. The amendment does not attempt to remove recorded covenants or restrictions;
   iii. The amendment does not increase the number of lots; and
   iv. The amendment does not create or require the creation of a new street or make necessary the extension of utility easements.

Notice, a hearing, and the approval of other lot owners are not required for the approval and issuance of an amending plat.

SECTION VII

MANUFACTURED HOME RENTAL COMMUNITY (MHRC)

1. **SURVEY AND INFRASTRUCTURE DEVELOPMENT PLANS REQUIRED:**
The Owner of a tract of land intended to be used as a MHRC shall have prepared and submitted to the Planning Department a survey and an Infrastructure Development Plan (IDP). The Owner shall submit four blue line prints and one reproducible print, all with original seals and signatures. The survey and an IDP shall show or be accompanied by the following information:

2. **DRAWING REQUIREMENTS:** The North arrow shall be shown along with scale (in figures and a bar) and date. The final survey shall be drawn on 24″X 36″ sheets to a scale not exceeding one (1) inch equals two hundred (200) feet. The recording survey shall be on permanent type material i.e. Mylar. All figures and letters shown must be plain, distinct, and of sufficient size as to be easily read, and must be of sufficient density to make a lasting and permanent record.

3. **MANUFACTURED HOME COMMUNITY NAME:** The name of the community, scale, date and North arrow, name or numbers of streets, and lots or spaces numbers within the community shall be shown. Adjacent communities and platted subdivisions shall also be shown and identified.

4. **OWNER IDENTIFICATION:** The names, addresses and telephone numbers of the owner or owners of the proposed community and the name, address and telephone number of the Surveyor responsible for the preparation of the final survey shall be shown. If the Owner is a corporation, partnership or joint venture, the names and addresses of the corporate officers, partners or joint ventures shall be provided.

5. **BOUNDARY LINES:** The perimeter boundary of the community shall be shown with bearings and distances, referenced to a corner of the original survey, shall be described by metes and bounds. The area of each lot or space and the total project area must be shown in each survey. A vicinity map must also be shown. The Point of Beginning (POB) shall be shown in state plane coordinates (NAD 83).

6. **UTILITIES SERVICE**: All utilities service providers shall approve the survey and IDP in writing and provide the Planning Department with a letter certifying its approval and its ability to provide service to the community.

7. **LOTS, STREETS, EASEMENTS, SET BACK LINE LAYOUT AND DRAINAGE**: Location of lots, spaces, streets, roads, public highways, utilities easements, parks, bench marks, 100 year flood plain boundaries and other pertinent features, shall be shown with accurate dimensions in feet and decimals of feet and bearing, with length, radii and central angle of all curves, and with all other information necessary to duplicate the survey on the ground. The location of drainage easements, and other public right-of-way or future right-of-

way shall be shown. The names and locations of all streets and roads shall be clearly shown. All lots shall be one (1) acre minimum net of all right-of-way and SFHA. Lot numbers and block designation shall be shown on the final survey. A minimum of a thirty (30) foot set back line shall be provided for each lot which shall have a minimum sixty (60) foot frontage.

8. **CERTIFICATION AND DEDICATION BY OWNER:** Certification by the Owner of his dedication of all street, public highways, alley, utility and drainage easements, parks, if any, any other land dedicated for public use forever, signed and acknowledged before a notary public by said Owner shall be placed on the face of the final survey.

9. **CERTIFICATION BY REGISTERED PROFESSIONAL LAND SURVEYOR:** Certification that the survey correctly represents a survey made by him, and that all the lot corner markers and boundary markers are correctly placed as shown thereon and all markers shall be shown on the face of the survey. Markers shall be at least one half (1/2) inch iron rods at least eighteen (18) inches in length, with caps, firmly placed in the ground on the corners of each lot so as to be permanent. The dimensions, acreage and other technical information needed for platting each lot shall be shown on the community survey. A Final Survey shall not be approved until all pins and benchmarks are placed and placement of same is certified by the Surveyor.

10. **CERTIFICATION AND APPROVAL BY CITY:** Certification of approval signed by the appropriate representatives of any city having extraterritorial jurisdiction over the area in which the community is located shall be placed on the face of the final survey. All city required information, i.e. plans and specifications, was necessitated for their approval, shall also be submitted to the Denton County Planning Department along with a final survey.

11. **RESTRICTIONS OF COMMUNITY:** A copy of the restrictions, if any, within the community shall accompany the Final Survey, shall be notarized and filed for record in the office of the County Clerk.

12. **ZONING REQUIREMENTS:** All communities lying within the jurisdiction of the Lake Ray Roberts Land Use Ordinance shall comply with the land use restrictions, setbacks and all other regulations and requirements set forth therein. Final Surveys shall contain a note that use of lots in the community is regulated by said Ordinance.

13. **DEVELOPMENT IN SFHA:** The owner or developer of a tract of land that contains a SFHA must comply with all provisions of the Denton County Regulations for Flood Plain Management and supply sufficient hydrological / hydraulic data suitable to determine flood plain and flood way limits and to determine base flood elevations. Lots that extend into the floodway must be adequately sized to insure that no encroachments will occur in the floodway.

14. **STATUS OF AD-VALOREM TAXES:** Each Owner or Applicant will provide a tax certificate for the community as furnished through the Denton County Tax Assessor-Collector office demonstrating there are no delinquent taxes owed and that taxes imposed for the current year have been paid.

IMPROVEMENTS STATEMENT: Each survey shall have the following statement placed on the face.

"Water service to be provided by XXXX."

All utility providers' names, addresses and phone numbers.

"Sanitary sewer to be handled by facilities approved by the Denton County Health Department."

"The maintenance of paving, grading and drainage improvements and/or easements shown on this survey are the responsibility of the individual property owners and do not constitute acceptance of same for maintenance purposes by Denton County."

"All surface drainage easements shall be kept clear of fences, buildings, foundations, plantings, and other obstructions to the operation and maintenance of the drainage facility."

"Blocking the flow of water or constructing improvements in surface drainage easements, and filling or obstructing the floodway is prohibited."

"Denton County will not be responsible for any damage, personal injury or loss of life or property occasioned by flooding or flooding conditions."

"The existing creeks or drainage channels traversing along or across the addition will remain as open channels and will be maintained by the individual property owners of the lot or lots that are traversed by or adjacent to the drainage courses along or across the lots."

"Construction not complete within two years of the Commissioners Court approval shall be subject to current County Subdivision Rules and Regulations."

"A driveway culvert must be obtained from Road and Bridge Departments by the owner of each lot prior to the construction, installation or placement of any driveway access improvements within the dedicated right-of-way."

"No construction, without written approval from Denton County shall be allowed within an identified "FIRM" floodplain area, and then only after a detailed floodplain development permit including engineering plans and studies show that no rise in the Base Flood Elevation (BFE) will result, that no flooding will result, that no obstruction to the natural flow of water will result; and subject to all owners of the property affected by such construction becoming a party to the request. Where construction is permitted, all finished floor elevations shall be a minimum of one foot above the 100-year flood elevation."

When engineering plans are provided, the engineer shall execute on the face of the survey the following statement:

> "I, _____, a Texas Licensed Engineer, do hereby affirm that to the best of my knowledge, information, and belief and based upon the information provided, the drainage improvements shown on this survey will have no adverse effect on any property adjacent to the property shown. I further declare that I will accept full responsibility for the drainage design and will defend and hold harmless Denton County from any claim or litigation arising out of any errors, omissions or other acts of negligence in the preparation of same."

15. **APPROVAL OF SURVEY AND IDP:** After examination of the survey, the Development Support Committee shall make a recommendation to Commissioners Court to approve or reject the survey and IDP within sixty (60) days of being submitted. A rejection shall be in writing and shall be served when placed in the mail addressed to the owner. Failure to reject the plan within the time prescribed shall constitute the Commissioner Courts acceptance of the plan. Construction of the community is prohibited until the plan is approved.

16. **INSPECTIONS REQUIRED**: Prior to the commencement of construction, the Owner, Owner's engineer, the Owner's contractor, and representatives of the County shall meet in a pre-construction meeting to discuss and establish timing of inspections by the County during all phases of construction. The final inspection shall occur not later than two (2) business days after the owner delivers written confirmation that all improvements have been completed.

17. **CERTIFICATE OF COMPLETION**: If the inspector determines that the infrastructure complies with the IDP, the Commissioners Court shall issue a certificate of completion no later than five (5) business days after final completion.

18. **UTILITY SERVICES**: A utility may not provide services, including water, sewer, gas, and electric services, to a community subject to an IDP or a manufactured home in the community unless the owner provides the utility with a copy of the certificate of compliance issued under Subsection 18 above. This subsection applies to:

    a) a municipality that provides utility services;

    b) a municipality owned or municipality operated utility that provide services;

    c) a public utility that provides services;

    d) a non-profit water supply or sewer service corporation organized and operating under Chapter 67, Texas Water Code, that provides utility services;

    e) a county that provides utility services, and

f) a special district or authority created by state law that provides utility services.

SECTION VIII

ENGINEERING PLANS

I. PLANS REQUIRED

Engineering Plans shall be submitted for all improvements required such as new roads, drainage ditches, open channels, detention ponds, erosion control devices or structures and all other required improvements. The engineering plans shall convey the existing and proposed conditions for the site being developed. Three (3) sets of engineering plans shall be submitted simultaneously with the Preliminary Plat. The total cost for such engineering plans shall be borne by the owner/developer. The developer is prohibited from disturbing any natural soils or constructing any improvements prior to acceptance and approval of the engineering plans by the Commissioner Courts. Any improvements constructed prior to this approval shall be removed at the owner / developer's expense. All plans shall be compiled in accordance with the following requirements:

The portions of the tract designated for use as roads, drainage facilities and structures in and adjacent to a proposed subdivision shall be platted, regardless of whether the owner intends to intends dedicate same to Denton County for maintenance. All such dedications or designations are subject to acceptance and approval by the Commissioners Court, whether dedicated public right-of-way easements or designated as private easements. All said improvements shall be constructed to the standards required by these regulations and inspections by Denton County to insure compliance with these regulations.

A. Denton County will not accept any drainage easement if any portion thereof lies within a SFHA.

B. The Developer of a subdivision shall be responsible for the cost of the construction of all roads, drainage improvements, and all other required improvements in the development, whether or not the streets were already County roads.

II. GENERAL REQUIREMENTS

A. All plan sheets containing plan and profiles shall be 1″ = 40' horizontal and 1″ = 4' vertical. Site plans and guarding plans shall be 1″= 30' or less but may be 1″ = 40' with the approval of Reviewing Engineer. The drainage plan/map shall be 1″ = 1000' or less but in general 1″ = 200' shall be the preferred scale.

B. All sheets shall be 24″X 36″ in size and shall be signed, and sealed by Texas Licensed Professional Engineer.

C. A North arrow indicating the directions of North.

D. A quantity takeoff sheet is provided with all engineering plans. The takeoff sheet shall list all material items need for the construction of the roads, drainage improvements,

culverts, and erosion control improvements and/or other required improvements. This information shall be placed in the detail sheets of the plans in clearly defined block.

E. Benchmarks shall be required to be placed in at least two (2) locations within every subdivision and shown for reference in the plans. In all there shall be a minimum of one benchmark for each 20 acres in the development. The location of each benchmark in reference to permanent objects such as trees, fence corners, drainage structures or fixed, permanent objects, the actual elevation of each benchmark and the GPS coordinates in NAD 83 shall be included on the Preliminary and Final Plat. For the purpose of this subsection, ″Elevation″ shall mean the approximate distance in feet relative to mean sea level. The monuments themselves shall be set in the field and shall consist of permanent brass caps set in a 4 inch x 4 inch x 18 inch concrete base with the exact coordinate location and monument number (as referenced on the plans and plats) clearly engraved in the brass surface. The base itself shall be buried so that no more than 3 inches and no less than 1 inch is exposed above ground level.

F. The Developer shall provide copies of all permits required by TxDOT, TCEQ, EPA, or any other governmental entity with jurisdiction of the real property or adjacent roads, streets or highways. TCEQ and EPA permits shall include, but are not limited to, a Storm Water Pollution Prevention Plan process permit. For Notice of Intent (NOI), a copy of the application shall be deemed in compliance with these regulations. Notice of Terminations (NOT) shall also be submitted at the end of the project.

G. An erosion control plan for the site shall be submitted with the engineering plans. It shall be designed in accordance with North Central Texas Council of Government standards and signed by a Texas Licensed Professional Engineer. Silt fence, check damns and other recognized methods shall be used and the details for the construction of each shall be included in the engineering plans. A note stating that ″ 75 % grass coverage of all disturbed areas shall be required before the construction activities will be accepted ″ is to be placed on the erosion control plan. If the contractor is unable to obtain this coverage with a standard TxDOT winter / summer (rye/Bermuda) mix or to sodding the affected areas, a bond, as set forth in Section VI, bond, as set forth in Section VI, Subsections 19, 20, & 21, may be posted to insure compliance and conditioned upon reaching compliance with this subsection within 6 months of approval of said bond by Commissioners Court. If the grass has not achieved the 75 % coverage over the affected areas the bond may be forfeited by the applicant and the Commissioners Court will complete the project with the remaining funds. The bond shall be in the amount of 120 % of $200 per disturbed acre.

H. A Mass Grading Plan shall be included in the engineering plans set forth for all roads and drainage improvements. The Mass Grading Plan shall cover all areas in which soils will be disturbed. This shall be required when large areas of cut or fill shall be constructed and that fall outside the ROW lines of new roads or over lot lines.

I. All engineering plans submitted to Denton County shall be of a level of detail and quality that is required of a qualified and competent engineer meeting the professional standards of a licensed professional engineer practicing in Denton County, Texas. All engineering

plans submitted pursuant to this subsection shall be sealed and contain sufficient details to be effectively used by a reasonable contractor and inspector.

J. Construction plans shall show all proposed utilities in both plan and profile view for all utilities in County right-of- way or easements. Underground utility lines may be permitted to cross County right-of-way, but will not be permitted longitudinally in the right-of-way. All utilities crossing under exiting roadways must be bored and encased in a casing pipe. Utilities crossing proposed roadways may be open cut. Utility lines 4inch and greater in diameter shall be encased in schedule 40 steel pipe. Utility lines less than 4 inch in diameter shall be encased in schedule 40 plastic (PVC) pipe. All utility lines crossing exiting or proposed roadways shall be encased regardless of whether they are bored or open cut. The ends of all casing pipes shall be sealed with end caps. Backfill may be native material from the trench excavations, or may be select granular material. Backfill shall be placed in maximum 8 inch loose lifts and compacted to a minimum 95 % standard proctor density at – 2% to + 4% optimum moisture. At least one density test shall be taken on each lift for each crossing. Trench backfill not placed and documented as described will be replaced. Alternatively, a flowable backfill may be used to backfill trenches. Flowable backfill must be in accordance with the TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges, current edition or as approved by the County Engineer. No pavement subgrade preparation may proceed until trench backfill has been approved. No water jetting of trenches will be allowed. Utilities shall have a minimum forty-two inches (42″) cover, measured from the lowest point of the adjacent roadside ditch. The minimum allowable width for all drainage/utilities easements shall be sixteen feet (16‘).

K. The Denton County Department of Public Works will review the construction plans for their conformance, and return one (1) set of the construction plans to the developer stating:

- that the plans have been approved

- the changes that will need to be made before the plans will be approved. If any changes are required, the developer shall have the necessary changes made and submit two (2) copies of the corrected plans to the Denton County Department of Public Works. If all necessary changes have been made, the Denton County Department of Public Works will return one (1) set of the corrected plans to the developer stating that the plans have been approved.

III. PAVING PLANS

A. General

1. All materials and construction methods shall conform to the latest edition of the TxDOT Standard Specifications for Construction of Highways, Street and Bridge, plus any other TxDOT specifications reference therein. Other specifications such as

North Central Texas Council of Governments may be used with the recommendation of the Director of Public Works/Engineering and approval of the Commissioners Court.

2. The geometric design of roads shall conform to the latest edition of The American Association of State Highway and Transportation Officials (AASHTO) ″Policy on Geometric Design of Highways and Streets.″

3. The Owner shall pay for and utilize the services of a geotechnical engineer to sample and test right-of-way site soils. The Owner's engineer shall make recommendations for soil stabilization in report form and shall design the roadway section for a minimum twenty (20) year service life. The minimum acceptable wearing surface shall be Type 'D' HMA with a two inch (2) minimum thickness or 3,000 psi minimum Portland Cement Concrete with a minimum six inch (6″) thickness. The Owner's engineer shall design the road sections based on projected traffic volume and type and soil conditions to comply with the performance criteria. Traffic levels will be based on authorized standards, such as those developed by the Institute of Transportation Engineers and/or AASHTO. The pavement design provided in the geotechnical report shall specify a minimum allowable tolerance to be applied during construction to the ″As-Built″ pavement thickness and for each item shown in the pavement cross section. If no tolerance is allowed, then the constructed pavement thickness must be equal to or greater than that specified in the design and a statement to that effect must be provided in the report.

4. Certified elevations, by a Surveyor, shall be taken for sub-grade, base, each course of asphalt pavement, and ditch/culvert flowline at 100' (foot) station intervals to verify elevations. These shall be submitted to the Reviewing Engineer for verification prior to beginning construction of the next roadway item. The survey data shall be in a tabular form listing roadway station, proposed elevation, measured elevation and elevation difference. The maximum allowable tolerance for final grade of all plan items shall be 0.10 feet for pavement finished grade and 0.20 feet for ditch and culvert flowlines.

5. All roads shall be designed and constructed according to the specifications required herein and subject to inspection as required by Section IX, Construction Requirements.

B. Perimeter Improvements

1. When a proposed subdivision of land abuts both sides of an existing road, street, highway, or drainage easement that is substandard according to the current Denton County Standard Specifications, the developer shall be required to improve the existing road and drainage to Denton County standards. The Developer shall also be required to dedicate the necessary right-of-way for the particular roadway, which shall be no less than sixty feet (60′).

2. When the proposed addition or subdivision is located adjacent to a substandard county road or street, the developer shall be required to upgrade the perimeter road based on the impact the subdivision has on the county road or street.

C. Layout Requirements

1. In subdivision where buildings are to be served by septic systems, the size of lots shall be sufficiently large to accommodate adequate drainage fields and to meet the standards set forth by the Denton County Environmental Health.

2. For lots with on-site septic systems, minimum lot size shall be 1.0 acres net. Net acreage is defined as the total acreage minus any area included in drainage easements or floodplain easements.

3. Side lot lines should normally be at a ninety-degree angle to the street.

4. All straight lines shall clearly show the length of the line, and the plat shall show enough information to readily determine the bearing of all lot lines.

5. The length of a block shall be considered to be the distance from property corner to property corner measured along the property line of the block face:

   - Of the greatest dimension, or
   - On which the greatest number of lots face.

6. The width of the block shall be considered to be the distance from property corner to property corner measured along the property line of the block face:

   - Of the least dimension, or
   - On which the fewest number of lots face.

7. Any land which, in its natural state, is subject to a 100-year flood or which cannot be properly drained shall not be subdivided, re-subdivided or developed until receipt of evidence that the construction of specific improvements proposed by the Subdivider can be expected to yield a usable building site. Thereafter, Commissioners Court may approve plat; however, construction upon such land shall be prohibited until the specific improvements have been planned and construction guaranteed.

8. All curved lot lines shall clearly show the length of the arc and radius of the curve, or show enough information on the plat to readily determine the radius of the curve. The right of way width dedicated for all roads shall be established based on Denton County requirements, but shall not be less than sixty feet (60′).

9. All roads designed to intersect an arterial shall intersect at a minimum centerline distance of three hundred feet (300′) from the closest adjacent intersecting road.

10. All other roads shall intersect at a minimum centerline distance of one hundred feet (100′) from the closest adjacent intersecting road.

11. Streets should be platted to allow two tiers of lots between streets when possible.

12. The reservation in private ownership of strips of land at the end or side of proposed or existing streets and intended solely or primarily for the purpose of controlling access to a County maintained road shall be prohibited.

13. Local streets will be laid out so that their use by through traffic will be discouraged.

14. Provision must be made for the extension of existing dead-end streets within recorded adjacent subdivisions. Proposed streets must conform to existing topography as nearly as possible in order that drainage may be provided. Streets should follow valleys or depressions so as to form a collection system for surface runoff. Streets extending further than one thousand (1,000) feet shall provide for an emergency vehicle turn-around at lease every one thousand feet (1,000′).

15. The system of streets designated for the subdivision must connect with streets already dedicated in any adjacent subdivision and, where no adjacent connection are platted, must be continued to the boundaries of the tracts subdivided, so that other subdivisions may connect therewith.

16. No dead-end streets without a cul-de-sac will be approved unless such dead-end streets are provided to connect with future streets on adjacent land.

17. Cul-de-sacs may be permitted where the form or contour of the land makes it difficult to plat with connecting streets. Such cul-de-sacs shall provide proper access to all lots, and a turn-around shall be provided at the closed end, with an outside right-of-way radius of at lease fifty feet (50′) and an outside edge of pavement radius of at lease forty feet (40′). Cul-de-sacs shall be constructed one (1) cul-de-sac per every one thousand feet (1000′) along the entire length of each dead-end street.

18. In subdivisions constructed in more than one (1) phase, temporary cul-de-sacs shall be required at the end of street or road which is intended to connect to future streets. The materials of which the temporary cul-de-sac shall be constructed shall conform to those required for the street itself in the Geotechnical report.

19. For reasons of safety and public convenience, Denton County requires construction of an all-weather turn-around, similar to a cul-de-sac, at the end of each dead-end private driveway.

20. The need to provide access for emergency services or align road and street right-of ways to provide the safe flow of traffic may require an additional entrance to a

subdivision from a Denton County Road or a State Highway or an altered alignment of the roads and streets within the subdivision.

21. Where an existing County road abuts the subdivision, the owner shall set back the subdivision line (road R.O.W. line) a minimum of one half the total R.O.W. width as established for that road.

22. All roads or streets shall have minimum grade of five-tenths percent (0.5%). Grades of more than ten percent (10%) shall only be allowed upon approval of the Denton County Public Works.

23. Where any portion of a road or street has been dedicated in an adjoining, subdivision, adjacent to and along the common property line of the two subdivisions, enough width of right-of-way must be dedicated in the new subdivision to provide the minimum width specified herein.

24. Roads or streets which are continuation of any existing road or street shall take the name of the existing road or street.

25. All roads or streets preferably shall intersect at a ninety-degree angle. Where this is not possible, the intersection, on the side of the acute angle, shall be rounded with a curve or a cutback, but in no case, shall the curve have less than a twenty-five foot (25') radius.

26. New roads or streets, which are a continuation of an existing road or street, shall be a continuation, without offset, of the existing road or street.

27. Where roads or streets in an adjoining subdivision end at the property line of the new subdivision the said roads or streets shall be continued throughout the new subdivision. Where there are not adjacent connections platted, the roads in the new subdivision shall be a reasonable projection of the roads or streets into the nearest subdivisions.

28. No decorative squares, tree, islands, ornamental entrances or any other obstruction to traffic shall be constructed or preserved within the right-of-way of a road dedicated to the public without the written permission of the Department of Public Works. If landscaping and /or irrigation are proposed within the right of way, the owner shall create a body (municipal utility district, home owners association, neighborhood association, etc.) that will be responsible for the maintenance and liability of the landscaping and/or irrigation system. This body shall have assessment authority to insure the proper funding for maintenance.

29. Private Roads

    - Private roads cannot be included in a subdivision without prior approval of the Commissioners' Court. When request for a private road is received by the

Department of Public Works, it will be presented to Commissioners' Court for their approval or disapproval.

- Private streets, roads, emergency access easements, etc. shall be termed as a vehicular access way under private ownership and maintenance.

- Private roads shall meet the same construction standards and specifications as public roads and streets.

30. Drainage easements shall be a minimum of sixteen feet (16') in width, and normally located along a property or lot line. It shall be the duty of the developer to insure that all easements are of the proper width and location to serve the using utility companies.

31. If new roads are constructed over existing petroleum pipe line crossings, the pipe lines must meet the following requirements:

    - Encased pipe must be at least 42 inches below the deepest proposed ditch grade

    - Noncased pipe (of extra wall thickness meeting Federal Regulations) must be at least 4 feet below the deepest proposed ditch.

32. Drainage easements shall generally be located along the existing drainage way, and shall have 4:1 side slopes. All easements shall be so designed to allow maintenance equipment to enter the easement from public property, and be able to perform the necessary work.

33. All streets signs, posts and mounting hardware shall be furnished by the Developer, Applicant or Owners (at his or her expense).

34. The following information shall be obtained from the Planning Division and lettered on all street signs:

    - the block range (written in lower right hand corner)
    - street name (with the suffix)

35. Street signs shall be mounted on steel post (minimum eight feet (8′) of clearance height). Street signs shall be manufactured with engineer grade reflective white letters, a minimum of four inches (4″) high, on green engineer grade reflective sheeting background. Proper traffic control signs shall also be furnished by the developer as required by the County Engineer.

36. All signs shall be constructed of material conforming to the requirements of the Texas Manual on Uniform Traffic Control Devices, latest edition, and installed by the developer or owner.

37. Street names will not be approved if said conflict or will cause confusion with existing street names. The information regarding street names and addressing of structures shall be provided in such a form as required by the Planning Department in order to facilitate use of said information by Denton County's Emergency 911 System.

D. Plan Requirements

Engineering Plans shall provide:

a. Centerline stationing beginning at an intersecting roadway centerline.

b. Station and elevation references shall be provided on plan and profile sheets at PT's, PC's, PI's, centerline intersections, VPT's, VPC's, VPI's, culvert crossing and other locations deemed necessary. Station and elevation shall be provided at the bottom of each profile at each one hundred foot (100′) station mark.

c. Spot elevations.

d. A joint spacing plan (concrete paving only).

e. Typical cross-section of the roadway showing each type of material to be used.

f. All lot corners, angle points, points of curvature, and points of tangency shall be identified with iron rods at lease eighteen inches (18″) in length. All lots shall have frontage on a dedicated public right-of-way or a private road which intersects a public right-of-way.

g. Cross sections every 100 feet except in areas where a cross section will cross through a culvert.

IV. DRAINAGE DESIGN

A. Drainage Plan/Map

a. A drainage plan/map shall be required for all subdivisions.

b. When calculating the runoff, the drainage plan shall show the boundary of the drainage area contributing runoff into the proposed system. The area shall be further divided into sub-areas to determine flow at concentration points.

c. The drainage plan should show all boundary lines, lot lines, drainage easements and labels, the location of all propose or existing detention ponds, open channels, swales and riprap, streets, street names, any zoning, zoning boundaries, existing ground on five foot (5′) contours and a hydraulic summary table. The hydraulic summary table shall show for each sub-area the following information:

   i. concentration point numbers or designations

   ii. area and or sub-area number

   iii. total acres in each area or sub-area

   iv. runoff coefficient "C"

   v. time of concentration "Tc"

   vi. design rainfall intensity "I"

   vii. design discharge "Q"

d. Direction of flow within streets, alleys, natural and man-made drainage-ways and at all systems intersections shall be clearly shown on the drainage area map. This includes sags, crests and corners.

e. The rainfall intensity "I" shall be shown for a 10, 50 and 100-year event when no detention pond is required and for a 2, 5, 10, 25, 50, & 100-year event when detention is required.

B. Drainage Design Criteria

Open Channel Design: Open channels are to be used whenever concentrated flows greater than 25 cfs occur. The use of existing channels in their condition is encouraged when possible. In such cases, an adequate drainage easement shall be dedicated to meet flow requirements. The design water surface in an open channel is shown in this section. All plan sheets for Open Channels shall show the one hundred

(100) year hydraulic grade line (HGL) in the profile, centerline stationing, and elevation information at one hundred foot (100) station intervals.

Barrow Ditch Design: Barrow Ditches are to be used along all roadways to convey drainage in accordance with the following criteria:

a. Ditches shall be designed to carry a one hundred (100) year storm and the back water effects of the most restrictive culvert to be placed in the ditch.

b. Ditches shall at all times maintain a minimum thirty inch (30″) depth.

c. The entire ditch should be contained within the ROW of the road. If the ditch cannot be contained additional ROW may be required. A second option would be to provide a minimum sixteen foot (16′) drainage easement and the following note on the plat: Note Drainage easements adjacent to roadways may not be fenced and must be left so that access can be obtained for maintenance purposes.

d. The side-slopes of all ditches shall be 4:1 maximum.

e. The minimum allowable bottom slope in any ditch shall be 0.50%

f. All plan and profile sheets for new roadways shall show the one hundred (100) year hydraulic grade line (HGL) in the profile for each ditch (profiles shall be split- left and right ditch, top and bottom), the existing grade at the center of each ditch, the proposed pavement centerline, proposed ditch flow-line, roadway centerline stationing, and elevation information at one hundred (100′) station intervals.

Drainage Swale Design: When concentrated flows occur on the property developed that are less than 25 cfs a drainage swale may by used. The primary function of a drainage swale is to intercept water and convey it to a drainage channel or other drainage facility. Swales shall be designed in accordance with the following criteria:

a. The minimum allowable bottom slope in a swale shall be 0.50%.

b. The side-slopes of all swales shall be 4:1 maximum.

c. The depth of all swales shall be eighteen inches (18″) or (1.5 feet).

d. The minimum allowable easement width for all swales shall be sixteen feet (16′).

Culvert Design: There are two principle categories of culverts that are used in roadway design, driveway culverts and crossing culverts. The following design criteria shall be used for each:

a. Sub-grade, bedding and backfill material for all culverts shall be compacted in accordance with Denton County specifications prior to final acceptance.

b. Drainage design for all culverts shall consider the backwater effects of inlet and outlet control. The barrow ditch size and depth shall be adjusted if necessary to accommodate and contain the culvert backwater.

Driveway Culverts:

a. All driveways and driveway culverts are the responsibility of the individual lot owner or developer. It is the developer's responsibility to insure that all lot owners are aware of this requirement. Driveway culverts shall be made of corrugated metal pipe (CMP). They shall have a minimum bottom slope of 0.50% and be no less than twenty-four feet (24′) in length and no greater than fifty feet (50′). The minimum allowable driveway culvert size shall be fifteen inches (15″) in diameter.

b. Concrete-Safety-Treatments (ends) are required for all new culverts in accordance with TxDOT standard details.

c. A minimum of six inches (6″) of cover shall be placed above all new culverts below the lowest bank of the ditch.

d. Where multiple culverts occur in ditches, the ditch bottom must be widened to have a bottom width that is six inches (6″) greater on each side than the distance from the outside walls of the outer two culverts. Each culvert shall also be separated by six inches (6″) of compacted fill material.

e. Driveway culverts shall be shown at the most restrictive section to be anticipated for each lot, in the roadway plan and profile. The Hydraulic Grade Line (HGL) shall reflect the effects of backwater in the profile. Proposed upstream and elevations for proposed culverts shall be shown in the plan and profile as well.

f. All driveway culverts must be installed prior to issuance of building permits or construction activities on the individual lot.

Crossing Culverts:

a. Crossing culverts shall be placed to relieve drainage at all low-points and drainage crossings. They shall be constructed of Class-III or better, Reinforced Concrete Pipe (RCP).

b. The minimum bottom slope in all crossing culverts shall be 0.50%. The minimum allowable crossing culverts size shall be eighteen inches (18″) in diameter.

c. Safety ends or headwalls shall be constructed at the ends of all Crossing Culverts to protect the embankment from erosion and culvert from displacement. The safety ends or headwalls shall be constructed in accordance with TxDOT standards as required by the physical conditions of the particular installation. Rock rip-rap or other suitable erosion control may be required at each location as supplemental protection.

d. All crossing culverts and related structures that are a part of the road construction shall be in place prior to final acceptance of the improvements for the subdivision.

Storm Water Runoff Management:
Denton County Storm Water Policy- it the intent of Denton County to have zero impact on properties adjacent to and or downstream of new subdivisions or developments. This shall be required of all new developments regardless of size. There is one condition that will serve as an exception to this requirement and that is when a "point discharge" would result if a detention pond or other drainage structure were to be constructed. Therefore, in cases where the overland distance of flow across the entire portion of the property being platted is less than three hundred feet (300′) and can be clearly shown to have only sheet flow that does not concentrate flow, a drainage plan clearly showing this condition will be all that is required to be submitted. If it is known that the final usage of such a property will result in a drainage runoff coefficient greater than 0.50 this exception will not apply and some form of storm water management will be required. There are several accepted methods of providing protection and safety for these downstream properties that can be used. They are:

Storm Water Detention
Storm Water Detention involves collecting excess runoff before it enters the main drainage systems. It can be used effectively and economically to reduce peak flow rates and mitigate problems of flooding, pollution, soil erosion issues.

Design Criteria: The Modified Rational Method shall be used to design all detention facilities except in cases where a large drainage basin is present and a method such as SCS Tabular, HEC-1 or TR-20 is justified. The pond and its outlets shall be designed to accommodate the 2, 5, 10, 25, 50 and 100- year storm events.

Pond Layout: Side slopes of berms and drop offs shall be 4:1 maximum and the bottom of all dry bottom ponds shall have a minimum 0.50% slope. Wet bottom ponds (Ponds that provide retention as well as detention) shall have a minimum depth below the lowest outlet elevation of five feet (5′) to avoid "mosquito trap" scenarios from developing. A minimum six inch (6″) freeboard above the one hundred (100) year event must be provided. Spot elevations for purposed and existing grades in the pond area and for at least one hundred and fifty feet (150′) downstream of all outlet structures shall be shown with differentiation on the plans.

Outlet Structures: Outlets shall be typically composed of one or all of the following elements, eighteen inch (18″) diameter or greater reinforced concrete pipes (RCP), reinforce concrete box structure, and reinforced concrete weir or v-notch structure. In all cases an earthen or concrete (if preferred) overflow structure must be provided above the one hundred (100) year flood event and have a minimum depth of twelve inches (12″).

Construction: All ponds shall be seeded or sodden with rye or Bermuda grass (or native grass as appropriate to the season) and attain a 75% gross coverage prior to final acceptance. All outlet elevations and pond geometry shall be verified for elevation and dimensions by the owner's/developer's surveyor and approved by County Engineer.

Conveyance: Conveyance requires that the storm water from the site be conveyed by way of a drainage channel or other suitable means to the one hundred (100) year flood plain. The proposed channel or conveyance structure must be designed and constructed in accordance with the requirements for open channels and must be contained within an easement. The increase in runoff may not cause a rise of one foot or greater in the one hundred (100) year water surface elevation of the receiving floodplain. If offsite easements are required, they must be provided to Denton County prior to plan approval.

Drainage Easements: It is to be clearly understood that all drainage easements must be a minimum of sixteen feet (16′) in width and shall be on a single lot and not split by lot lines.

For subdivisions with lots that do not meet standard Denton County criteria of one (1) acre of total area less floodplain, a High Density/Urban Development Standard is available through the variance process. If such a variance is granted the developer will design all roads and drainage structures in accordance with the City of Fort Worth Regulations and Denton County will review them accordingly.

Estimating Runoff

Introduction to Hydrologic Methods

There are a number of empirical hydrologic methods available to estimate runoff characteristics for a site or drainage sub-basin; however, the following methods have been selected to support hydrologic site analysis for the design methods and procedures included in this Manual:

- Rational Method
- SCS Unit Hydrograph Method
- Snyder's Unit Hydrograph Method

Table IV.1-1 provides some limitations on the use of these methods.

Table IV.1-1
Constraints on Using Recommended Hydrologic Methods

Method	Size Limitations[1]	Comments
Rational	0 – 200 acres	Method can be used for estimating peak flows and the design of small site or subdivision storm sewer systems.
Modified Rational	0 – 200 acres	Method can be used for estimating runoff volumes for storage design.
Unit Hydrograph[2]	> 100 acres	Method can be used for estimating peak flows and hydrographs for all design applications.

[1]Size limitation refers to the drainage basin for the storm water management facility (e.g., culvert, inlet).
[2]This refers to the SCS and Snyder's routing methodology included in many readily available programs (such as HEC-HMS or HEC-1) that utilize this methodology.

If other hydrologic methods are to be considered they must be approved in writing by the Denton County Engineer.

Note: It must be realized that any hydrologic analysis is only an approximation. The relationship between the amount of precipitation on a drainage basin and the amount of runoff from the basin is complex and too little data are available on the factors influencing the rainfall-runoff relationship to expect exact solutions.

Rainfall Estimation

The first step in any hydrologic analysis is an estimation of the rainfall that will fall on the site for a given time period. The amount of rainfall can be quantified with the following characteristics:

Duration (hours) – Length of time over which rainfall (storm event) occurs

Depth (inches) – Total amount of rainfall occurring during the storm duration

Intensity (inches per hour) – Depth divided by the duration

The Frequency of a rainfall event is the recurrence interval of storms having the same duration and volume (depth). This can be expressed either in terms of *exceedance probability* or *return period*.

Exceedance Probability – Probability that a storm event having the specified duration and volume will be exceeded in one given time period, typically in years.

Return Period – Average length of time between events, which have the same duration and volume.

Thus, if a storm event with a specified duration and volume has a 1% chance of occurring in any given year, then it has an exceedance probability of 0.01 and a return period of 100 years. Rainfall intensities for Denton County are provided in the next section and should be used for all hydrologic analysis.

$$\mathbf{i = b/(t + d)^e} \qquad \textbf{Equ. (IV.1-1)}$$

where *i* is inches per hour and *t* is the rainfall duration in minutes. The parameters *b, d and e* are found at the top of each of the tables in the next section.

- The tabular values in Table IV.1-3 were determined from the TxDOT IDF (Intensity, Duration) Frequency curves for Denton County.

IV.1.2 Rational Method

Introduction

The Rational Method can be used to estimate storm water runoff peak flows for the design of gutter flows, drainage inlets, storm drainpipe, culverts, and small ditches. It is most applicable to small, highly impervious areas. The recommended maximum drainage area that should be used with the Rational Method is 200 acres.

The Rational Method should not be used for storage design or any other application where a more detailed routing procedure is required. However, the Modified Rational method is used by some for design of small detention facilities, so the method has been included in Subsection IV.1.4. The normal use of the Modified Rational method significantly under predicts detention volumes, but the improved method in Section IV.1.4 corrects this deficiency in the method and can be used for detention design for drainage areas up to 200 acres.

The Rational Method should not be used for calculating peak flows downstream of bridges, culverts, or storm sewers that may act as restrictions causing storage, which impacts the peak rate of discharge.

Equations

The Rational Formula estimates the peak rate of runoff at any location in a watershed as a function of the drainage area, runoff coefficient, and the mean rainfall intensity for duration equal to the time of concentration, t_c (the time required for water to flow from the most remote point of the basin to the location being analyzed).

The Rational Formula is expressed as follows:

Q = CIA **Equ. (IV.1-2)**

where:

Q = maximum rate of runoff (cfs)
C = runoff coefficient representing a ratio of runoff to rainfall
I = average rainfall intensity for a duration equal to the t_c (in/hr)
A = drainage area contributing to the design location (acres)

Time of Concentration

Use of the Rational Formula requires the time of concentration (t_c) for each design point within the drainage basin. The duration of rainfall is then set equal to the time of concentration and is used to estimate the design average rainfall intensity (I). The time of concentration consists of an overland flow time to the point where the runoff is concentrated or enters a defined drainage feature (e.g., open channel) plus the time of flow in a closed conduit or open channel to the design point.

The USDA *Urban Hydrology for Small Watersheds TR-55* equations should be used to determine time of concentration for each drainage area or sub-basin. Basic methodology for TR-55 time of concentration calculations is described in Section IV.1.3 of this document.

For each drainage area, the distance is determined from the inlet to the most remote point in the tributary area. From a topographic map, the average slope is determined for the same distance. The runoff coefficient (C) is determined by the procedure described in a subsequent section of this chapter. In urban areas, the length of overland flow distance should realistically be no more than 50 – 100 feet. In rural and undeveloped areas, 300 feet is a maximum overland flow distance.

The following table gives recommended minimum and maximum times of concentration for developed areas only based on land use categories. The minimum time of concentration should be used for the most upstream inlet (minimum inlet time). Computed downstream travel times will be added to determine times of concentration through the system. For anticipated future upstream development, the time of concentration should be no greater than the maximum.

Table IV.1-2 Time of Concentration Based on Land Use		
Land Use	Minimum (minutes)	Maximum (minutes)
Residential Development	15	30
Commercial and Industrial	10	25
Central Business District	10	15

Two common errors should be avoided when calculating time of concentration. First, in some cases runoff from a portion of the drainage area which is highly impervious may result in a greater peak discharge than would occur if the entire area were considered. Second, when designing a drainage system, the overland flow path is not necessarily the same before and after development and grading operations have been completed. Selecting overland flow paths in excess of 50 feet for impervious areas should be done only after careful consideration.

Rainfall Intensity (I)

The rainfall intensity (I) is the average rainfall rate in inches per hour for a duration equal to the time of concentration for a selected return period. Once a particular return period has been selected for design and a time of concentration calculated for the drainage area, the rainfall intensity can be determined from Rainfall-Intensity-Duration data given in the rainfall table below.

Table IV.1-3 Rainfall-Intensity-Duration Data							
Denton County							
	Return Period (Years)						
Coefficients	1	2	5	10	25	50	100
e	0.82089	0.80553	0.79891	0.78388	0.76912	0.76817	0.75660
b	43.381	50.455	65.467	70.683	78.538	89.853	95.776
d	8	9	11	11	11	12	12
Minutes	Rainfall Intensity (inches per hour)						
5	5.28	6.02	7.15	8.04	9.31	10.19	11.23
6	4.97	5.70	6.81	7.67	8.89	9.76	10.75
7	4.70	5.41	6.50	7.33	8.50	9.36	10.32
8	4.46	5.15	6.23	7.03	8.16	9.00	9.93
9	4.24	4.92	5.98	6.75	7.84	8.67	9.57
10	4.04	4.71	5.75	6.50	7.55	8.36	9.24
11	3.87	4.52	5.54	6.27	7.29	8.08	8.93
12	3.71	4.34	5.35	6.05	7.04	7.82	8.65
13	3.56	4.18	5.17	5.85	6.82	7.58	8.39
14	3.43	4.04	5.00	5.67	6.61	7.36	8.14
15	3.31	3.90	4.85	5.50	6.41	7.14	7.91
16	3.19	3.77	4.70	5.34	6.23	6.95	7.70
17	3.09	3.66	4.57	5.19	6.05	6.76	7.50

Table IV.1-3 Rainfall-Intensity-Duration Data							
Denton County							
Return Period (Years)							
Coefficients	1	2	5	10	25	50	100
e	0.82089	0.80553	0.79891	0.78388	0.76912	0.76817	0.75660
b	43.381	50.455	65.467	70.683	78.538	89.853	95.776
d	8	9	11	11	11	12	12
Minutes	Rainfall Intensity (inches per hour)						
18	2.99	3.55	4.44	5.05	5.89	6.59	7.31
19	2.90	3.44	4.32	4.91	5.74	6.43	7.13
20	2.81	3.35	4.21	4.79	5.60	6.27	6.96
21	2.73	3.26	4.11	4.67	5.46	6.12	6.80
22	2.66	3.17	4.01	4.56	5.34	5.99	6.65
23	2.59	3.09	3.91	4.45	5.21	5.85	6.50
24	2.52	3.02	3.82	4.35	5.10	5.73	6.36
25	2.46	2.95	3.74	4.26	4.99	5.61	6.23
26	2.40	2.88	3.66	4.17	4.89	5.50	6.11
27	2.34	2.81	3.58	4.08	4.79	5.39	5.99
28	2.29	2.75	3.51	4.00	4.69	5.28	5.88
29	2.24	2.69	3.44	3.92	4.60	5.18	5.77
30	2.19	2.64	3.37	3.85	4.51	5.09	5.66
31	2.14	2.58	3.31	3.77	4.43	5.00	5.56
32	2.10	2.53	3.24	3.71	4.35	4.91	5.47
33	2.06	2.49	3.18	3.64	4.28	4.83	5.38
34	2.02	2.44	3.13	3.58	4.20	4.75	5.29
35	1.98	2.39	3.07	3.51	4.13	4.67	5.20
36	1.94	2.35	3.02	3.46	4.06	4.59	5.12
37	1.91	2.31	2.97	3.40	4.00	4.52	5.04
38	1.87	2.27	2.92	3.35	3.94	4.45	4.96
39	1.84	2.23	2.88	3.29	3.88	4.38	4.89
40	1.81	2.19	2.83	3.24	3.82	4.32	4.82
41	1.78	2.16	2.79	3.19	3.76	4.26	4.75
42	1.75	2.13	2.74	3.15	3.71	4.20	4.68
43	1.72	2.09	2.70	3.10	3.65	4.14	4.62
44	1.69	2.06	2.66	3.06	3.60	4.08	4.56
45	1.67	2.03	2.63	3.01	3.55	4.02	4.50
46	1.64	2.00	2.59	2.97	3.50	3.97	4.44
47	1.62	1.97	2.55	2.93	3.46	3.92	4.38
48	1.59	1.94	2.52	2.89	3.41	3.87	4.32
49	1.57	1.92	2.49	2.85	3.37	3.82	4.27
50	1.55	1.89	2.45	2.82	3.33	3.77	4.22
51	1.53	1.86	2.42	2.78	3.28	3.73	4.17
52	1.51	1.84	2.39	2.75	3.24	3.68	4.12

Table IV.1-3 Rainfall-Intensity-Duration Data							
Denton County							
	Return Period (Years)						
Coefficients	1	2	5	10	25	50	100
e	0.82089	0.80553	0.79891	0.78388	0.76912	0.76817	0.75660
b	43.381	50.455	65.467	70.683	78.538	89.853	95.776
d	8	9	11	11	11	12	12
Minutes	Rainfall Intensity (inches per hour)						
53	1.49	1.82	2.36	2.71	3.21	3.64	4.07
54	1.47	1.79	2.33	2.68	3.17	3.60	4.02
55	1.45	1.77	2.30	2.65	3.13	3.55	3.98
56	1.43	1.75	2.28	2.62	3.09	3.51	3.93
57	1.41	1.73	2.25	2.59	3.06	3.48	3.89
58	1.39	1.71	2.22	2.56	3.03	3.44	3.85
59	1.37	1.69	2.20	2.53	2.99	3.40	3.81
60 (1 hr)	1.36	1.67	2.17	2.50	2.96	3.36	3.77
120 (2 hr)	0.81	1.01	1.33	1.55	1.85	2.11	2.38
180 (3 hr)	0.59	0.74	0.99	1.15	1.38	1.58	1.79
360 (6 hr)	0.34	0.43	0.58	0.68	0.83	0.95	1.09
720 (12 hr)	0.19	0.25	0.34	0.40	0.49	0.57	0.65
1440 (24 hr)	0.11	0.14	0.20	0.23	0.29	0.33	0.39

Runoff Coefficient (C)

Table IV.1-4 Runoff Coefficient Values	
Description of Area	Runoff Coefficients (C)
Lawns:	
Sandy soil, flat, 2%	0.10
Sandy soil, average, 2 - 7%	0.15
Sandy soil, steep, > 7%	0.20
Clay soil, flat, 2%	0.17
Clay soil, average, 2 - 7%	0.22
Clay soil, steep, > 7%	0.35
Agricultural	0.30
Forest	0.15
Streams, Lakes, Water Surfaces	1.00
Business:	
Commercial areas	0.95
Neighborhood areas	0.70

Table IV.1-4 Runoff Coefficient Values	
Description of Area	Runoff Coefficients (C)
Residential:	
Single Family (1/8 acre lots)	0.65
Single Family (1/4 acre lots)	0.60
Single Family (1/2 acre lots)	0.55
Single Family (1+ acre lots)	0.45
Multi-Family Units, (Light)	0.65
Multi-Family, (Heavy)	0.85
Commercial/Industrial:	
Light areas	0.70
Heavy areas	0.80
Parks, cemeteries	0.25
Playgrounds	0.35
Railroad yard areas	0.40
Streets:	
Asphalt and concrete	0.95
Brick	0.85
Drives, walks, and roofs	0.95
Gravel areas	0.50
Graded or no plant cover:	
Sandy soil, flat, 0 - 5%	0.30
Sandy soil, flat, 5 - 10%	0.40
Clayey soil, flat, 0 - 5%	0.50
Clayey soil, average, 5 - 10%	0.60

IV.1.3 SCS Hydrologic Method

Introduction

The Soil Conservation Service[1](SCS) hydrologic method requires basic data similar to the Rational Method: drainage area, a runoff factor, time of concentration, and rainfall. The SCS approach; however, is more sophisticated in that it also considers the time distribution of the rainfall, the initial rainfall losses to interception and depression storage, and an infiltration rate that decreases during the course of a storm. Details of the methodology can be found in the SCS National Engineering Handbook, Section 4, Hydrology.

A typical application of the SCS method includes the following basic steps:

1. Determination of curve numbers that represent different land uses within the drainage area.

2. Calculation of time of concentration to the study point.

3. Using the unit hydrograph approach, the hydrograph of direct runoff from the drainage basin can be developed.

Application

The SCS method can be used for both the estimation of storm water runoff peak rates and the generation of hydrographs for the routing of storm water flows. The simplified method can be used for drainage areas up to 2,000 acres. Thus, the SCS method can be used for most design applications, including storage facilities and outlet structures, storm drain systems, culverts, small drainage ditches, open channels, and energy dissipaters.

Equations and Concepts

Runoff Factor (CN)

The principal physical watershed characteristics affecting the relationship between rainfall and runoff are land use, land treatment, soil types, and land slope. The SCS method uses a combination of soil conditions and land uses (ground cover) to assign a runoff factor to an area. These runoff factors, called runoff curve numbers (CN), indicate the runoff potential of an area. The higher the CN, the higher the runoff potential. Soil properties influence the relationship between runoff and rainfall since soils have differing rates of infiltration. Based on infiltration rates, the SCS has divided soils into four hydrologic soil groups.

Group A - Soils having a low runoff potential due to high infiltration rates. These soils consist primarily of deep, well-drained sands and gravels.

Group B - Soils having a moderately low runoff potential due to moderate infiltration rates. These soils consist primarily of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C - Soils having a moderately high runoff potential due to slow infiltration rates. These soils consist primarily of soils in which a layer exists near the surface that impedes the downward movement of water or soils with moderately fine to fine texture.

Group D - Soils having a high runoff potential due to very slow infiltration rates. These soils consist primarily of clays with high swelling potential, soils with permanently high water tables, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious parent material.

A list of soils throughout the State of Texas and their hydrologic classification can be found in the publication *Urban Hydrology for Small Watersheds, 2nd Edition, Technical Release Number 55, 1986*. Soil Survey maps can be obtained from local USDA Natural Resources Conservation

Service offices for use in estimating soil type. County specific data can be found on-line through NRCS at http://soils.usda.gov/ and/or www.nctcog.dst.tx.us/.

Consideration should be given to the effects of urbanization on the natural hydrologic soil group. If heavy equipment can be expected to compact the soil during construction or if grading will mix the surface and subsurface soils, appropriate changes should be made in the soil group selected. Also, runoff curve numbers vary with the antecedent soil moisture conditions. Average antecedent soil moisture conditions (AMC II) are recommended for most hydrologic analysis. Areas with high water table conditions may want to consider using AMC III antecedent soil moisture conditions. This should be considered a calibration parameter for modeling against real calibration data. Table IV.1-5 gives recommended curve number values for a range of different land uses.

When a drainage area has more than one land use, a composite curve number can be calculated and used in the analysis. It should be noted that when composite curve numbers are used, the analysis does not take into account the location of the specific land uses but sees the drainage area as a uniform land use represented by the composite curve number.

Composite curve numbers for a drainage area can be calculated by using the weighted method.

Table IV.1-5 Runoff Curve Numbers[1]					
Cover Description		Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition	*Average percent impervious area*[2]	A	B	C	D
Cultivated Land:					
Without conservation treatment		72	81	88	91
With conservation treatment		62	71	78	81
Pasture or range land:					
Poor condition		68	79	86	89
Good condition		39	61	74	80
Meadow:					
Good condition		30	58	71	78
Wood or forest land:					
Thin stand, poor cover		45	66	77	83
Good cover		25	55	70	77
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved; curbs and storm drains (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89

Table IV.1-5 Runoff Curve Numbers[1]					
Cover Description		Curve numbers for hydrologic soil groups			
Cover type and hydrologic condition	*Average percent impervious area*[2]	A	B	C	D
Urban districts:					
Commercial and	85%	89	92	94	95
Business Industrial	72%	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town house)	65%	77	85	90	92
1/4 acre	38%	61	75	83	87
1/3 acre	30%	57	72	81	86
1/2 acre	25%	54	70	80	85
1 acre	20%	51	68	79	84
2 acres	12%	46	65	77	82
Developing urban areas and newly graded areas (previous areas only, no vegetation)		77	86	91	94

[1] Average runoff condition, and $I_a = 0.2S$

[2] The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. If the impervious area is not connected, the SCS method has an adjustment to reduce the effect.

[3] CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

Travel Time Estimation

Travel time (T_t) is the time it takes water to travel from one location to another within a watershed, through the various components of the drainage system. Time of concentration (t_c) is computed by summing all the travel times for consecutive components of the drainage conveyance system from the hydraulically most distant point of the watershed to the point of interest within the watershed. Following is a discussion of related procedures and equations (USDA, 1986).

Travel Time

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type of flow that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time is the ratio of flow length to flow velocity:

$$T_t = L/3600V \qquad \text{Equ(IV.1-3)}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours

Sheet Flow

Sheet flow can be calculated using the following formula:

$$T_t = \frac{0.42\,(nL)^{0.8}}{60\,(P_2)^{0.5}(S)^{0.4}} = \frac{0.007(nL)0.8}{(P_2)^{0.5}(S)^{0.4}} \qquad \text{Equ(IV.1-4)}$$

where:

T_t = travel time (hr)
n = Manning roughness coefficient (see Table IV.1-6)
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall
S = land slope (ft/ft)

Table IV.1-6 Roughness Coefficients (Manning's n) for Sheet Flow[1]	
Surface Description	n
Smooth surfaces (concrete, asphalt, gravel or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils: Residue cover < 20% Residue cover > 20%	 0.06 0.17
Grass: Short grass prairie Dense grasses[2] Bermuda grass	 0.15 0.24 0.41
Range (natural)	0.13
Woods[3] Light underbrush Dense underbrush	 0.40 0.80
[1] The n values are a composite of information by Engman (1986). [2] Includes species such as bluestem grass, buffalo grass, grama grass, and native grass mixtures. [3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow. Source: SCS, TR-55, Second Edition, June 1986.	

Shallow Concentrated Flow

After 50 to 100 feet, sheet flow usually becomes shallow concentrated flow.

Average velocities for estimating travel time for shallow concentrated flow can be computed from using the following equations. These equations can also be used for slopes less than 0.005 ft/ft.

Unpaved $\mathbf{V = 16.13(S)^{0.5}}$ **Equ(IV.1-5)**

Paved $\mathbf{V = 20.33(S)^{0.5}}$ **Equ(IV.1-6)**

where:

V = average velocity (ft/s)

S = slope of hydraulic grade line (watercourse slope, ft/ft)

After determining average velocity using equations IV.1-5 or IV.1-6 use equation IV.1-3 to estimate travel time for the shallow concentrated flow segment.

Open Channels

Velocity in channels should be calculated from the Manning equation. Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, where channels have been identified by the county, or where stream designations appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity for travel time calculations is usually determined for bank-full elevation assuming low vegetation winter conditions.

Manning's equation is:

$$V = (1.49/n)\,(R)^{2/3}\,(S)^{1/2} \qquad \text{Equ(IV.1-7)}$$

where:

V = average velocity (ft/s)
R = hydraulic radius (ft) and is equal to A/P_w
A = cross sectional flow area (ft^2)
P_w = wetted perimeter (ft)
S = slope of the hydraulic grade line (ft/ft)
n = Manning's roughness coefficient for open channel flow

After average velocity is computed using equation IV.1-7, T_t for the channel segment can be estimated using equation IV.1-3.

Limitations

- Equations in this section should not be used for sheet flow longer than 50 feet for impervious surfaces.

- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate t_c.

- In some cases, a culvert or bridge can act as detention structure if the culvert is significantly undersized. For culverts or bridges with capacity below a 5-year return event, detailed storage routing procedures should be used to determine the outflow through the culvert or bridge.

IV.1.4 The Modified Rational Method

Introduction

For drainage areas of *less than 200 acres*, a modification of the Rational Method can be used for the estimation of storage volumes for detention calculations.

The Modified Rational Method uses the peak flow calculating capability of the Rational Method paired with assumptions about the inflow and outflow hydrographs to compute an approximation of storage volumes for simple detention calculations. There are many variations on the approach. The rising and falling limbs of the inflow hydrograph have a duration equal to the time of concentration (t_c). An allowable target outflow is set (Q_a) based on pre-development conditions. The storm duration is t_d, and is varied until the storage volume (shaded gray area) is maximized. It is normally an iterative process done by hand or on a spreadsheet. Downstream analysis is not possible with this method as only approximate graphical routing takes place.

Design Equations

The design of detention using the Modified Rational Method is presented as a non-iterative approach suitable for spreadsheet calculation (Debo & Reese, 2003).

The allowable release rate can be determined from:

$$\mathbf{Q_a = C_a\, i\, A} \qquad \textbf{Equ(IV.1-8)}$$

where:
Q_a = allowable release rate (cfs)
C_a = predevelopment Rational Method runoff coefficient
i = rainfall intensity for the corresponding time of concentration (in/hr)
A = area (acres)

The critical duration of storm, the time value to determine rainfall intensity, at which the storage volume is maximized, is:

$$T_d = \sqrt{2CAab/Q_a} - b \qquad \textbf{Equ(IV.1-9)}$$

where:

T_d = critical storm duration (min)
Q_a = allowable release rate (cfs)
C = developed condition Rational Method runoff coefficient
A = area (acres)
a/b = rainfall factors dependent on location and return period taken from Table IV.1-7

The required storage volume, in cubic feet can be obtained from the equations below:

$$\mathbf{V_{preliminary} = 60\,[CAa - (2CabAQ_a)^{1/2} + (Q_a/2)\,(b - t_c)]} \qquad \textbf{Equ(IV.1-10a)}$$

$$\mathbf{V_{Max} = V_{preliminary} * P_{180}/P_{td}} \qquad \textbf{Equ(IV.1-10b)}$$

where:
$V_{preliminary}$ = preliminary required storage (ft^3)

V = required storage (ft^3)
t_c = time of concentration for the developed condition (min)
P_{180} = 3-hour (180-minute) storm depth (in)
P_{td} = storm depth for the critical duration (in)
All other variables are as defined above

The equations above include the use of an adjustment factor to the calculated storage volume to account for under sizing. The factor (P_{180}/P_{td}) is the ratio of the 3-hour storm depth for the return frequency divided by the rainfall depth for the critical duration calculated in equation IV.1-9.

Table IV.1-7
Rainfall factors "a" and "b" for the Modified Rational Method
(1-year through 100-year return events)

County		Return Interval 1	2	5	10	25	50	100
Denton	a	101.14	129.51	177.49	209.08	250.52	283.13	320.81
	b	14.214	16.634	20.174	21.668	22.821	23.455	24.502

IV.1.5 Downstream Hydrologic Assessment

It is the responsibility of all new development to assess downstream conditions and determine the likelihood that an adverse impact will be created. Where downstream conditions warrant, it will be the developer's responsibility to mitigate for increased peak discharge and increased erosion potential for 2, 5, 10, 25 and 100 return event storms.

Due to a site's location within a watershed, there may be very little reason for requiring flood control from a particular site. In certain circumstances where detention is in place or a master drainage plan has been adopted, a development may receive or plan to receive less that ultimate developed flow conditions from upstream. This might be considered in the detention needed and its influence on the downstream assessment. Any consideration in such an event would be with the written approval of the County Engineer. The next section outlines a procedure for determining the impacts of post-development storm water peak flows and volumes.

References

U. S. Department of Agriculture, Soil Conservation Service, Engineering Division, 1986. Urban Hydrology for Small Watersheds. Technical Release 55 (TR-55).

U. S. Department of Transportation, Federal Highway Administration, 1984. Hydrology. Hydraulic Engineering Circular No. 19.

U. S. Geological Survey, May 1982. Techniques for Estimating the Magnitude and Frequency of Floods in Dallas-Fort Worth Metropolitan Area, Texas. Water-Resources Investigation Report 82-18.

U. S. Geological Survey, 1997. Regional Equations fro Estimation of Peak-Stream Flow Frequency for Rural Basins in Texas. Water-Resources Investigation Report 96-4307.

Wright-McLaughlin Engineers, 1969. Urban Storm Drainage Criteria Manual. Volumes I and II. Prepared for the Denver Regional Council of Governments, Denver, Colorado

IV.2 Key Issues in Storm Water System Design

IV.2.1 General Design Considerations

- Storm water systems should be planned and designed so as to generally conform to natural drainage patterns and discharge to natural drainage pathways within a drainage basin. These natural drainage pathways should only be modified as a last resort to contain and safely convey the peak flows generated by the development.

- Runoff must be discharged in a manner that will not cause adverse impacts on downstream properties or storm water systems. In general, runoff from development sites within a drainage basin should be discharged at the existing natural drainage outlet or outlets. If the developer wishes to change discharge points he or she must demonstrate that the change will not have any adverse impacts on downstream properties or storm water (minor) systems.

- It is important to ensure that the combined on-site flood control system and major storm water system can handle blockages and flows in excess of the design capacity to minimize the likelihood of nuisance flooding or damage to private properties. If failure of minor storm water systems and/or major storm water structures occurs during these periods, the risk to life and property could be significantly increased.

- In establishing the layout of storm water systems, it is essential to ensure that flows are not diverted onto private property during flows up to the major storm water system design capacity.

Design Storm Requirements

Listed below are the design storm requirements for various storm water drainage system components to be designed and constructed in accordance with these Denton County Standards. It is required that the full build-out conditions be used to calculate flows for the design storm frequencies below.

Storm Drainage Systems

All calculations shall assume full development watershed conditions.

- 100-year design storm in pipe, 100-year design storm in right-of-way (for closed pipe design)

- 100-year design storm in road side ditches and driveway culverts. Road side ditch design must account for losses from driveway culverts.

- 100-year design storm on grade (for inlet design)

- 100-year design storm for sumped inlets, (unless overflow facilities are provided). In all cases, sumped inlets shall have a positive overflow route downstream.

- 100-yr design storm plus 1-foot freeboard (for bridges, culverts, and roadway crossing design)

IV.2.2 On-Site Flood Control System Design

Introduction

On-Site Flood Control Systems, also known as minor drainage systems, quickly remove runoff from areas such as streets and sidewalks for public safety purposes. The on-site flood control system consists of inlets, street and roadway gutters, roadside ditches, small channels and swales, and small underground pipe systems which collect storm water runoff and transport it to structural control facilities, pervious areas, and/or the larger storm water system (i.e., natural waterways, large man-made conduits, and large water impoundments).

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

- Street and roadway gutters

- Storm water inlets

- Storm drain pipe systems

  Ditch, channel and swale design criteria and guidance are covered in Section IV.3.4, *Open Channel Design*.

Procedures for performing gutter flow calculations are based on a modification of Manning's Equation. Inlet capacity calculations for grate, curb, and combination inlets are based on information contained in HEC-12 (USDOT, FHWA, 1984). Storm drain system design is based on the use of the Rational Method Formula.

General Criteria

Design Frequency

See Section IV.2.1 for design storm requirements for the sizing of storm system components. Fully developed conditions should be used for design.

Flow Spread Limits

Road side ditches and inlets shall be spaced so that the spread in the street for the design flow shall not exceed the following, as measured from the face of the curb:

- 8 feet if the street is classified as a Collector or Arterial street (for 4-lane streets or greater, spread may extend across one travel lane)

- 16 feet at any given section, but in no case greater than 10 feet on one side of the street, if the street is classified as a Local street

- A minimum of one 12-foot lane shall remain clear in a 100-year return-event storm for all roadway classifications.

Formula

The following form of Manning's Equation should be used to evaluate gutter flow hydraulics:

$$\mathbf{Q = [0.56/n]\ S_x^{5/3} S^{1/2} T^{8/3}}$$

Equ(IV.2-1)

where:

Q = gutter flow rate, cfs
S_x = pavement cross slope, ft/ft
n = Manning's roughness coefficient
S = longitudinal slope, ft/ft
T = width of flow or spread, ft
Equation IV.2.1 was first presented by C.F. Izzard in 19IV6.

Table IV.2-1
Manning's n Values for Street and Pavement Gutters

Type of Gutter or Pavement	Manning's n
Concrete gutter, troweled finish	0.014
Asphalt pavement: Smooth texture Rough texture	 0.015 0.019
Concrete gutter with asphalt pavement: Smooth Rough	 0.015 0.018
Concrete pavement: Float finish Broom finish	 0.017 0.019
For gutters with small slopes, where sediment may accumulate, increase above values of n by	0.002

Parabolic Cross Slope

The following methodology regarding Parabolic cross-slopes was excerpted from the City of Austin Drainage Criteria Manual dated July 2003.

Note: The street width used in this section is measured from face of curb to face of curb.

Streets Without Curb Split

Curb split is the vertical difference in elevation between curbs at a given street cross section. The gutter flow equation for parabolic crown streets without any curb split is:

$$\log Q = K_0 + K_1 \log S_0 + K_2 \log y_0 \qquad \text{Equ(IV.2-2)}$$

where:

Q = Gutter flow rate, cfs
S_0 = Street grade, ft/ft
Y_0 = Water depth in the gutter, feet
K_0, K_1, K_2 = Constant coefficients shown in Table IV.2-2 for different street widths

Table IV.2-2
Coefficients for Equation IV.2-2, Streets Without Curb Split

Street Width* (ft)	Coefficients		
	K0	K1	K2
30	2.85	0.50	3.03
36	2.89	0.50	2.99
40	2.85	0.50	2.89
44	2.84	0.50	2.83
48	2.83	0.50	2.78
60	2.85	0.50	2.74
***Note:** Based on the Transportation Criteria Manual the street width is measured from face of curb to face of curb (FOC-FOC).			
Source: City of Austin, Watershed Engineering Division			

Streets With Curb Split

The gutter flow equation for parabolic crown streets with curb split is:

$$\log Q = K_0 + K_1 \log S_0 + K_2 \log y_0 + K_3 \qquad \text{Equ(IV.2-3)}$$

where:

Q = Gutter flow rate, cfs

S_0 = Street grade, ft/ft
Y_0 = Water depth in the gutter, feet
CS = Curb split, feet
K_0, K_1, K_2, K_3 = Constant coefficients shown in Tables IV.2-3 and IV.2-4

The K values in Equation IV.2-3 are found in Tables IV.2-3 and IV.2-4 for different street widths. Table IV.2-3 is used when calculating the higher gutter flows, and Table IV.2-4 is used when calculating the lower gutter flows.

Table IV.2-3
Coefficients for Equation IV.2-3, Streets With Curb Split – Higher Gutter

Street Width* (ft)	Coefficients				Curb Split Range (ft)
	K0	**K1**	**K2**	**K3**	
30	2.85	0.50	3.03	-0.131	0.0-0.6
36	2.89	0.50	2.99	-0.140	0.0-0.8
40	2.85	0.50	2.89	-0.084	0.0-0.8
44	2.84	0.50	2.83	-0.091	0.0-0.9
48	2.83	0.50	2.78	-0.095	0.0-1.0
60	2.85	0.50	2.74	-0.043	0.0-1.2
Source: City of Austin, Watershed Engineering Division					

Table IV.2-4
Coefficients for Equation IV.2-3, Streets With Curb Split – Lower Gutter

Street Width* (ft)	Coefficients				Curb Split Range (ft)
	K0	**K1**	**K2**	**K3**	
30	2.70	0.50	2.74	-0.215	0.0-0.6
36	2.74	0.50	2.73	-0.214	0.0-0.8
40	2.75	0.50	2.73	-0.198	0.0-0.8
44	2.76	0.50	2.73	-0.186	0.0-0.9
48	2.77	0.50	2.72	-0.175	0.0-1.0
60	2.80	0.50	2.71	-0.159	0.0-1.2
Source: City of Austin, Watershed Engineering Division					

All the crown heights for different street widths are calculated by the following equation:

Crown Height (feet) = 0.5 + [(W 30)/120] **Equ(IV.2-4)**

where,

W = street width, feet

Parabolic Crown Location

The gutter flow equation presented for parabolic crowns with split curb heights is based on a procedure for locating the street crown. The procedure allows the street crown to shift from the street center line toward the high ¼ point of the street in direct proportion to the amount of curb split. The maximum curb split occurs with the crown at the ¼ point of the street. The maximum allowable curb split for a street with parabolic crowns is 0.02 feet per foot of street width, except for 30-foot side streets where the maximum curb split is considered to be 5 feet.

Curb splits that are determined by field survey, whether built intentionally or not, should be considered when determining the capacity of the curb flow.

Special consideration should be given when working with cross sections which have the pavement crown above the top of curb. When the crown exceeds the height of the curb the maximum depth of water is equal to the height of the curb, not the crown height. It should be noted that a parabolic section where the crown equals the top of curb will carry more water than a section which has the crown one (1) inch above the top of curb. For other parabolic roadway sections not included in Tables IV.2-2, IV.2-3, and IV.2-4, see HEC-22 Urban Design Manual by the Federal Highway Administration, dated August 2001.

IV.2.3 Storm Water Inlets

Inlets are drainage structures used to collect surface water through grate or curb openings and convey it to storm drains or direct outlet to culverts. Grate inlets subject to traffic shall be bicycle safe and be load-bearing adequate. Appropriate frames shall be provided.

Inlets used for the drainage of highway surfaces can be divided into three major classes:

- Grate Inlets – These inlets include grate inlets consisting of an opening in the gutter covered by one or more grates, and slotted inlets consisting of a pipe cut along the longitudinal axis with a grate or spacer bars to form slot openings.

- Curb-Opening Inlets – These inlets are vertical openings in the curb covered by a top slab.

- Combination Inlets – These inlets usually consist of both a curb-opening inlet and a grate inlet placed in a side-by-side configuration, but the curb opening may be located in part upstream of the grate.

Inlets may be classified as being on a continuous grade or in a sump. The term "continuous grade" refers to an inlet located on the street with a continuous slope past the

inlet with water entering from one direction. The "sump" condition exists when the inlet is located at a low point and water enters from both directions. Sump areas should have an overflow route or channel.

Where significant ponding can occur, in locations such as underpasses and in sag vertical curves in depressed sections, to the designer shall place flanking inlets on each side of the inlet at the low point in the sag. The flanking inlets should be placed so they will limit spread on low gradient approaches to the level point and act in relief of the inlet at the low point if it should become clogged or if the design spread is exceeded.

The design of grate inlets, curb inlet design, and combination inlets will be discussed later in this section.

Grate Inlet Design

Grate Inlets on Grade

The capacity of an inlet depends upon its geometry and the cross slope, longitudinal slope, total gutter flow, depth of flow, and pavement roughness. The depth of water next to the curb is the major factor in the interception capacity of both gutter inlets and curb opening inlets. At low velocities, all of the water flowing in the section of gutter occupied by the grate, called frontal flow, is intercepted by grate inlets, and a small portion of the flow along the length of the grate, termed side flow, is intercepted. On steep slopes, only a portion of the frontal flow will be intercepted if the velocity is high or the grate is short and splash-over occurs. For grates less than 2 feet long, intercepted flow is small.

A parallel bar grate is the most efficient type of gutter inlet; however, when crossbars are added for bicycle safety, the efficiency is greatly reduced. Where bicycle traffic is a design consideration, the curved vane grate and the tilt bar grate are recommended for both their hydraulic capacity and bicycle safety features. They also handle debris better than other grate inlets but the vanes of the grate must be turned in the proper direction.

The ratio of frontal flow to total gutter flow, Eo, for straight cross slope is expressed by the following equation:

$$E_0 = Q_w/Q = 1 - (1 - W/T)^{2.67} \qquad \textbf{Equ(IV.2-5)}$$

where:

Q = total gutter flow, cfs
Qw = flow in width W, cfs
W = width of depressed gutter or grate, ft
T = total spread of water in the gutter, ft

Grate Inlets in Sag

A grate inlet in a sag operates as a weir up to a certain depth, depending on the bar configuration and size of the grate, and as an orifice at greater depths. For a standard gutter inlet grate, weir operation continues to a depth of about 0.4 feet above the top of grate and when depth of water exceeds about 1.4 feet, the grate begins to operate as an orifice. Between depths of about 0.4 feet and about 1.4 feet, a transition from weir to orifice flow occurs.
The capacity of grate inlets operating as a weir is:

$$\mathbf{Q_t = CPd^{1.5}} \qquad \textbf{Equ(IV.2-6)}$$

where:

P = perimeter of grate excluding bar widths and the side against the curb, ft
C = 3.0
d = depth of water above grate, ft

and as an orifice is:

$$\mathbf{Q_t = CA(2gd)^{0.5}} \qquad \textbf{Equ(IV.2-7)}$$

where:

C = 0.67 orifice coefficient
A = clear opening area of the grate, ft^2
g = 32.2 ft/s^2

Curb Inlet Design

Curb Inlets on Grade

Following is a discussion of the procedures for the design of curb inlets on grade. Curb-opening inlets are effective in the drainage of pavements where flow depth at the curb is sufficient for the inlet to perform efficiently. Curb openings are relatively free of clogging tendencies and offer little interference to traffic operation. They are a viable alternative to grates in many locations where grates would be in traffic lanes or would be hazardous for pedestrians or bicyclists.

The length of inlet required for total interception by depressed curb-opening inlets or curb-openings in depressed gutter sections can be found by the use of an equivalent cross slope, S_e, in the following equation:

$$\mathbf{S_e = S_w + S'_w E_0} \qquad \textbf{Equ(IV.2-8)}$$

where:

E_0 = ratio of flow in the depressed section to total gutter flow
S'_w = cross slope of gutter measured from the cross slope of the pavement, S_x
$S'_w = (a/12W)$

where:

a = gutter depression, in
W = width of depressed gutter, ft

Curb Inlets in Sump

For the design of a curb-opening inlet in a sump location, the inlet operates as a weir to depths equal to the curb opening height and as an orifice at depths greater than 1.4 times the opening height. At depths between 1.0 and 1.4 times the opening height, flow is in a transition stage.

The capacity of curb-opening inlets in a sump location can be determined from Figure IV.2-1, which accounts for the operation of the inlet as a weir and as an orifice at depths greater than 1.4h. This figure is applicable to depressed curb-opening inlets and the depth at the inlet includes any gutter depression. The height (h) in the figure assumes a vertical orifice opening (see sketch on Figure IV.2-1). The weir portion of Figure IV.2-1 is valid for a depressed curb-opening inlet when $d \leq (h + a/12)$.

The capacity of curb-opening inlets in a sump location with a vertical orifice opening but without any depression can be determined from Figure IV.2-2. The capacity of curb-opening inlets in a sump location with other than vertical orifice openings can be determined by using Figure IV.2-3.

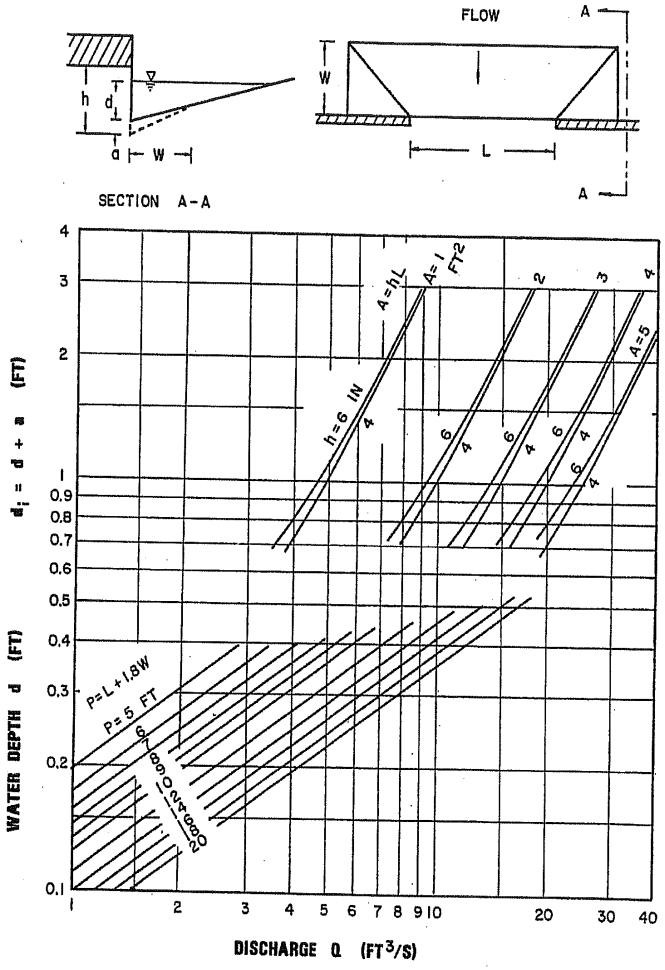


Figure 4.2-1 Depressed Curb-Opening Inlet Capacity in Sump Locations
(Source: AASHTO Model Drainage Manual, 1991)

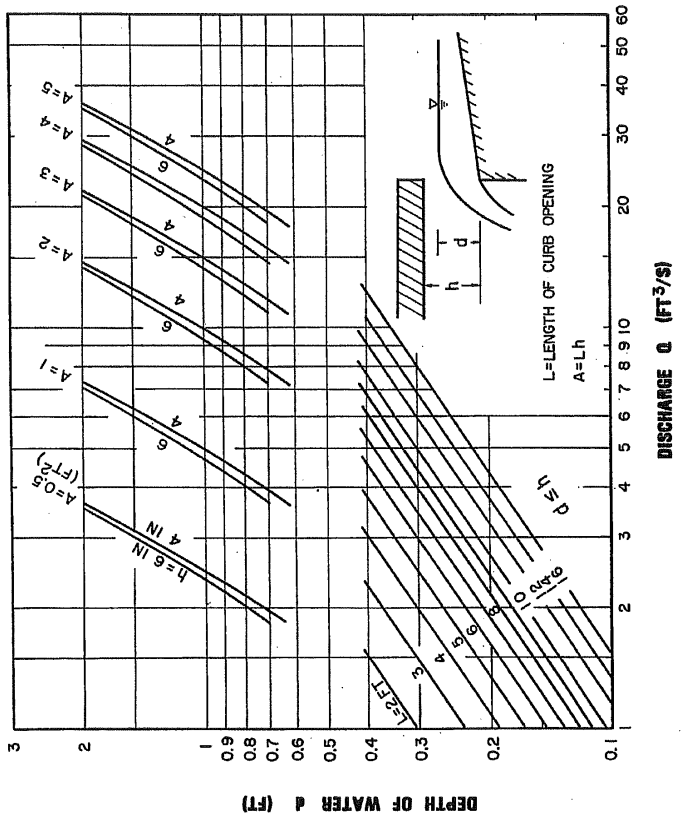


Figure 4.2-2 Curb-Opening Inlet Capacity in Sump Locations
(Source: AASHTO Model Drainage Manual, 1991)

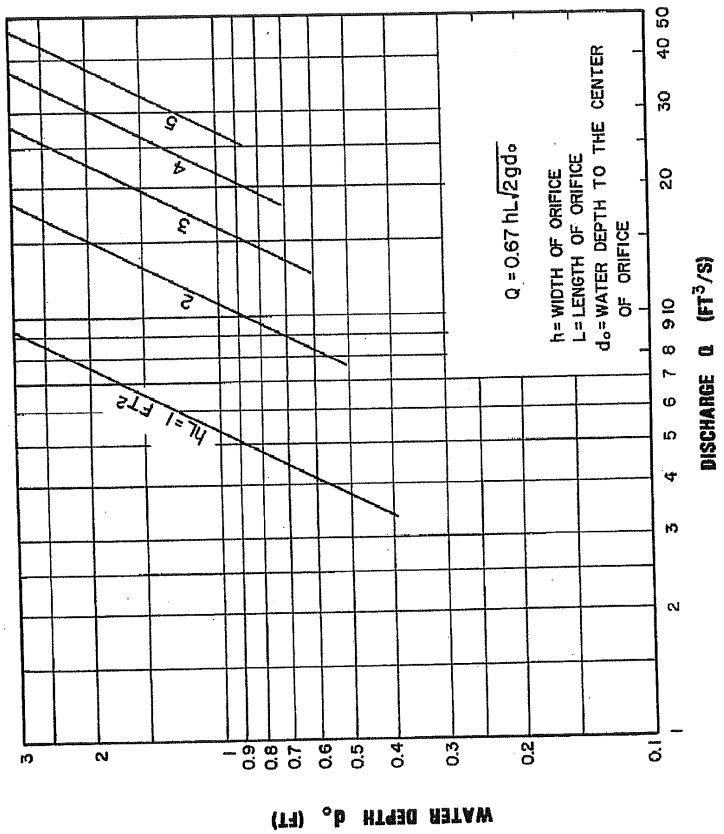


Figure 4.2-3 Curb-Opening Inlet Orifice Capacity for Inclined and Vertical Orifice Throats
(Source: AASHTO Model Drainage Manual, 1991)

Combination Inlets

Combination Inlets on Grade

On a continuous grade, the capacity of an unclogged combination inlet with the curb opening located adjacent to the grate is approximately equal to the capacity of the grate inlet alone. Thus capacity is computed by neglecting the curb opening inlet and the design procedures should be followed based on the use of equation IV.2-5.

Combination Inlets in Sump

All debris carried by storm water runoff that is not intercepted by upstream inlets will be concentrated at the inlet located at the low point, or sump. Because this will increase the probability of clogging for grated inlets, it is generally appropriate to estimate the capacity of a combination inlet at a sump by neglecting the grate inlet capacity. Assuming complete clogging of the grate, Figures IV.2-1, IV.2-2, and IV.2-3 for curb-opening inlets should be used for design.

IV.2.4 Closed Conduit Systems (Storm Drains/Sewers)

Inlets

The primary function is to allow surface water to enter the closed conduit system. Inlet structures may also serve as access points for cleaning and inspection. Typical inlets structures are a standard drop inlet, catch basin, curb inlet, combination inlet, and Y inlet. (See Figures IV.2-4 and IV.2-5).

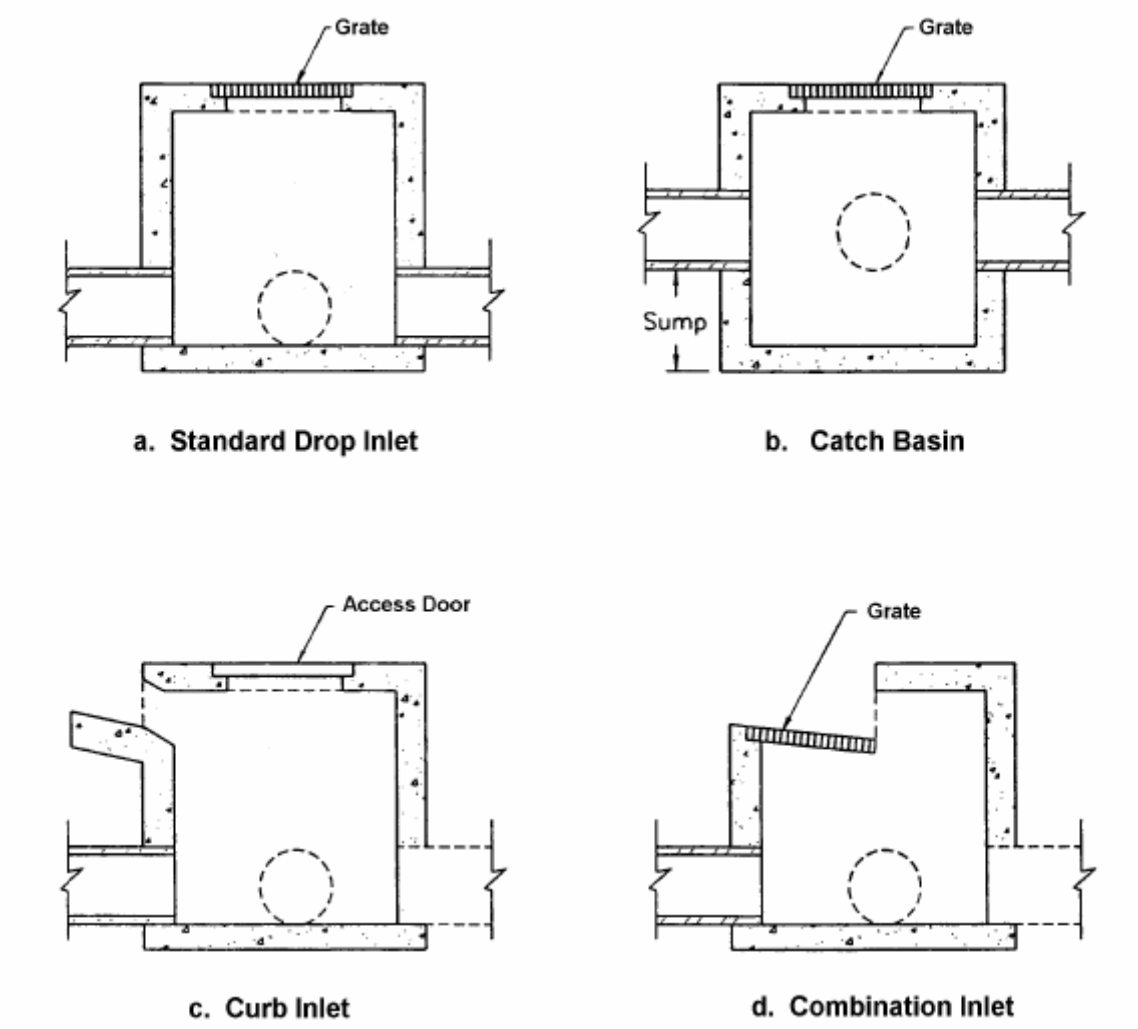


Figure IV.2-4 Inlet Structures (HEC 22, 2001)

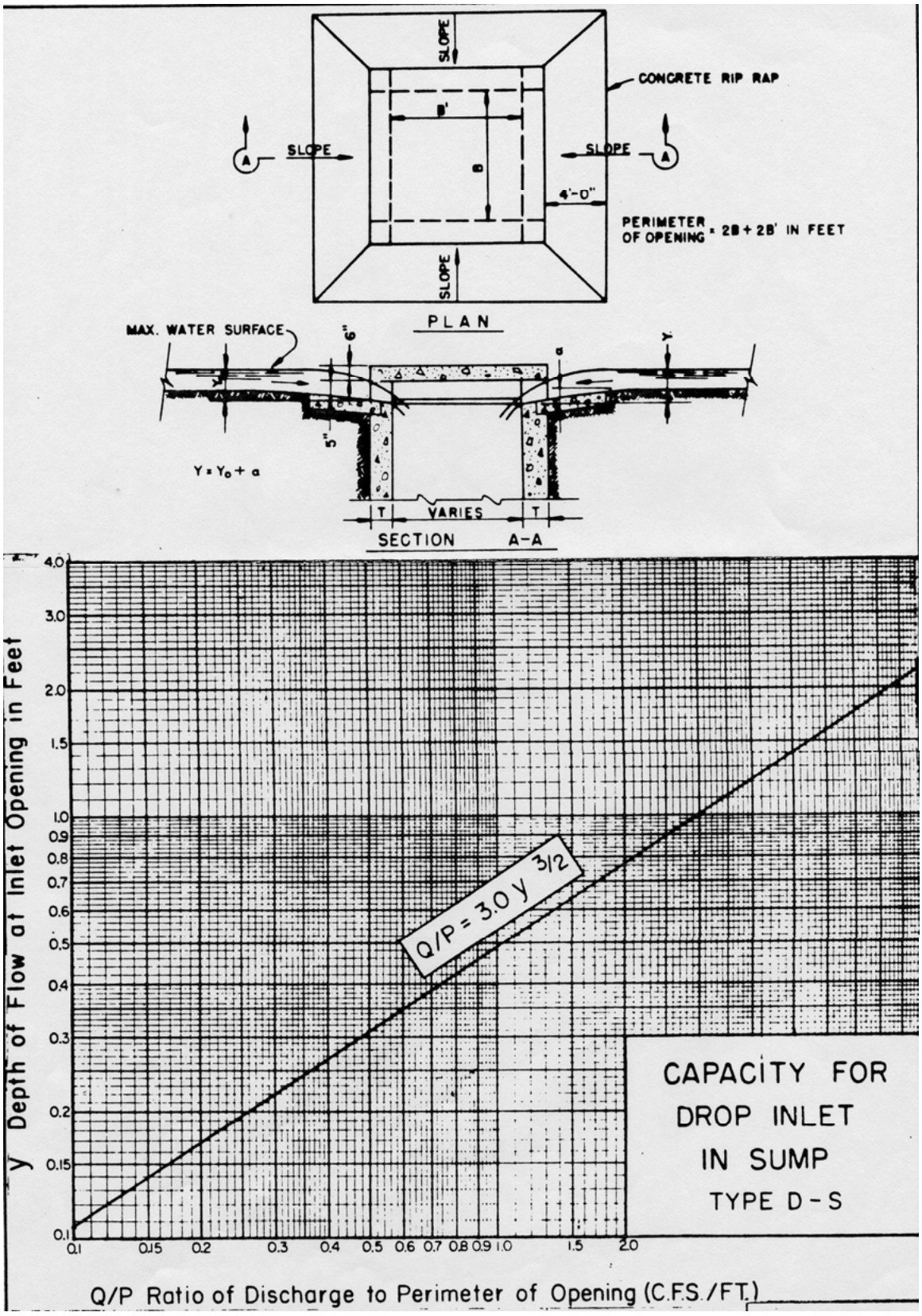


Figure IV.2-5 Capacity for Y Inlet in Sump (Fort Worth, 1967)

Inlet structures are located at the upstream end and at intermediate points within the closed conduit system. Inlet placement is generally a trial and error procedure that attempts to produce the most economical and hydraulically effective system (HEC 22, 2001).

Access Holes (Manholes)

The primary function of an access hole is to provide access to the closed conduit system. An access hole can also serve as a flow junction and can provide ventilation and pressure relief. Typical access holes are shown in Figures IV.2-5 and IV.2-6 (HEC 22, 2001). The materials commonly used for access hole construction are precast concrete and cast-in-place concrete.

At a minimum, access holes should be located at the following points:

- Where two or more storm drains converge
- Where pipe sizes change
- Where a change in alignment occurs
- Where a change in grade occurs

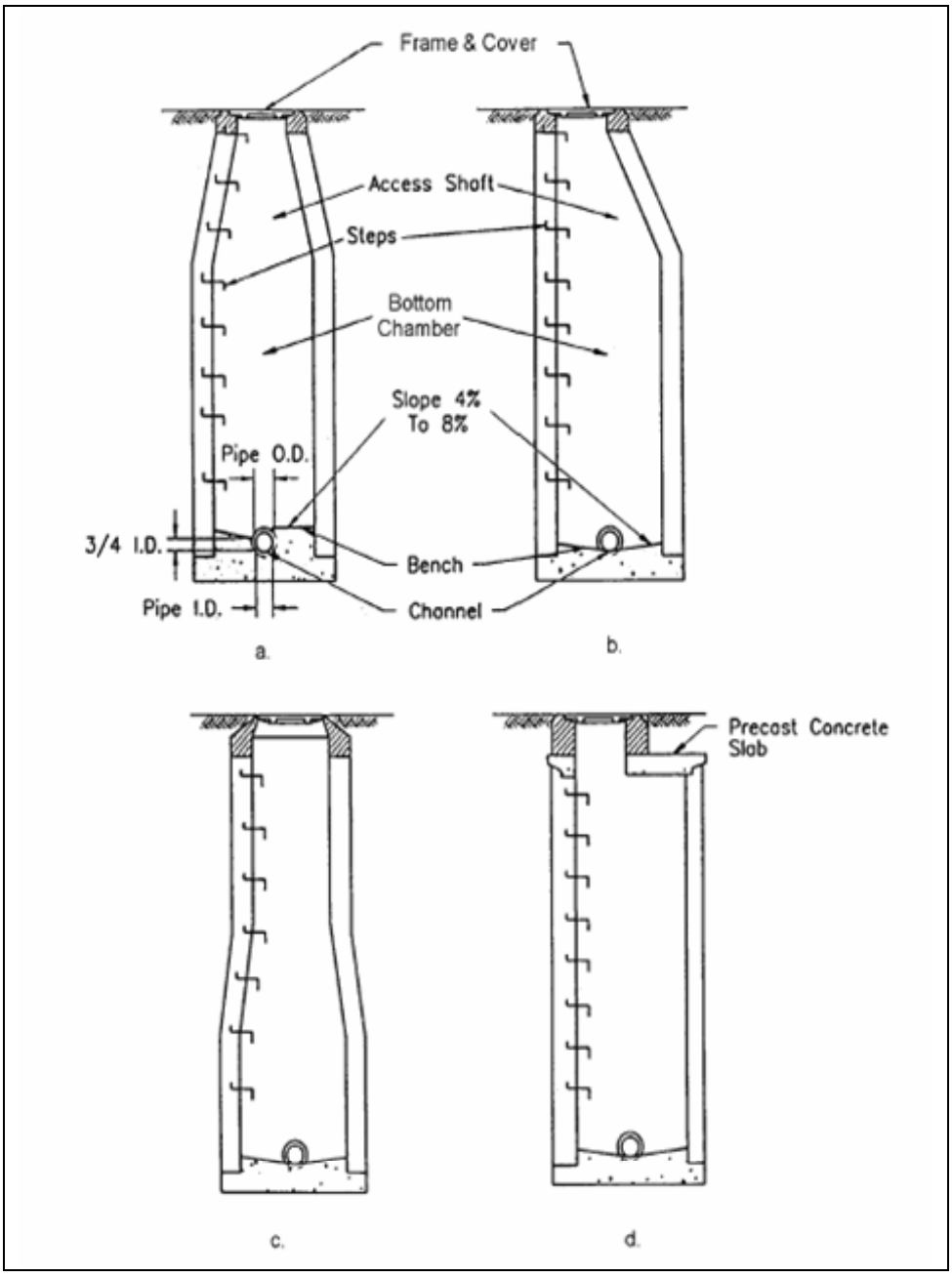


Figure IV.2-6 Typical Access Hole Configurations (HEC22, 2001)

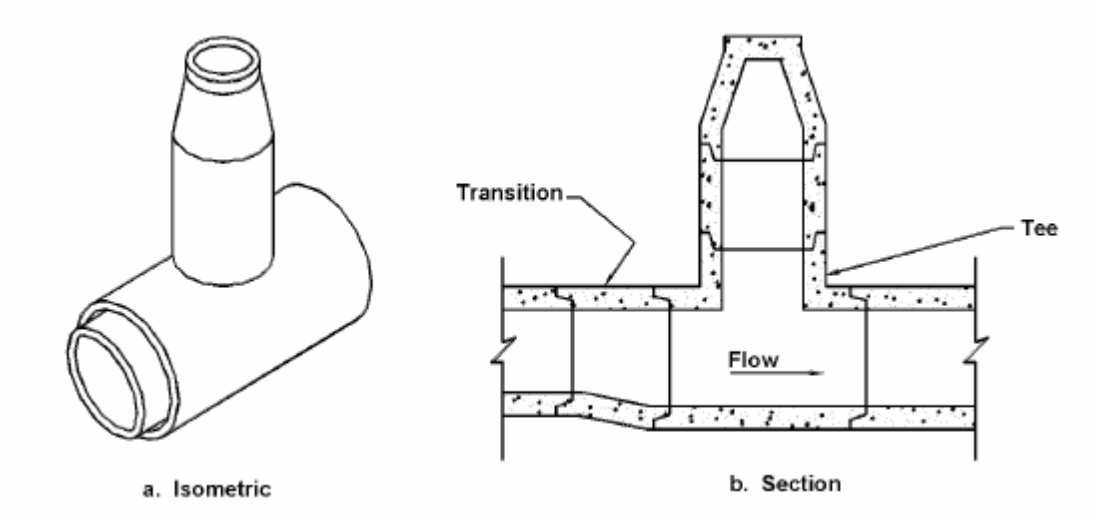


Figure IV.2-7 "Tee" Access Hole for Large Storm Drains (HEC 22, 2001)

Access holes may be needed at intermediate points along straight runs of closed conduits. Table IV.2-5 gives maximum spacing criteria.

Table IV.2-5
Access Hole Spacing Criteria
(HEC 22, 2001)

Pipe Size (inches)	Maximum Spacing (feet)
12-24	300
27-36	400
42-54	500
60 and up	1000

Junction Chambers

A junction chamber, or junction box, is a special design underground chamber used to join two or more large storm drain conduits. This type of structure is required where storm drains are larger than the size that can be accommodated by standard access holes. It is required that riser structures be used to provide surface access and/or to intercept surface runoff at each junction chamber.

To minimize flow turbulence in junction boxes, flow channels and benches are typically built into the bottom of the chambers. Where junction chambers are used as access points for the storm drain system, their location should adhere to the spacing criteria outlined in Table IV.2-5.

Design Criteria

In the design of closed conduit systems, the following are offered for consideration in setting local criteria:

- The maximum hydraulic gradient should not produce a velocity that exceeds 15 ft/s.
- The minimum desirable physical slope should be 0.3% or the slope that will produce a velocity of 2.5 feet per second when the storm sewer is flowing full, whichever is greater.
- A computerized design tool such as StormCAD, WinStorm, etc. is acceptable. Hand calculations will follow the methodology described below.

General Design Procedure

The design of storm drain systems generally follows these steps:

Step 1 Determine inlet location and spacing as outlined earlier in this section.

Step 2 Prepare a tentative plan layout of the storm sewer drainage system including:

a. Location of storm drains

b. Direction of flow

c. Location of manholes

d. Location of existing facilities such as water, gas, or underground cables

Step 3 Determine drainage areas and compute runoff using the Rational Method

Step 4 After the tentative locations of inlets, drain pipes, and outfalls (including tailwaters) have been determined and the inlets sized, compute the rate of discharge to be carried by each storm drain pipe and determine the size and gradient of pipe required to care for this discharge. This is done by proceeding in steps from the upstream end of a line downstream to the point at which the line connects with other lines or the outfall, whichever is applicable. The discharge for a run is calculated, the pipe serving that discharge is sized, and the process is repeated for the next run downstream. The storm drain system design computation form can be used to summarize hydrologic, hydraulic and design computations.

Step 5 Examine assumptions to determine if any adjustments are needed to the final design.

The rate of discharge at any point in the storm drainage system is not the sum of the inlet flow rates of all inlets above the section of interest. It is generally less that this total. The Rational Method is the most common means of determining design discharges for storm drain design. The time of concentration is very influential in the determination of the design discharge using the Rational Method. The time of concentration is defined as the period required for water to travel from the most hydraulically distant point of the watershed to the point of interest. The designer is usually concerned with two different times of concentration: one for inlet spacing and the other for pipe sizing. The time of concentration for inlet spacing is the time required for water to flow from the hydraulically most distant point of the unique drainage area contributing only to that inlet. Typically, this is the sum of the times required for water to travel overland to the pavement gutter and along the length of the gutter between inlets. If the total time of concentration to the upstream inlet is less than five minutes, a minimum time of concentration of five minutes is used as the duration of rainfall. The time of concentration for each successive inlet should be determined independently in the same manner as was used for the first inlet.

The time of concentration for pipe sizing is defined as the time required for water to travel for the most hydraulically distant point in the total contributing watershed to the design point. Typically, this time consists of two components: (1) the time for overland and gutter flow to reach the first inlet, and (2) the time to flow through the storm drainage system to the point of interest.

The flow path having the longest time of concentration to the point of interest in the storm drainage system will usually define the duration used in selecting the intensity value in the Rational Method. Exceptions to the general application of the Rational Equation exist. For example, a small relatively impervious area within a larger drainage area may have an independent discharge higher than that of the total area. This anomaly may occur because of the higher runoff coefficient (C value) and higher intensity resulting from a short time of concentration. If an exception does exist, it can generally be classified as one of two exception scenarios.

The first exception occurs when a highly impervious section exists at the most downstream area of a watershed and the total upstream area flows through the lower impervious area. When this situation occurs, two separate calculations should be made.

- First, calculate the runoff from the total drainage area with its weighed C value and the intensity associated with the longest time of concentration.

- Secondly, calculate the runoff using only the smaller less pervious area. The typical procedure would be followed using the C value for the small less pervious area and the intensity associated with the shorter time of concentration.

The results of these two calculations should be compared and the largest value of discharge should be used for design.

The second exception exists when a smaller less pervious area is tributary to the larger primary watershed. When this scenario occurs, two sets of calculations should also be made.

- First, calculate the runoff form the total drainage area with its weighted C value and the intensity associated with the longest time of concentration.

- Secondly, calculate the runoff to consider how much discharge from the larger primary area is contributing at the same time the peak from the smaller less pervious tributary area is occurring. When the small area is discharging, some discharge from the larger primary area is also contributing to the total discharge. In this calculation, the intensity associated with the time of concentration from the small less pervious area is used. The portion of the larger primary area to be considered is determined by the following: $A_c=A\ (t_{c1}/t_{c2})$.

A_c is the most downstream part of the larger primary area that will contribute to the discharge during the time of concentration associated with the smaller, less pervious area. A is the area of the larger primary area, t_{c1} is the time of concentration of the smaller, less pervious, tributary area, and t_{c2} is the time of concentration associated with the larger primary area as is used in the first calculation. The C value to be used in this computation should be the weighted C value of the smaller less pervious tributary area and the area A_c. The area to be used in the Rational Method would be the area of the less pervious area plus A_c . The second calculation should only be considered when the less pervious area is tributary to the area with the longer time of concentration and is at or near the downstream end of the total drainage area.

Finally, the results of these calculations should be compared and the largest value of discharge should be used for design.

Capacity Calculations

The design procedures presented here assume flow within each storm drain segment is steady and uniform. This means the discharge and flow depth in each segment are assumed to be constant with respect to time and distance. Also, since storm drain conduits are typically prismatic, the average velocity throughout a segment is considered to be constant.

The most widely used formula for determining the hydraulic capacity of storm drain pipes for gravity and pressure flows is the Manning's Formula, expressed by the following equation:

$$\mathbf{V = (1.486/n)\ R^{2/3}\ S^{1/2}} \qquad \textbf{Equ(IV.2-9)}$$

where:

V = mean velocity of flow, ft/s
R = the hydraulic radius, ft - defined as the area of flow divided by the wetted flow surface
or wetted perimeter (A/WP)
S = the slope of hydraulic grade line, ft/ft
n = Manning's roughness coefficient

In terms of discharge, the above formula becomes:

$$\mathbf{Q = (1.486/n)\ A\ R^{2/3}\ S^{1/2}} \qquad \textbf{Equ(IV.2-10)}$$

where:

Q = rate of flow, cfs
A = cross sectional area of flow, ft^2

For pipes flowing full, the area is $(\pi/4)D^2$ and the hydraulic radius is D/4, so, the above equations become:

$$\mathbf{V = [0.590\ D^{2/3}S^{1/2}]/n} \qquad \textbf{Equ(IV.2-11)}$$
$$\mathbf{Q = [0.463\ D^{8/3}S^{1/2}]/n} \qquad \textbf{Equ(IV.2-12)}$$

where:

D = diameter of pipe, ft
S = slope of the pipe = S_f hydraulic grade line, ft/ft

The Manning's equation can be written to determine friction losses for storm drain pipes as:

$$\mathbf{Hf = [0.453\ n^2V^2L]/[R^{4/3}]} \qquad \textbf{Equ(IV.2-13)}$$
$$\mathbf{Hf = [(2.87\ n^2V^2L]/[D^{4/3}]} \qquad \textbf{Equ(IV.2-14)}$$
$$\mathbf{Hf = [(185n^2\ (V^2/2g)L]/[D^{4/3}]} \qquad \textbf{Equ(IV.2-15)}$$

where:

H_f = total head loss due to friction, ft (S_f x L)

n = Manning's roughness coefficient
D = diameter of pipe, ft
L = length of pipe, ft
V = mean velocity, ft/s
R = hydraulic radius, ft
g = acceleration of gravity = 32.2 ft/sec^2

Representative values of the Manning's coefficient for various storm drain materials are provided in Table IV.2-6. It should be remembered that the values in the table are for new pipe tested in a laboratory. Actual field values for conduits may vary depending on the effect of abrasion, corrosion, deflection, and joint conditions.

Table IV.2-6 **Manning's Coefficients for Storm Drain Conduits** (HEC 22, 2001)		
Type of Culvert	Roughness or Corrugation	Manning's n
Concrete Pipe	Smooth	0.010-0.011
Concrete Boxes	Smooth	0.012-0.015
Spiral Rib Metal Pipe	Smooth	0.012-0.013
Corrugated Metal Pipe, Pipe-Arch and Box (Annular or Helical Corrugations Manning's n varies with barrel size)	68 by 13 mm 2-2/3 by 1/2 in Annular 68 by 13 mm 2-2/3 by 1/2 in Helical 150 by 25 mm 6 by 1 in Helical 125 by 25 mm 5 by 1 in 75 by 25 mm 3 by 1 in 150 by 50 mm 6 by 2 in Structural Plate 230 by 64 mm 9 by 2-1/2 in Structural Plate	0.022-0.027 0.011-0.023 0.022-0.025 0.025-0.026 0.027-0.028 0.033-0.035 0.033-0.037
Corrugated Polyethylene	Smooth	0.009-0.015
Corrugated Polyethylene	Corrugated	0.018-0.025
Polyvinyl chloride (PVC)	Smooth	0.009-0.011
*NOTE: The Manning's n values indicated in this table were obtained in the laboratory and are supported by the provided reference. Actual field values for culverts may vary depending on the effect of abrasion, corrosion, deflection, and joint conditions.		

Minimum Grades and Desirable Velocities

The minimum slopes are calculated by the modified Manning's formula:

$$S = [(nV)^2]/[2.208R^{4/3}] \qquad \textbf{Equ(IV.2-16)}$$

where:

S = the slope of the hydraulic grade line, ft/ft
n = Manning's roughness coefficient
V = mean velocity of flow, ft/s
R = hydraulic radius, ft (area dived by wetted perimeter)

For circular conduits flowing full but not under pressure, R=D/4, and the hydraulic grade line is equal to the slope of the pipe. For these conditions equation IV.2-16 may be expressed as:

$$S = 2.87(nV)^2/D^{4/3} \qquad \textbf{Equ(IV.2-17)}$$

For a minimum velocity of 2.5 ft/s, the minimum slope equation becomes:

$$S = 17.938(n^2/D^{4/3}) \qquad \textbf{Equ(IV.2-18)}$$

where:

D = diameter, ft

Minimum Grades

Storm drains should operate with velocities of flow sufficient to prevent excessive deposits of solid materials; otherwise objectionable clogging may result. The controlling velocity is near the bottom of the conduit and considerably less than the mean velocity of the sewer. Storm drains shall be designed to have a minimum mean velocity flowing full of 2.5 fps. Table IV.2-7 gives minimum slopes for two commonly used materials: concrete pipe (n = 0.013) and corrugated metal pipe (n = 0.024), flowing at 2.5 fps.

Desirable Velocities

Velocities in sewers are important mainly because of the possibilities of excessive erosion on the storm drain inverts. Table IV.2-8 shows the maximum acceptable velocities for most storm drainage design.

Table IV.2-7 Minimum Grades for Storm Drains for 2.5 fps		
Pipe Size (inches)	Concrete Pipe (n = 0.013) Slope ft/ft	Corrugated Metal Pipe (n = 0.024) Slope ft/ft
15	0.0023	0.0077
18	0.0018	0.0060
21	0.0014	0.0049
24	0.0012	0.0041
27	0.0010	0.0035
30	0.0009	0.0030
33	0.0008	0.0027
36	0.0007	0.0024
39	0.0006	0.0021
42	0.0006	0.0020
45	0.0005	0.0018
48	0.0005	0.0016
54	0.0004	0.0014
60	0.0004	0.0012
66	0.0003	0.0011
72	0.0003	0.0010
78	0.0003	0.0009
84	0.0002	0.0008
96	0.0002	0.0006

Table IV.2-8 Maximum Velocity in Storm Drains	
Description	Maximum Velocity
Culverts (All types)	15 ft/s
Storm Drains (Inlet laterals)	No Limit
Storm Drains (Collectors)	15 ft/s
Storm Drains (Mains)	12 ft/s.
Exit Velocities for all storm systems	7 ft/s *

* Exit velocities shall be evaluated for specific outfall conditions. Exit velocities must be low enough to prevent erosion unless specific erosion protection is designed at outfall location.

Storm Drain Outfalls

All storm drains have an outlet where flow from the storm drainage system is discharged. The discharge point can be a natural river or stream, an existing storm drainage system, or a channel which is either existing or proposed for the purpose of conveying the storm water. The procedure for calculating the energy grade line through a storm drainage system begins at the outfall. Therefore, consideration of outfall conditions is an important part of storm drain design.

Several aspects of outfall design must be given serious consideration. These include the flowline or invert (inside bottom) elevation of the proposed storm drain outlet, tailwater elevations, the need for energy dissipation, and the orientation of the outlet structure.

The flowline or invert elevation of the proposed outlet should be equal to or higher than the flowline of the outfall. If this is not the case, there may be a need to pump or otherwise lift the water to the elevation of the outfall. Written approval of the County Engineer is required prior to designing an outlet below grade.

The tailwater depth or elevation in the storm drain outfall must be considered carefully. Evaluation of the hydraulic grade line for a storm drainage system begins at the system outfall with the tailwater elevation. For most design applications, the tailwater will either be above the crown of the outlet or can be considered to be between the crown and critical depth of the outlet. The tailwater may also occur between the critical depth and the invert of the outlet. However, the starting point for the hydraulic grade line determination should be either the design tailwater elevation or the average of critical depth and the height of the storm drain conduit, $(d_c + D)/2$, whichever is greater.

An exception to the above rule would be for a very large outfall with low tailwater where a water surface profile calculation would be appropriate to determine the location where the water surface will intersect the top of the barrel and full flow calculations can begin. In this case, the downstream water surface elevation would be based on critical depth or the design tailwater elevation, whichever was highest.

If the outfall channel is a river or stream, it may be necessary to consider the joint or coincidental probability of two hydrologic events occurring at the same time to adequately determine the elevation of the tailwater in the receiving stream. The relative independence of the discharge from the storm drainage system can be qualitatively evaluated by a comparison of the drainage area of the receiving stream to the area of the storm drainage system. For example, if the storm drainage system has a drainage area much smaller than that of the receiving stream, the peak discharge from the storm drainage system may be out of phase with the peak discharge from the receiving watershed. Table IV.2-9 provides a comparison of discharge frequencies for coincidental occurrence for the 2-, 5-, 10-, 25-, 50-, and 100-year design storms. This table can be used to establish an appropriate design tailwater elevation for a storm drainage system based on the expected coincident storm frequency on the outfall channel. For example, if the receiving stream has a drainage area of 200 acres and the storm drainage system has a drainage area of 2 acres, the ratio of receiving area to storm drainage area is 200 to 2 which equals 100 to 1. From Table IV.2-9 and considering a 10-year design storm occurring over both areas, the flow rate in the main stream will be equal to that of a five year storm when the drainage system flow rate reaches its 10-year peak flow at the outfall. Conversely, when the flow rate in the main channel reaches its 10-year peak flow rate, the flow rate from the storm drainage system will have fallen to the 5- year peak flow rate discharge. This is because the drainage areas are different sizes, and the time to peak for each drainage area is different.

Table IV.2-9
Frequencies for Coincidental Occurrences
(TxDOT, 2002)

Area ratio	2-year design		5-year design	
	Main Stream	Tributary	Main Stream	Tributary
10,000:1	1	2	1	5
	2	1	5	1
1,000:1	1	2	2	5
	2	1	5	2
100:1	2	2	2	5
	2	2	5	5
10:1	2	2	5	5
	2	2	5	5
1:1	2	2	5	5
	2	2	5	5
Area ratio	10-year design		25-year design	
	Main Stream	Tributary	Main Stream	Tributary
10,000:1	1	10	2	25
	10	1	25	2
1,000:1	2	10	5	25
	10	2	25	5
100:1	5	10	10	25
	10	5	25	10
10:1	10	10	10	25
	10	10	25	10
1:1	10	10	25	25
	10	10	25	25
Area ratio	50-year design		100-year design	
	Main Stream	Tributary	Main Stream	Tributary
10,000:1	2	50	2	100
	50	2	100	2
1,000:1	5	50	10	100
	50	5	100	10
100:1	10	50	25	100
	50	10	100	25
10:1	25	50	50	100
	50	25	100	50
1:1	50	50	100	100
	50	50	100	100

There may be instances in which an excessive tailwater causes flow to back up the storm drainage system and out of inlets and access holes, creating unexpected and perhaps hazardous flooding conditions. The potential for this should be considered. Flap gates

placed at the outlet can sometimes alleviate this condition; otherwise, it may be necessary to isolate the storm drain from the outfall by use of a pump station. Flap gates and/or pump stations will require written approval of the County Engineer.

Energy dissipation may be required to protect the storm drain outlet. Protection is usually required at the outlet to prevent erosion of the outfall bed and banks. Riprap aprons or energy dissipaters should be provided if high velocities are expected.

The orientation of the outfall is another important design consideration. Where practical, the outlet of the storm drain should be positioned in the outfall channel so that it is pointed in a downstream direction. This will reduce turbulence and the potential for excessive erosion. If the outfall structure can not be oriented in a downstream direction, the potential for outlet scour must be considered. For example, where a storm drain outfall discharges perpendicular to the direction of flow of the receiving channel, care must be taken to avoid erosion on the opposite channel bank. If erosion potential exists, a channel bank lining of riprap or other suitable material should be installed on the bank. Alternatively, an energy dissipater structure could be used at the storm drain outlet.

Energy Losses

Prior to computing the hydraulic grade line, all energy losses in pipe runs and junctions must be estimated. In addition to the principal energy involved in overcoming the friction in each conduit run, energy (or head) is required to overcome changes in momentum or turbulence at outlets, inlets, bends, transitions, junctions, and access holes. The following sections present relationships for estimating typical energy losses in storm drainage systems

Pipe Friction Losses

The major loss in a storm drainage system is the friction or boundary shear loss. The head loss due to friction in a pipe is computed as follows:

$$\mathbf{H_f = S_f L} \qquad \textbf{Equ(IV.2-19)}$$

where:

H_f = friction loss, ft
S_f = friction slope, ft/ft
L = length of pipe, ft

The following section gives the equation for computing the friction loss in pipes flowing full.

The friction slope in equation IV.2-19 is also the slope of the hydraulic gradient for a particular pipe run. As indicated by equation IV.2-19, the friction loss is simply the hydraulic gradient multiplied by the length of the run. Since this design procedure

assumes steady uniform flow in open channel flow, the friction slope will match the pipe slope for part full flow. Pipe friction losses for full flow can be determined by the use of Equation IV.2-13.

Exit Losses

The exit loss from a storm drain outlet is a function of the change in velocity at the outlet of the pipe. For a sudden expansion such as at an endwall, the exit loss is:

$$H_0 = 1.0 \left[(V_0^2/2g) - (V_d^2/2g)\right] \qquad \text{Equ(IV.2-20)}$$

where:

V_0 = average outlet velocity
V_d = channel velocity downstream of outlet

Note that when $V_d = 0$, as in a reservoir, the exit loss is one velocity head. For part full flow where the pipe outlets in a channel with water moving in the same direction as the outlet water, the exit loss may be reduced to virtually zero.

Bend Losses

The bend loss coefficient for storm drain design is minor but can be estimated using the following formula (AASHTO, 1991):

$$h_b = 0.0033\ (\Delta)\ (V^2/2g) \qquad \text{Equ(IV.2-21)}$$

where:

Δ = angle of curvature in degrees

Transition Losses

A transition is a location where a conduit or channel changes size. Typically, transitions should be avoided and access holes should be used when pipe size increases. However, sometimes transitions are unavoidable. Transitions include expansions, contractions, or both. In small storm drains, transitions may be confined within access holes. However, in larger storm drains or when a specific need arises, transitions may occur within pipe runs .

Energy losses in expansions or contractions in non-pressure flow can be expressed in terms of the kinetic energy at the two ends. Contraction and expansion losses can be evaluated with equations IV.2.22 and IV.2-23 respectively.

$$H_c = K_c \left[V_1^2/(2g) - V_2^2/(2g)\right] \qquad \text{Equ(IV.2-22)}$$

$$H_e = K_e [V_1^2/(2g) - V_2^2/(2g)] \qquad \text{Equ(IV.2-23)}$$

where:

K_e = expansion coefficient
K_c = contraction coefficient (0.5 K_e)
V_1= velocity upstream of transition
V_2 = velocity downstream of transition
g = acceleration due to gravity (32.2 ft/s^2)

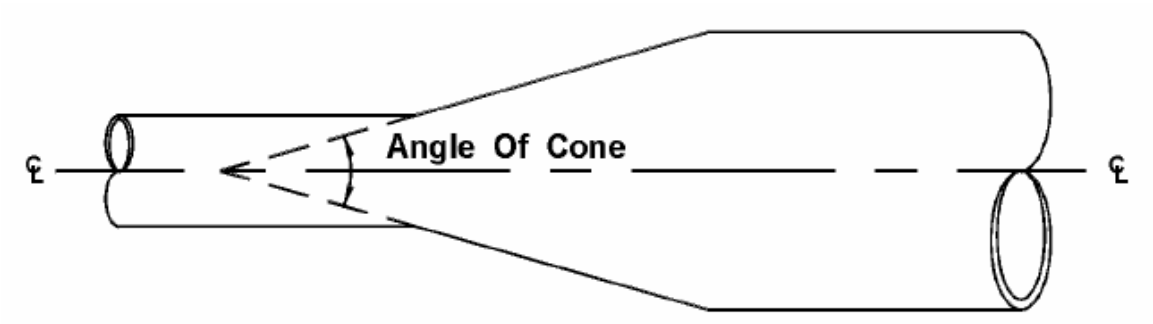


Figure IV.2-8 Angle of Cone for Pipe Diameter Changes

For gradual contractions, it has been observed that K_c = 0.5 K_e. Typical values of K_e for gradual enlargements are tabulated in Table IV.2-10a. Typical values of K_c for sudden contractions are tabulated in Table IV.2-10b. The angle of the cone that forms the transition is defined in Figure IV.2-7.

Table IV.2-10a
Typical Values for K_e for Gradual Enlargement of Pipes in Non-Pressure Flow

D2/D1	Angle of Cone						
	10°	20°	45°	60°	90°	120°	180°
1.5	0.17	0.40	1.06	1.21	1.14	1.07	1.00
3	0.17	0.40	0.86	1.02	1.06	1.04	1.00
D_2/D_1= Ratio of Diameter of larger pipe to smaller pipe (ASCE, 1992)							

Table IV.2-10b
Typical Values of K_c for Sudden Pipe Contractions

D2/D1	Kc
0.2	0.5
0.4	0.4
0.6	0.3
0.8	0.1
1	0
D_2/D_1= Ratio of Diameter of smaller pipe to larger pipe (ASCE, 1992)	

For storm drain pipes functioning under pressure flow, the loss coefficients listed in Tables IV.2-11 and IV.2-12 can be used with Equation IV.2-24 for sudden and gradual expansions respectively. For sudden contractions in pipes with pressure flow, the loss coefficients listed in Table IV.2-13 can be used in conjunction with Equation IV.2-25 (ASCE, 1992).

$$H_e = K_e (V1_1^2/2g) \qquad \textbf{Equ(IV.2-2IV)}$$

$$H_c = K_c (V_2^2/2g) \qquad \textbf{Equ(IV.2-25)}$$

where:

Ke = expansion coefficient (Tables IV.2-11 and IV.2-12)
Kc = contraction coefficient (Table IV.2-13)
V1 = velocity upstream of transition
V2 = velocity downstream of transition
g = acceleration due to gravity 32.2 ft/s^2

Table IV.2-11
Values of K_e for Determining Loss of Head due to Sudden Enlargement in Pipes

D2/D1	Velocity, V1, in feet per second												
	2.0	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**10.0**	**12.0**	**15.0**	**20.0**	**30.0**	**40.0**
1.2	0.11	0.10	0.10	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09	0.09	0.08
1.4	0.26	0.26	0.25	0.24	0.24	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.20
1.6	0.40	0.39	0.38	0.37	0.37	0.36	0.36	0.35	0.35	0.34	0.33	0.32	0.32
1.8	0.51	0.49	0.48	0.47	0.47	0.46	0.46	0.45	0.44	0.43	0.42	0.41	0.40
2.0	0.60	0.58	0.56	0.55	0.55	0.54	0.53	0.52	0.52	0.51	0.50	0.48	0.47
2.5	0.74	0.72	0.70	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.62	0.60	0.58
3.0	0.83	0.80	0.78	0.77	0.76	0.75	0.74	0.73	0.72	0.70	0.69	0.67	0.65
4.0	0.92	0.89	0.87	0.85	0.84	0.83	0.82	0.80	0.79	0.78	0.76	0.74	0.72
5.0	0.96	0.93	0.91	0.89	0.88	0.87	0.86	0.84	0.83	0.82	0.80	0.77	0.75
10.0	1.00	0.99	0.96	0.95	0.93	0.92	0.91	0.89	0.88	0.86	0.84	0.82	0.80
∞	1.00	1.00	0.98	0.96	0.95	0.94	0.93	0.91	0.90	0.88	0.86	0.83	0.81

D_2/D_1 = ratio of diameter of larger pipe to smaller pipe
V_1 = velocity in smaller pipe (upstream of transition)
(ASCE, 1992)

Table IV.2-12
Values of K_e for Determining Loss of Head due to Gradual Enlargement in Pipes

D2/D1	Angle of Cone										
	2°	**6°**	**10°**	**15°**	**20°**	**25°**	**30°**	**35°**	**40°**	**50°**	**60°**
1.1	0.01	0.01	0.03	0.05	0.10	0.13	0.16	0.18	0.19	0.21	0.23
1.2	0.02	0.02	0.04	0.09	0.16	0.21	0.25	0.29	0.31	0.35	0.37
1.4	0.02	0.03	0.06	0.12	0.23	0.30	0.36	0.41	0.44	0.50	0.53
1.6	0.03	0.04	0.07	0.14	0.26	0.35	0.42	0.47	0.51	0.57	0.61
1.8	0.03	0.04	0.07	0.15	0.28	0.37	0.44	0.50	0.54	0.61	0.65
2.0	0.03	0.04	0.07	0.16	0.29	0.38	0.46	0.52	0.56	0.63	0.68
2.5	0.03	0.04	0.08	0.16	0.30	0.39	0.48	0.54	0.58	0.65	0.70
3.0	0.03	0.04	0.08	0.16	0.31	0.40	0.48	0.55	0.59	0.66	0.71
∞	0.03	0.05	0.08	0.16	0.31	0.40	0.49	0.56	0.60	0.67	0.72

D_2/D_1 = ratio of diameter of larger pipe to smaller pipe
Angle of cone is the angle in degrees between the sides of the tapering section
(ASCE, 1992)

Table IV.2.13 Values of K_e for Determining Loss of Head due to Sudden Contraction													
D2/ D1	Velocity, V1, in feet per second												
	2.0	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**10.0**	**12.0**	**15.0**	**20.0**	**30.0**	**40.0**
1.1	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06
1.2	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.09	0.11	0.11
1.4	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.18	0.18	0.18	0.18	0.19	0.20
1.6	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.25	0.25	0.24
1.8	0.34	0.34	0.34	0.34	0.34	0.34	0.33	0.33	0.32	0.32	0.32	0.29	0.27
2.0	0.38	0.38	0.37	0.37	0.37	0.37	0.36	0.36	0.35	0.34	0.33	0.31	0.29
2.2	0.40	0.40	0.40	0.39	0.39	0.39	0.39	0.38	0.37	0.37	0.35	0.33	0.30
2.5	0.42	0.42	0.42	0.41	0.41	0.41	0.40	0.40	0.39	0.38	0.37	0.34	0.31
3.0	0.44	0.44	0.44	0.43	0.43	0.43	0.42	0.42	0.41	0.40	0.39	0.36	0.33
4.0	0.47	0.46	0.46	0.46	0.45	0.45	0.45	0.44	0.43	0.42	0.41	0.37	0.34
5.0	0.48	0.48	0.47	0.47	0.47	0.46	0.46	0.45	0.45	0.44	0.42	0.38	0.35
10.0	0.49	0.48	0.48	0.48	0.48	0.47	0.47	0.46	0.46	0.45	0.43	0.40	0.36
∞	0.49	0.49	0.48	0.48	0.48	0.47	0.47	0.47	0.46	0.45	0.44	0.41	0.38
D_2/D_1 = ratio of diameter of larger pipe to smaller pipe													
V_1 = velocity in smaller pipe (upstream of transition)													
(ASCE, 1992)													

Junction Losses

A pipe junction is the connection of a lateral pipe to a larger trunk pipe without the use of an access hole structure. The minor loss equation for a pipe junction is a form of the momentum equation as follows:

$$H_j=[((Q_o V_o) - (Q_l V_l) - (Q_l V_l \cos\theta)) / (0.5g(A_o-A_l))] + h_l - h_o \qquad \text{Equ(IV.2-26)}$$

where:

H_l = junction loss (ft)
Q_o, Q_l, Q_l = outlet, inlet, and lateral flows respectively (ft^3/s)
V_o, V_l V_l = outlet, inlet, and lateral velocities, respectively (ft/s)
h_o, h_i = outlet and inlet velocity heads (ft)
A_o, A_i = outlet and inlet cross-sectional areas (ft^2)
θ = angle between the inflow and outflow pipes

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IV.3 General Design Considerations

- Storm water systems should be planned and designed so as to generally conform to natural drainage patterns and discharge to natural drainage pathways within a drainage basin. These natural drainage pathways should only be modified as a last resort to contain and safely convey the peak flows generated by the development.

- Runoff must be discharged in a manner that will not cause adverse impacts on downstream properties or storm water systems. In general, runoff from development sites within a drainage basin should be discharged at the existing natural drainage outlet or outlets. If the developer wishes to change discharge points he or she must demonstrate that the change will not have any adverse impacts on downstream properties or storm water (minor) systems.

- It is important to ensure that the combined on-site flood control system and major storm water system can handle blockages and flows in excess of the design capacity to minimize the likelihood of nuisance flooding or damage to private properties. If failure of minor storm water systems and/or major storm water structures occurs during these periods, the risk to life and property could be significantly increased.

- In establishing the layout of storm water systems, it is essential to ensure that flows are not diverted onto private property during flows up to the major storm water system design capacity.

IV.3.1 Design Storm Requirements

Section IV.2.1 contains design storm requirement for Denton County.

IV.3.2 Culvert Design

Symbols and Definitions

Table IV.3-1
Symbols and Definitions

Symbol	Definition	Units
A	Area of cross section of flow	ft^2
B	Barrel width	ft
C_d	Overtopping discharge coefficient	-
D	Culvert diameter or barrel depth	in or ft
d	Depth of flow	ft
d_c	Critical depth of flow	ft
du	Uniform depth of flow	ft
g	Acceleration of gravity	ft/s

Table IV.3-1 Symbols and Definitions		
Symbol	Definition	Units
H_f	Depth of pool or head, above the face section of invert	ft
h_o	Height of hydraulic grade line above outlet invert	ft
HW	Headwater depth above invert of culvert (depth from inlet invert to upstream total energy grade line)	ft
K_e	Inlet loss coefficient	-
L	Length of culvert	ft
N	Number of barrels	-
Q	Rate of discharge	cfs
S	Slope of culvert	ft/ft
TW	Tailwater depth above invert of culvert	ft
V	Mean velocity of flow	ft/s
V_c	Critical velocity	ft/s

Velocity Limitations

Both minimum and maximum velocities shall be considered when designing a culvert. The maximum velocity should be consistent with channel stability requirements at the culvert outlet. The maximum allowable velocity for corrugated metal and reinforced concrete pipe is 15 feet per second. Outlet protection shall be provided where discharge velocities will cause erosion problems

Buoyancy Protection

Headwalls, endwalls, slope paving, or other means of anchoring to provide buoyancy protection should be considered for all flexible culverts. Geotechnical substantiation will be required prior to approval of flexible culvert pipe.

Length and Slope

The culvert length and slope should be chosen to approximate existing topography and, to the degree practicable, the culvert invert should be aligned with the channel bottom and the skew angle of the stream, and the culvert entrance should match the geometry of the roadway embankment. The maximum slope using concrete pipe is 10% and for CMP is 14% before pipe-restraining methods must be taken. Maximum vertical distance from throat of intake to flowline

in a drainage structure is 10 feet. Drops greater than 4 feet will require additional structural design.

Debris Control

In designing debris control structures, it is recommended that the Hydraulic Engineering Circular No. 9 entitled *Debris Control Structures* be consulted.

Headwater Limitations

Headwater is water above the culvert invert at the entrance end of the culvert. The allowable headwater elevation is that elevation above which damage may be caused to adjacent property and/or the roadway and is determined from an evaluation of land use upstream of the culvert and the proposed or existing roadway elevation. It is this allowable headwater depth that is the primary basis for sizing a culvert.

The following criteria related to headwater should be considered:

- The *allowable headwater* is the depth of water that can be ponded at the upstream end of the culvert during the design flood, which will be limited by one or more of the following constraints or conditions:

    1. Headwater be non-damaging to upstream property

    2. Ponding depth be no greater than one foot below the low point in the road grade

    3. Ponding depth be no greater than the elevation where flow diverts around the culvert

    4. Elevations established to delineate floodplain zoning

    5. Freeboard requirements: Culverts shall be sized to have 100-year fully developed conditions capacity with a 12-inch freeboard at the low-point of the road.

- The maximum acceptable outlet velocity is 7 feet per second unless a variance is specifically approved by the County Engineer. Supporting geotechnical documentation and/or erosion protection design at outlet will be required to support any request for variance.

- Either the headwater should be set to produce acceptable velocities, or stabilization or energy dissipation should be provided where these velocities are exceeded.

- In general, the constraint that gives the lowest allowable headwater elevation establishes the criteria for the hydraulic calculations.

Tailwater Considerations

The hydraulic conditions downstream of the culvert site must be evaluated to determine a tailwater depth for a range of discharges. At times there may be a need for calculating backwater curves to establish the tailwater conditions. The following conditions must be considered:

- If the culvert outlet is operating with a free outfall, the critical depth and equivalent hydraulic grade line should be determined.

- For culverts that discharge to an open channel, the stage-discharge curve for the channel must be determined. See Section IV.3.4, *Open Channel Design*.

- If an upstream culvert outlet is located near a downstream culvert inlet, the headwater elevation of the downstream culvert may establish the design tailwater depth for the upstream culvert.

- If the culvert discharges to a lake, pond, or other major water body, the expected high water elevation of the particular water body may establish the culvert tailwater.

Culvert Inlets

The inlet coefficient K_e, is a measure of the hydraulic efficiency of the inlet, with lower values indicating greater efficiency. Recommended inlet coefficients are given in Table IV.3-2.

Inlets with Headwalls

Headwalls are required for all metal culverts and where buoyancy protection is necessary. If high headwater depths are to be encountered, or the approach velocity in the channel will cause scour, a short channel apron should be provided at the toe of the headwall. This apron should extend at least one pipe diameter upstream from the entrance, and the top of the apron should not protrude above the normal streambed elevation.

Culvert Skews

Culvert skews shall not exceed 45 degrees as measured from a line perpendicular to the roadway centerline without approval.

Culvert Sizes

The minimum allowable pipe diameter shall be 18 inches.

Table IV.3-2 Inlet Coefficients	
Type of Structure and Design of Entrance	Coefficient Ke
Pipe, Concrete	
Projecting from fill, socket end (grove-end)	0.2
Projecting from fill, square cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded [radius = 1/12(D)]	0.2
Mitered to conform to fill slope	0.7
*End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal[1]	
Projecting form fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to fill slope, paved or unpaved slope	0.7
*End Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Slide- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	0.5
Square-edged on 3 edges	0.2
Rounded on 3 edges to radius of [1/12(D)] or [1/12(B)] or beveled edges on 3 sides	
Wingwalls at 30° to 75° to barrel	0.4
Square-edged at crown	0.2
Crown edge rounded to radius of [1/12(D)] or beveled top edge	
Wingwalls at 10^{o} or 25^{o} to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

Although laboratory tests have not been completed on K_e values for High-Density Polyethylene (HDPE) pipes, the K_e values for corrugated metal pipes are recommended for HDPE pipes.

*Note: "End Section conforming to fill slope", made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections incorporating a closed taper in their design have a superior hydraulic performance. These latter sections can be designed using the information given for the beveled inlet.
Source: HDS No. 5, 2001

Note: For further information concerning Manning n values for selected conduits consult Hydraulic Design of Highway Culverts, Federal Highway Administration, 2001, HDS No. 5 pages 201-208

Table IV.3-3 Manning's n Values		
Type of Conduit	**Wall & Joint Description**	**Manning's n**
Concrete Pipe	Good joints, smooth walls	0.012
	Good joints, rough walls	0.016
	Poor joints, rough walls	0.017
Concrete Box	Good joints, smooth finished walls	0.012
	Poor joints, rough, unfinished walls	0.018
Corrugated Metal Pipes and Boxes Annular Corrugations	2 2/3-by 1/2-inch corrugations	0.024
	6- by 1-inch corrugations	0.025
	5- by 1-inch corrugations	0.026
	3- by 1-inch corrugations	0.028
	6- by 2-inch structural plate	0.035
	9-by 2-1/2 inch structural plate	0.035
Corrugated Metal Pipes, Helical Corrugations, Full Circular Flow	2 2/3- by 1/2-inch corrugated 24-inch plate width	0.012
Spiral Rib Metal Pipe	3/4 by 3/4 in recesses at 12-inch spacing, good joints	0.013
High Density Polyethylene (HDPE)	Corrugated Smooth Liner	0.015
	Corrugated	0.02
Polyvinyl Chloride (PVC)		0.011

Environmental Considerations

Documentation must be submitted to the County Engineer indicating that all applicable state and federal environmental regulations, including USACE Section 404 permit requirements have been adhered to for any drainage design project.

Design Procedure

Final design of culverts shall be performed using a computerized backwater analysis program such as HEC-RAS. Digital copies of culvert design models must be submitted with construction plans for County Engineer review and approval.

IV.3.3 Bridge Design

Design Criteria

The design of a bridge should take into account many different engineering and technical aspects at the bridge site and adjacent areas. The following design criteria should be considered for all

bridge designs as applicable. Final design of all bridges shall be performed using a computerized backwater analysis program such as HEC-RAS. Digital copies of culvert design models must be submitted with construction plans for County Engineer review and approval.

Frequency Flood

All bridge design shall include 100-year return event discharges, assuming fully developed watershed conditions.

Freeboard

Bridge freeboard shall be a minimum of 12-inches to the lowest crossing grade.

Loss Coefficients

The contraction and expansion of water through the bridge opening creates hydraulic losses. These losses are accounted for through the use of loss coefficients. Table IV.3-4 gives recommended values for the Contraction (K_c) and Expansion (K_e) Coefficients.

Table IV.3-4
Recommended Loss Coefficients for Bridges

Transition Type	Contraction (Kc)	Expansion (Ke)
No losses computed	0.0	0.0
Gradual transition	0.1	0.3
Typical bridge	0.3	0.5
Severe transition	0.6	0.8

Design Procedures

The following is a general bridge hydraulic design procedure.

1. Determine the most efficient alignment of proposed roadway, attempting to minimize skew at the proposed stream crossing.

2. Determine the fully-developed watershed design discharge

3. If available, obtain effective FEMA hydraulic backwater model. It is assumed that if a bridge is required instead of a culvert, the drainage area would exceed one square mile and could already be included in a FEMA study. If an effective FEMA model or other model is not available, a basic hydrologic model and backwater analysis for the stream must be prepared. The HEC-RAS computer model or other computer program approved by the County Engineer shall be used to compute backwater water surface profiles.

4. Using USACE or FEMA guidelines, compute or duplicate an existing conditions water surface profile for the design storm(s). Compute a profile for the fully-developed watershed to use as a baseline for design of a new bridge/roadway crossing.

5. Use the design discharge to compute an approximate opening that will be needed to pass the design storm (for preliminary sizing, use a normal-depth design procedure, or simply estimate a required trapezoidal opening.

6. Prepare a bridge crossing data set in the hydraulic model to reflect the preliminary design opening, which includes the required freeboard and any channelization upstream or downstream to transition the floodwaters through the proposed structure.

7. Compute the proposed bridge flood profile and design parameters (velocities, flow distribution, energy grade, etc.). Review for criteria on velocities and freeboard, and revise model as needed to accommodate design flows.

8. Review the velocities and determine erosion control requirements downstream, through the structure, and upstream.

9. Finalize the design size and erosion control features, based on comparing the proposed model with the existing conditions profiles, impacts on other properties, FEMA guidelines, and Local Criteria.

10. Exceptions/Other Issues

    A. Conditional Letter of Map Amendment (CLOMR) may be needed for new crossings of streams studied by FEMA.

    B. If applicable, coordinate with USACE Regulatory Permit requirements.

    C. Evaluate the project with respect to iSWM policy regarding downstream impacts.

    D. Design should be for fully developed watershed conditions. If the available discharges are from FEMA existing conditions hydrology, the following options are available: (1) obtain new hydrology, (2) extrapolate fully-developed from existing data, or (3) variance from the County Engineer on design discharges

IV.3.4 Open Channel Design

Overview

Introduction

Open channels include drainage ditches, grass channels, dry and wet enhanced swales, stone riprap channels and concrete-lined channels.

The purpose of this section is to provide an overview of open channel design criteria and methods.

Open Channel Types

The three main classifications of open channel types according to channel linings are vegetated, flexible, and rigid. Vegetated linings include grass with mulch, sod and lapped sod, and wetland channels. Stone riprap and some forms of flexible man-made linings or gabions are examples of flexible linings, while rigid linings are generally concrete or rigid block.

Vegetative Linings – Vegetation, where practical, is the most desirable lining for an artificial channel.

Conditions under which vegetation may not be acceptable include but are not limited to:

- High velocities (greater than 7 feet per second or as supported by geotechnical investigation).
- Standing or continuously flowing water
- Lack of regular maintenance necessary to prevent growth of taller or woody vegetation
- Lack of nutrients and inadequate topsoil
- Excessive shade

Proper seeding, mulching, and soil preparation are required during construction to assure establishment of healthy vegetation. Geotextile material will be required to protect constructed vegetated channel until stabilizing vegetation is established. Geotextile material must have UV protection and a design life of at least 24 months to protect exposed soils.

If low flows are prevalent, a hard lined pilot channel may be needed, and it should be wide enough to accommodate maintenance equipment. Whether to allow pilot channels should be included in the local criteria section.

Flexible Linings – Rock riprap, including rubble and gabion baskets, cable matting, and articulated blocks, are acceptable flexible lining for channels. They may require the use of a filter fabric depending on the underlying soils, and the growth of grass, weeds, and trees may present maintenance problems. Supporting geotechnical documentation will be required to support channel lining design selection.

Rigid Linings – Rigid linings are generally constructed of concrete and used where high flow capacity is required. Higher velocities, however, create the potential for scour at channel lining transitions and channel headcutting.

Symbols and Definitions

Table IV.3-5 Symbols and Definitions		
Symbol	Definition	Units
α	Energy coefficient	-
A	Cross-sectional area	ft^2
b	Bottom width	ft
C_g	Specific weight correction factor	-
D or d	Depth of flow	ft
d	Stone diameter	ft
delta d	Super-elevation of the water surface profile	ft
d_x	Diameter of stone for which x percent, by weight, of the gradation is finer	ft
E	Specific energy	ft
Fr	Froude Number	-
g	Acceleration of gravity	32.2 ft/s^2
h_{loss}	Head loss	ft
K	Channel conveyance	-
k_e	Eddy head loss coefficient	ft
K_T	Trapezoidal open channel conveyance factor	-
L	Length of channel	ft
L_p	Length of downstream protection	ft
n	Manning's roughness coefficient	-
P	Wetted perimeter	ft
Q	Discharge rate	ft^3/s
R	Hydraulic radius of flow	ft
R_c	Mean radius of the bend	ft
S	Slope	ft/ft
SW_s	Specific weight of stone	lbs/ft^3
T	Top width of water surface	ft
V or v	Velocity of flow	ft/s
w	Stone weight	lbs
y_c	Critical depth	ft
y_n	Normal depth	ft
Z	Critical flow section factor	-

General Criteria

The following criteria should be followed for open channel design:

- Channels with bottom widths greater than 10 feet shall be designed with a minimum bottom cross slope of 12 to 1, or with compound cross sections.

- Channel side slopes shall be stable throughout the entire length and the side slope shall depend on the channel material. A maximum of 4:1 should be used for earthen channel side slopes, unless otherwise justified by calculation and approved in writing by the County Engineer. Roadside ditches should have a maximum side slope of 3:1.

- Trapezoidal or parabolic cross sections are preferred over triangular shapes.

- For vegetative channels, flow velocities within the channel should not exceed the maximum permissible velocities given in Tables IV.3-6 and IV.3-7.

- If relocation of a stream channel is unavoidable, the cross-sectional shape, meander, pattern, roughness, sediment transport, and slope should conform to the existing conditions insofar as practicable. Some means of energy dissipation may be necessary when existing conditions cannot be duplicated. Relocation of stream channel will not be permitted without written approval from the County Engineer. Jurisdiction determination and USACE 404 compliance will be required by written documentation submitted to the County Engineer.

- Streambank stabilization should be provided, when appropriate, as a result of any stream disturbance such as encroachment and should include both upstream and downstream banks as well as the local site.

- Open channel drainage systems shall be designed for the 100-year design storm with one foot of freeboard to the top of bank,.

- HEC-RAS or other acceptable computerized water surface profile calculation program shall be used to confirm the water surface profiles in open channels, and shall be used to evaluate water surface profiles in roadside ditches as well.

Velocity Limitations

The final design of artificial open channels should be consistent with the velocity limitations for the selected channel lining. Maximum acceptable velocity values for selected lining categories are presented in Table IV.3-6. Velocity limitations for vegetative linings are reported in Table IV.3-7. Stone riprap design procedures are presented in Section IV.3.5.

Maximum velocity is 15 ft/s in concrete lined channels. For gabions, maximum design velocities are 10 ft/s for 6-inch thick mattresses and 15 ft/s for 1-foot thick mattresses.

Manning's n Values

Manning's n values for existing artificial channels with rigid, unlined, temporary, and stone riprap linings are given in Table IV.3-8. Manning's values for existing natural channels that are either excavated or dredged, and natural are given in Table IV.3-6.

Table IV.3-6
Roughness Coefficients (Manning's n)
and Allowable Velocities for Natural Channels

Channel Description	Manning's n	Maximum Permissible Channel Velocity (ft/s)
MINOR NATURAL STREAMS		
Fairly regular section		
1. Some grass and weeds; little or no brush	0.030	3 to 6
2. Dense growth of weeds, depth of flow materially greater than weed height	0.035	3 to 6
3. Some weeds, light brush on banks	0.035	3 to 6
4. Some weeds, heavy brush on banks	0.050	3 to 6
5. Some weeds, dense willows on banks	0.060	3 to 6
For trees within channels with branches submerged at high stage, increase above values by	0.010	
Irregular section with pools, slight channel meander, increase above values by	0.010	
Floodplain – Pasture		
1. Short grass	0.030	3 to 6
2. Tall grass	0.035	3 to 6
Floodplain – Cultivated Areas		
1. No crop	0.030	3 to 6
2. Mature row crops	0.035	3 to 6
3. Mature field crops	0.040	3 to 6
Floodplain – Uncleared		
1. Heavy weeds scattered brush	0.050	3 to 6
2. Wooded	0.120	3 to 6

Table IV.3-6 Roughness Coefficients (Manning's n) and Allowable Velocities for Natural Channels		
Channel Description	Manning's n	Maximum Permissible Channel Velocity (ft/s)
MAJOR NATURAL STREAMS		
Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or	Range from 0.028 to 0.060	3 to 6
UNLINED VEGETATED CHANNELS		
Clays (Bermuda Grass)	0.035	5 to 6
Sandy and Silty Soils (Bermuda Grass)	0.035	3 to 5
UNLINED NON-VEGETATED CHANNELS		
Sandy Soils	0.030	1.5 to 2.5
Silts	0.030	0.7 to 1.5
Sandy Silts	0.030	2.5 to 3.0
Clays	0.030	3.0 to 5.0
Coarse Gravels	0.030	5.0 to 6.0
Shale	0.030	6.0 to 10.0
Rock	0.025	15

Table IV.3-7
Maximum Velocities for Vegetative Channel Linings

Vegetation Type	Slope Range (%)1	Maximum Velocity2 (ft/s)
Bermuda grass	0-5	6
Bahia		4
Tall fescue grass mixtures3	0-10	4
Kentucky bluegrass	0-5	6
Buffalo grass	5-10	5
	>10	4
Grass mixture	0-5[1]	4
	5-10	3
Sericea lespedeza, Weeping lovegrass, Alfalfa	0-5[4]	3
Annuals[5]	0-5	3
Sod		4
Lapped sod		5

[1]Do not use on slopes steeper than 10% except for side-slope in combination channel.

[2] Use velocities exceeding 5 ft/s only where good stands can be maintained.

[3] Mixtures of Tall Fescue, Bahia, and/or Bermuda

[4] Do not use on slopes steeper than 5% except for side-slope in combination channel.

[5] Annuals - used on mild slopes or as temporary protection until permanent covers are established.

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

Table IV.3-8 Manning's Roughness Coefficients (n) for Artificial Channels				
		Depth Ranges		
Category	Lining Type	0-0.5 ft	0.5-2.0 ft	>2.0 ft
Rigid	Concrete	0.015	0.013	0.013
	Grouted Riprap	0.040	0.030	0.028
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil	0.023	0.020	0.020
	Rock Cut	0.045	0.035	0.025
Temporary*	Woven Paper Net	0.016	0.015	0.015
	Jute Net	0.028	0.022	0.019
	Fiberglass Roving	0.028	0.022	0.019
	Straw with Net	0.065	0.033	0.025
	Curled Wood Mat	0.066	0.035	0.028
	Synthetic Mat	0.036	0.025	0.021
Gravel Riprap	1-inch D_{50}	0.044	0.033	0.030
	2-inch D_{50}	0.066	0.041	0.034
Rock Riprap	6-inch D_{50}	0.104	0.069	0.035
	12-inch D_{50}	–	0.078	0.040
Note: Values listed are representative values for the respective depth ranges. Manning's roughness coefficients, n, vary with the flow depth. *Some "temporary" linings become permanent when buried.				

Source: HEC-15, 1988.

When designing open channels, required Manning's roughness coefficients may be found in Table 4.3-9.

Table IV.3-9 Manning's Roughness Coefficients for Design		
Lining Type	Manning's n	Comments
Grass Lined	0.040	
Concrete Lined	0.015	
Gabions	0.030	
Rock Riprap	0.040	$n = 0.0395 d_{50}^{1/6}$ where d_{50} is the stone size of which 50% of the sample is smaller
Grouted Riprap	0.028	FWHA

IV.3.5 Stone Riprap Design

Introduction

A number of agencies and researchers have studied and developed empirical equations to estimate the required size of rock riprap to resist various hydraulic conditions, including the U.S. Army Corps of Engineers (USACE), Natural Resource Conservation Service (NRCS), and the Federal Highway Administration (FHWA). As with all empirical equations based on the results of laboratory experiments, they must be used with an understanding of the range of data on which they are based.

One acceptable method is outlined below. Other methodology will be considered upon written explanation submitted to the County Engineer.

Gregory Method (based on USACE design manual)

The following procedure is based on excerpts from a paper prepared by Garry Gregory (June, 1987) and has been widely used in the Dallas-Fort Worth area for riprap design.

Procedure

Following are the steps in the procedure for riprap design using the method by Gregory:

Step 1 Calculate the boundary shear (tractive stress or tractive force) by:

$$T_o = U_w RS \qquad \textbf{Equ(IV.3-1)}$$

where:

T_o = average tractive stress on channel bottom (lb/ft^2)
U_w = unit weight of water (62.4 lb/ft^3)
R = hydraulic radius of channel (ft)
S = slope of energy gradient (ft/ft)

$$T_o' = T_o((1-\sin^2 F)/\sin^2 Q)^{0.5} \qquad \textbf{Equ(IV.3-2)}$$

where:

T_o' = average tractive stress on channel side slopes (lb/ft^2)
F = angle of side slopes with the horizontal
Q = angle of repose of riprap (approximate 40°)

Step 2 Determine the tractive stress in a bend in the channel by:

$$T_b = 3.15T(r/w)^{-0.5} \qquad \textbf{Equ(IV.3-3)}$$

where:

Tb = local tractive stress in the bend (lb/ft2)
T = the greater of To or To' from equations IV.3-1 and IV.3-2
r = center-line radius of the bend (ft)
w = water surface width at upstream end of bend (ft)

Step 3 Determine D_{50} size of riprap stone (size at which 50% of the gradation is finer weight)

from:

$$D_{50} = T / 0.04(U_s - U_w) \qquad \textbf{Equ(IV.3-4)}$$

where:

D_{50} = required average size of riprap stone (ft)
T = the greater of To or To' from equations IV.3-1 and IV.3-2
Us = saturated surface dry (SSD) unit weight of stone (lb/ft3)
Uw = unit weight of water (62.4 lb/ft3)

Step 4 Select minimum riprap thickness required from grain size curves in Figures IV.3-1 through IV.3-6. Select from smaller side of band at 50% finer gradation.

Step 5 Select riprap gradations table (Figures IV.3-7 and IV.3-8) based on riprap thickness selected in Step 4.

Step 6 Select bedding thickness from grain size curves in Figures IV.3-1 through IV.3-6, which was used to select the riprap thickness in Step 4. Note: The bedding thicknesses included in Figures IV.3-1 through IV.3-6 are based on using a properly designed geotextile underneath the bedding. If a geotextile is not used, the bedding thickness must be increased to a minimum of 9 inches for 24 inch and 30 inch riprap and a minimum of 12 inches for the 36 inch riprap.

Step 7 To provide stability in the riprap layer the riprap gradations should meet the following criteria for GRADATION INDEX:

GRADATION INDEX: $[D_{85}/D_{50} + D_{50}/D_{15}] \leq 5.5$ **Equ(IV.3-5)**

where: D_{85}, D_{50}, and D_{15} are the riprap grain sizes (mm) of which 85%, 50%, and 15% respectively are finer by weight.

Step 8 To provide stability of the bedding layer the bedding should meet the following filter criteria with respect to the riprap:

$D_{15}/d_{85} < 5 < D_{15}/d_{15} < 40$

$D_{50}/d50 < 40$

where: D refers to riprap sizes, and d refers to bedding sizes, both in mm.

Step 9 The geotextile underneath the bedding should be designed as a filter to the soil.

Step 10 Typical riprap design sections are shown in Figures IV.3-9 and IV.3-10, from the USACE publication EM1110-2-160

Culvert Outfall Protection

The following procedure is used to design riprap from protection at culvert outfalls.

Step 1 Determine D_{50} size of riprap determined from:

$$D_{50} = \sqrt{V}/[1.8\sqrt{(2g(U_s-U_w)/U_w)}]$$

Step 2 Select riprap and bedding from Figures IV.3-1 through IV.3-6 using D_{50} from equation IV.3-4.

Step 3 Select gradations from tables in Figures IV.3-7 and IV.3-8.

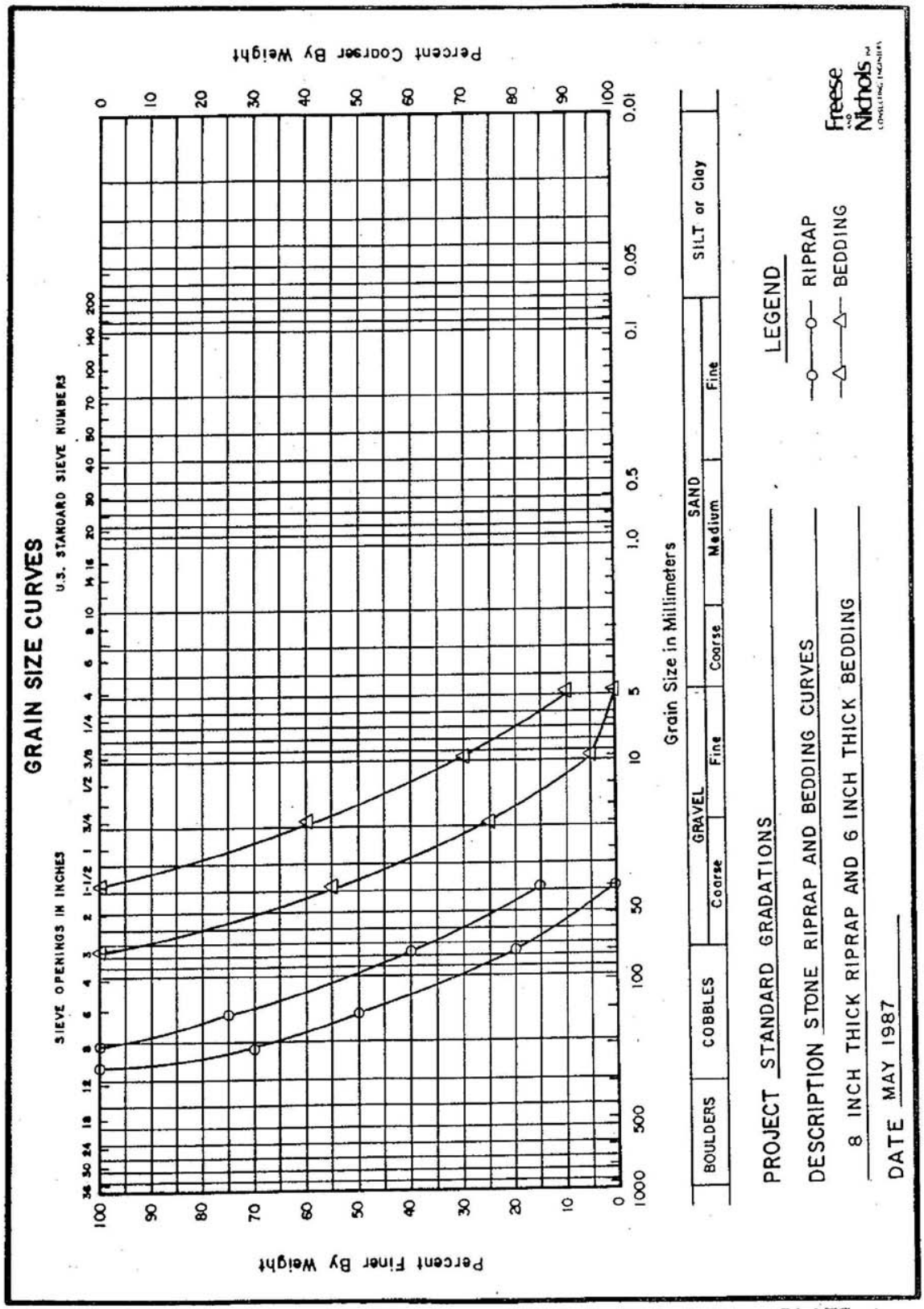


Fig IV.3-1 Grain Size Curve for 8” Riprap and 6” Bedding

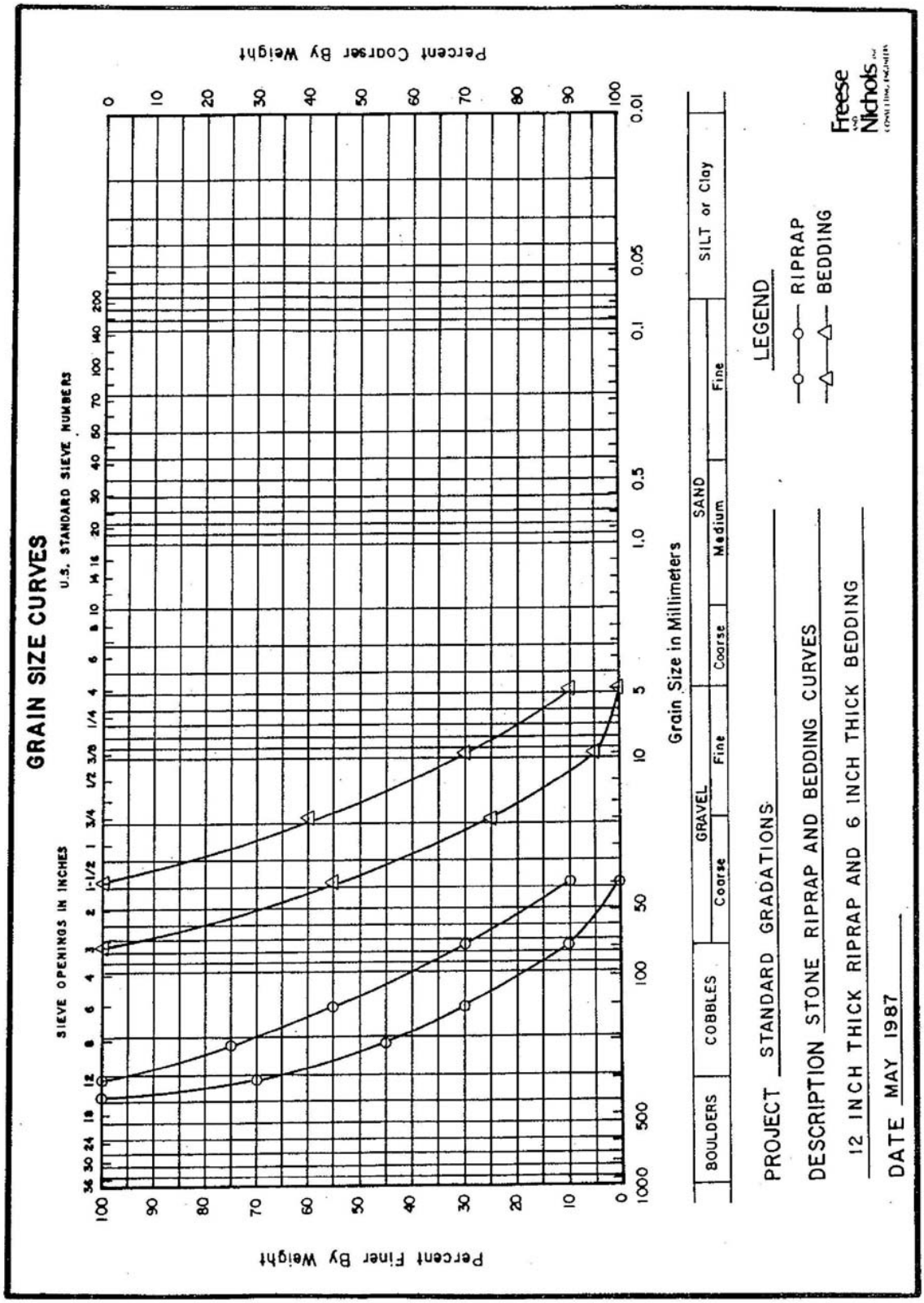


Fig IV.3-2 Grain Size Curve for 12” Riprap and 6” Bedding

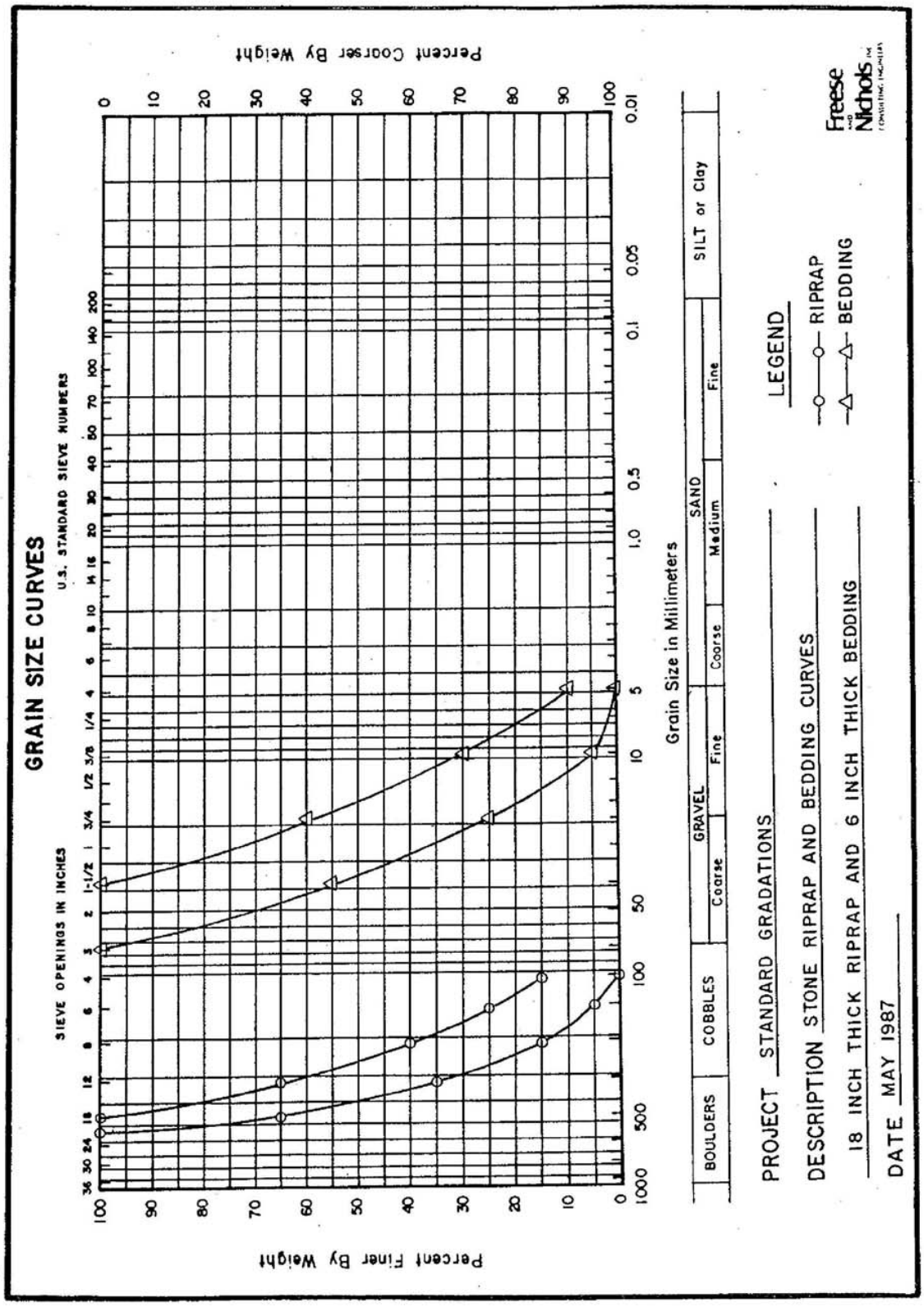


Fig IV.3-3 Grain Size Curve for 18" Riprap and 6" Bedding

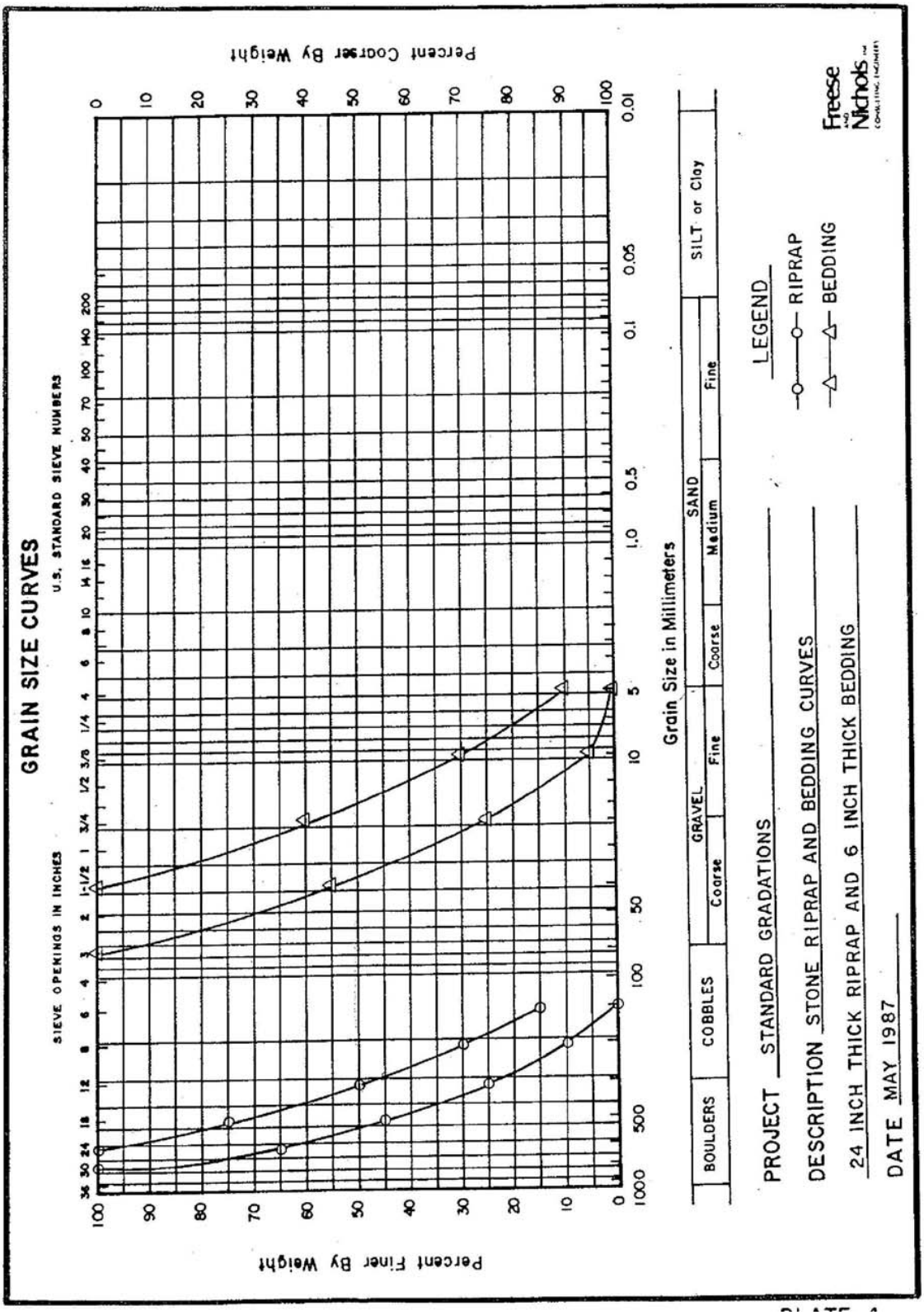


Fig IV.3-4 Grain Size Curve for 24" Riprap and 6" Bedding

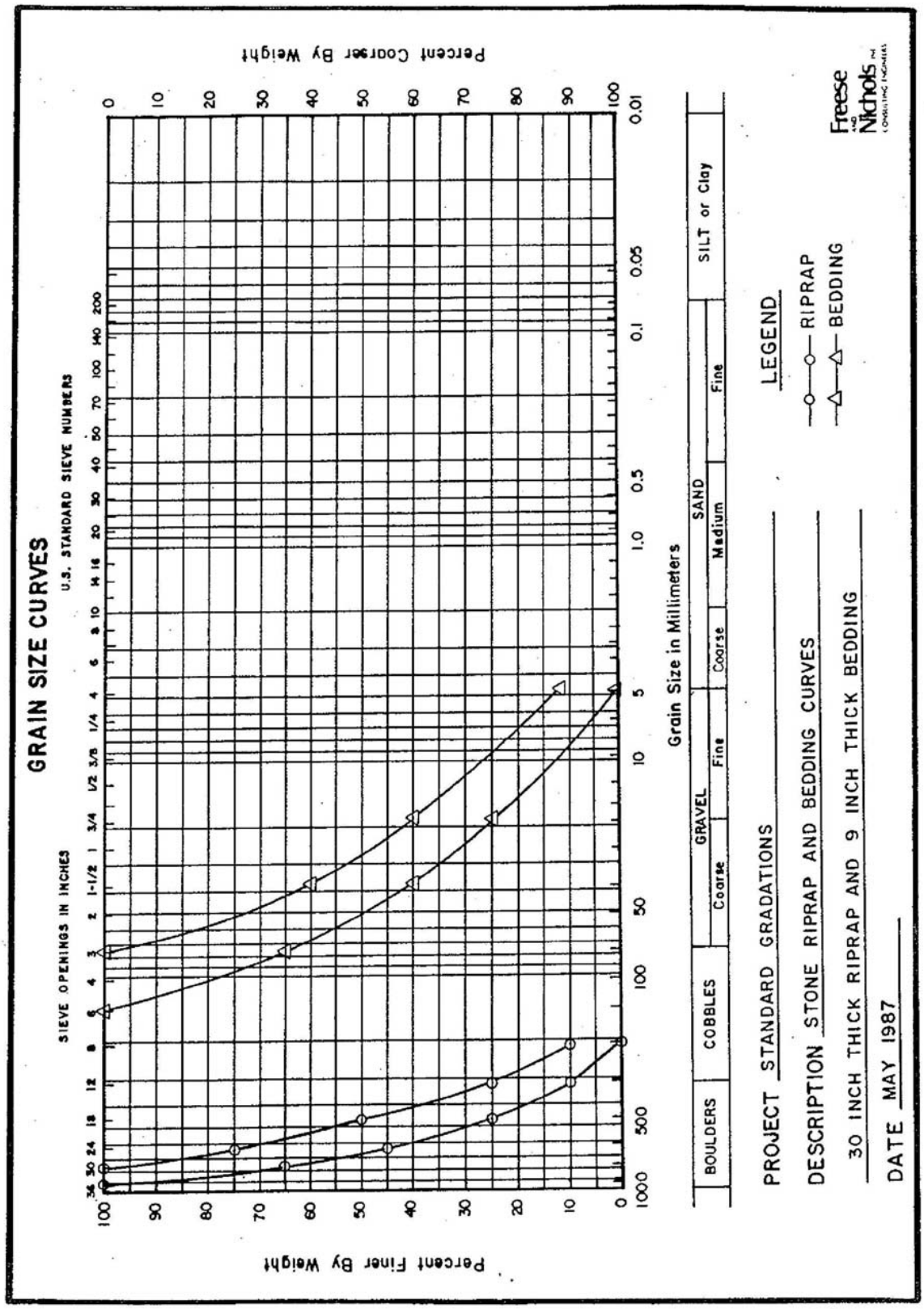


Fig IV.3-5 Grain Size Curve for 30" Riprap and 9" Bedding

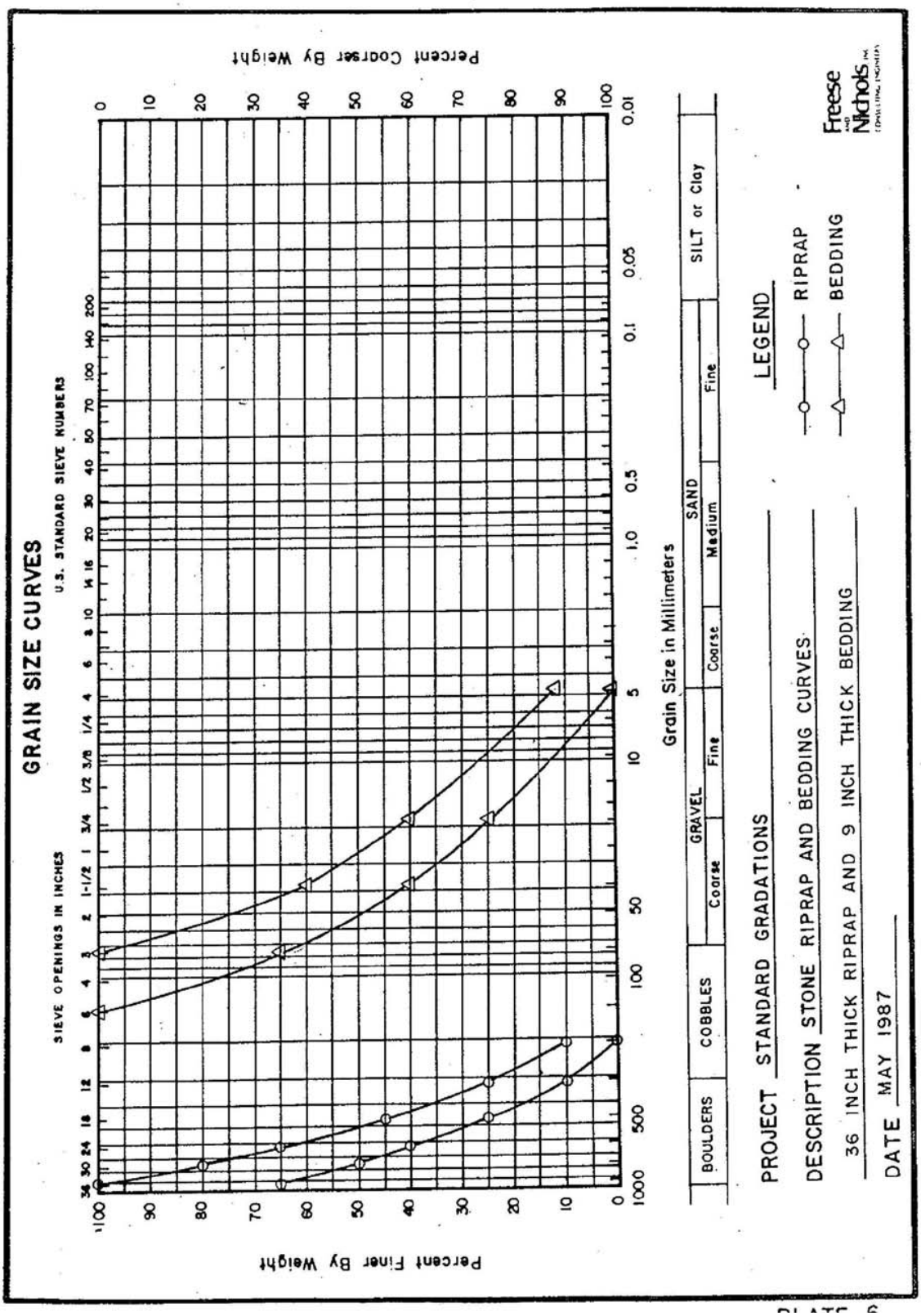
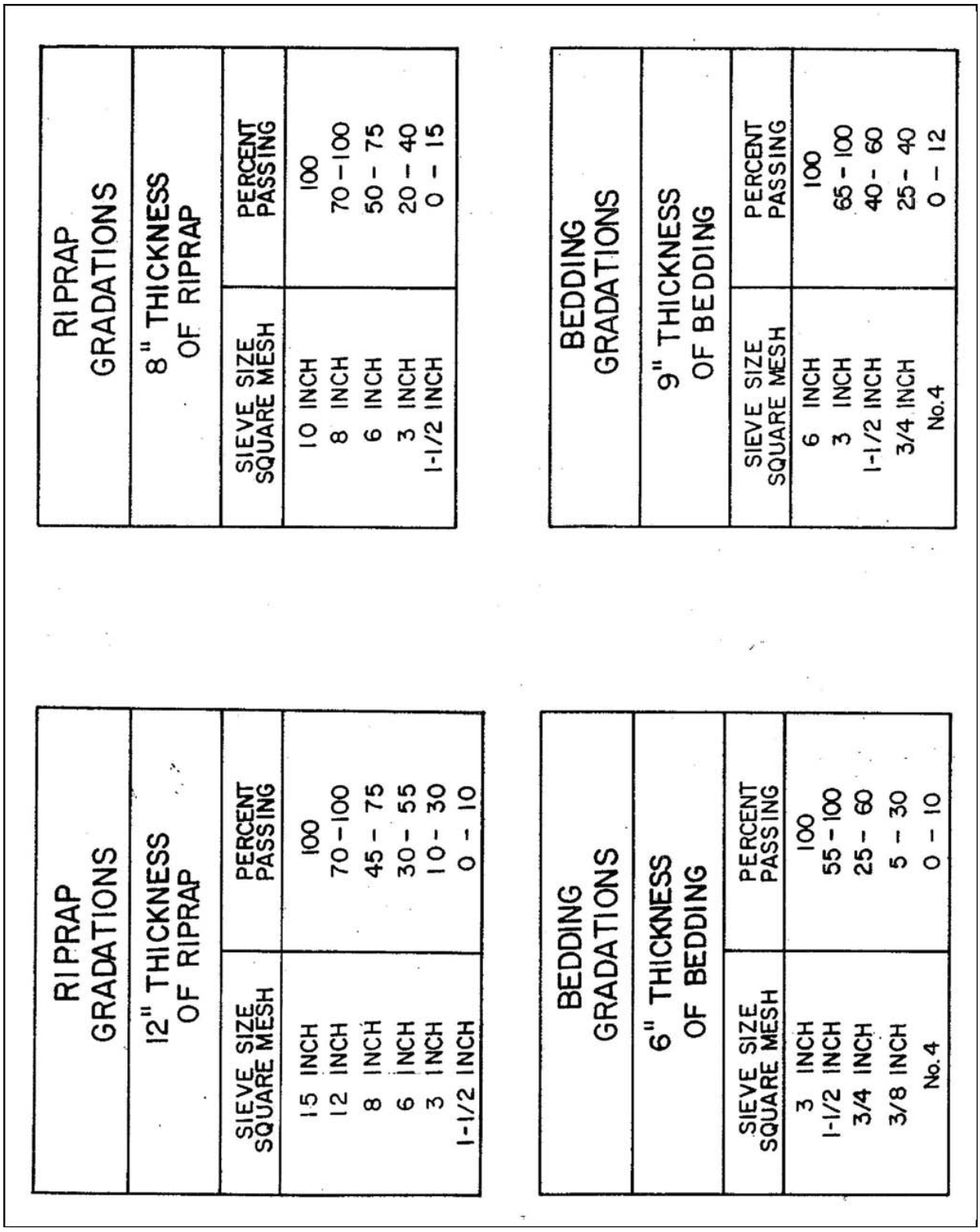


Fig IV.3-6 Grain Size Curve for 36" Riprap and 9" Bedding



RIPRAP GRADATIONS	
12" THICKNESS OF RIPRAP	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
15 INCH	100
12 INCH	70 – 100
8 INCH	45 – 75
6 INCH	30 – 55
3 INCH	10 – 30
1-1/2 INCH	0 – 10

BEDDING GRADATIONS	
6" THICKNESS OF BEDDING	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
3 INCH	100
1-1/2 INCH	55 – 100
3/4 INCH	25 – 60
3/8 INCH	5 – 30
No.4	0 – 10

RIPRAP GRADATIONS	
8" THICKNESS OF RIPRAP	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
10 INCH	100
8 INCH	70 – 100
6 INCH	50 – 75
3 INCH	20 – 40
1-1/2 INCH	0 – 15

BEDDING GRADATIONS	
9" THICKNESS OF BEDDING	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
6 INCH	100
3 INCH	65 – 100
1-1/2 INCH	40 – 60
3/4 INCH	25 – 40
No.4	0 – 12

Fig IV.3-7 Riprap Gradation Tables for 6”, 8”, 9”, and 12” Thickness of Riprap

RIPRAP GRADATIONS	
36" THICKNESS OF RIPRAP	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
44 INCH	100
36 INCH	65 – 100
30 INCH	50 – 80
18 INCH	25 – 45
12 INCH	10 – 25
8 INCH	0 – 10

RIPRAP GRADATIONS	
24" THICKNESS OF RIPRAP	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
30 INCH	100
24 INCH	65 – 100
18 INCH	45 – 75
12 INCH	25 – 50
8 INCH	10 – 30
6 INCH	0 – 15

RIPRAP GRADATIONS	
30" THICKNESS OF RIPRAP	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
36 INCH	100
30 INCH	65 – 100
24 INCH	45 – 75
18 INCH	25 – 50
12 INCH	10 – 25
8 INCH	0 – 10

RIPRAP GRADATIONS	
18" THICKNESS OF RIPRAP	
SIEVE SIZE SQUARE MESH	PERCENT PASSING
21 INCH	100
18 INCH	65 – 100
12 INCH	35 – 65
8 INCH	15 – 40
6 INCH	5 – 25
4 INCH	0 – 15

Fig IV.3-8 Riprap Gradation Tables for 18”, 24”, 30”, and 36” Thickness of Riprap

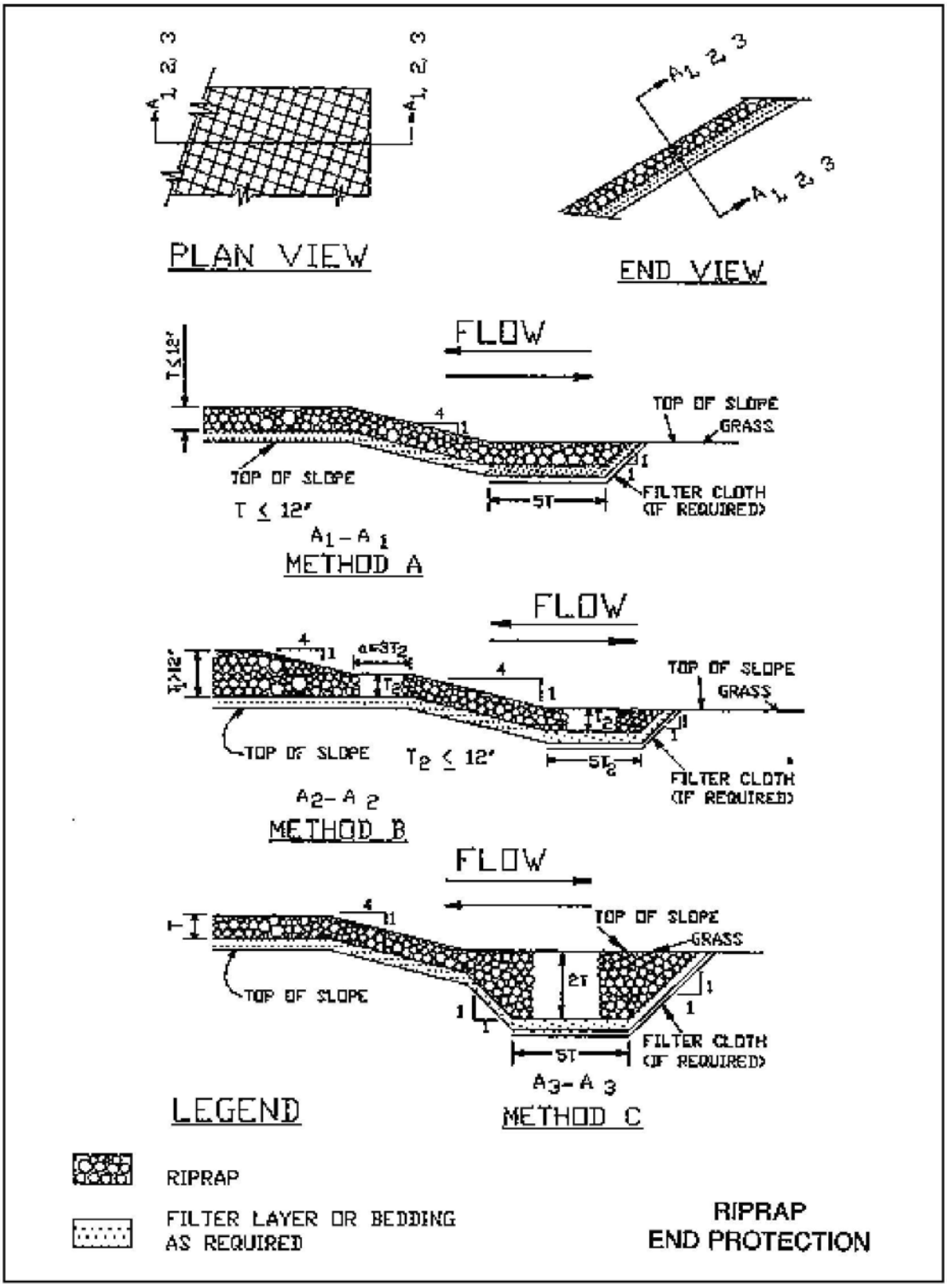


Fig IV.3-9 Typical Riprap Design Cross Sections

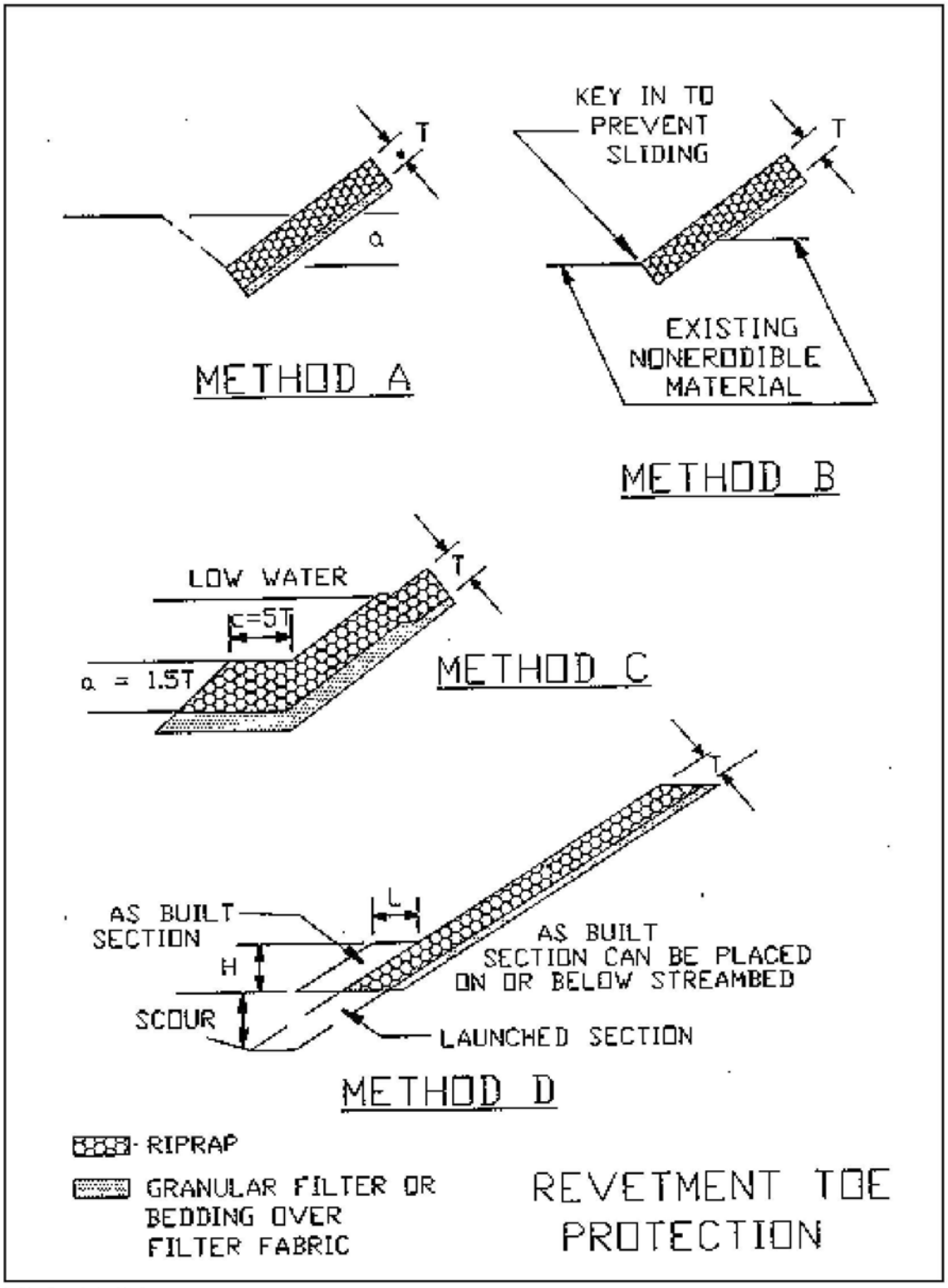


Fig IV.3-10 Typical Riprap Design for Revetment Toe Protection

IV.3.6 Rectangular, Triangular & Trapezoidal Open Channel Design

Open channels shall be designed using a computerized hydraulic backwater program. Acceptable programs include USACE HEC-2 and HEC-RAS. Other programs will be considered upon submittal of written request and documentation to the County Engineer.

IV.3.7 Energy Dissipation

Overview

Introduction

The outlets of pipes and lined channels are points of critical erosion potential. Storm water transported through man-made conveyance systems at design capacity generally reaches a velocity that exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at storm water outlets, protect the outlet structure and minimize the potential for downstream erosion, a flow transition structure is needed to absorb the initial impact of flow and reduce the speed of the flow to a non-erosive velocity.

Energy dissipaters are engineered devices such as rip-rap aprons or concrete baffles placed at the outlet of storm water conveyances for the purpose of reducing the velocity, energy and turbulence of the discharged flow.

General Criteria

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

Energy dissipaters shall be employed whenever the velocity of flows leaving a storm water management facility exceeds the erosion velocity of the downstream area channel system. Energy dissipater designs will vary based on discharge specifics and tailwater conditions.

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

Recommended Energy Dissipaters

For many designs, the following outlet protection devices and energy dissipaters provide sufficient protection at a reasonable cost:

- Riprap apron
- Riprap outlet basins
- Baffled outlets

- Grade Control Structures

This section focuses on the design of these measures. The reader is referred to the Federal Highway Administration Hydraulic Engineering Circular No. 14 entitled, Hydraulic Design of Energy Dissipaters for Culverts and Channels, for the design procedures of other energy dissipaters.

Symbols and Definitions

Table IV.3-10
Symbols and Definitions

Symbol	Definition	Units
A	Cross-sectional area	ft^2
D	Height of box culvert	ft
d_{50}	Size of riprap	ft
d_w	Culvert width	ft
Fr	Froude Number	-
g	Acceleration of gravity	ft/s^2
h_s	Depth of dissipater pool	ft
L	Length	ft
L_a	Riprap apron length	ft
L_B	Overall length of basin	ft
L_s	Length of dissipater pool	ft
Pl	Plasticity index	-
Q	Rate of discharge	ft^3/s
S_v	Saturated shear strength	lbs/in^2
t	Time of scour	min.
t_c	Critical tractive shear stress	lbs/in^2
TW	Tailwater depth	ft
V_L	Velocity L feet from brink	ft/s
V_o	Normal velocity at brink	ft/s

Table IV.3-10 Symbols and Definitions		
Symbol	Definition	Units
V_o	Outlet mean velocity	ft/s
V_s	Volume of dissipater pool	ft^2
W_o	Diameter or width of culvert	ft
W_s	Width of dissipater pool	ft
y_e	Hydraulic depth at brink	ft
y_o	Normal flow depth at brink	ft

Design Guidelines

If outlet protection is required, choose an appropriate type. Suggested outlet protection facilities and applicable flow conditions (based on Froude number and dissipation velocity) are described below:

a. Riprap aprons may be used when the outlet Froude number (Fr) is less than or equal to 2.5. In general, riprap aprons prove economical for transitions from culverts to overland sheet flow at terminal outlets, but may also be used for transitions from culvert sections to stable channel sections. Stability of the surface at the termination of the apron should be considered.

b. Riprap outlet basins may also be used when the outlet Fr is less than or equal to 2.5. They are generally used for transitions from culverts to stable channels. Since riprap outlet basins function by creating a hydraulic jump to dissipate energy, performance is impacted by tailwater conditions.

c. Baffled outlets have been used with outlet velocities up to 50 feet per second. Practical application typically requires an outlet Fr between 1 and 9. Baffled outlets may be used at both terminal outlet and channel outlet transitions. They function by dissipating energy through impact and turbulence and are not significantly affected by tailwater conditions.

When outlet protection facilities are selected, appropriate design flow conditions and site-specific factors affecting erosion and scour potential, construction cost, and long-term durability should be considered.

If outlet protection is not provided, energy dissipation will occur through formation of a local scourhole. A cutoff wall will be needed at the discharge outlet to prevent structural

undermining. The wall depth should be slightly greater than the computed scourhole depth, h_s. The scourhole should then be stabilized. If the scourhole is of such size that it will present maintenance, safety, or aesthetic problems, other outlet protection will be needed.

Evaluate the downstream channel stability and provide appropriate erosion protection if channel degradation is expected to occur.

V. WATER AND SEPTIC SYSTEM REQUIREMENTS

The owner(s) must submit a plan for providing utility service within the proposed subdivision. The proposed water supply should be clearly indicated, i.e. municipal water, rural water supply corporation, privately owned water system, individual well, etc., including location of fire hydrants, if any.

The plan for sewage disposal should be clearly indicated, ie. municipal sewer service, privately owned/organized sewage disposal system, private sewage facilities, etc. If it is the Owner's intent that each lot purchaser shall provide private sewage facilities, those faculties must meet the requirements of the Denton County Environmental Health Department.

Persons proposing residential subdivision, manufactured housing communities, multi-unit residential development, business parks, or other similar uses and utilizing On-site Sewage Facility's (OSSF) for sewage disposal must submit planning materials for these developments to the permitting authority. The planning materials must include and overall site plan, detailing the types of OSSF's to be considered and their compatibility with area wide drainage and ground water. A comprehensive drainage and 100-year floodplain impact plan must also be included in these planning materials. Planning materials shall also address potential replacement areas.

VI. STORM WATER POLLUTION PREVENTION PLAN (SW3P)

A site's Storm Water Pollution Plan shall govern the control measures necessary to prevent and control soil erosion, sedimentation, and water pollution which may degrade receiving waters including rivers. Streams, lakes, reservoirs, groundwater and wetlands. The control measures contained herein shall be installed and maintained throughout the construction contract, and coordinated with any permanent or temporary pollution control features specified elsewhere on the plans, and in the specification to assure effective and continuous water pollution control throughout the construction and post construction periods. These control measures shall not be used as a substitute for the permanent pollution controls may include silt fences, rock berms, diversion dikes, interceptor swales, sediment traps and basins, pipe slope drains, inlet protection, stabilized construction entrances, seeding, siding, mulching, soil retention blankets, or other structural or non-structural storm water pollution controls. Additional information regarding these controls can be found in NCTCOG's guidance manual entitled Storm

Water Quality Best Management Practices for Construction Activities – North Central Texas.

The Contractor is responsible for obtaining all permits required for Storm Water Pollution Prevention.

The construction plans must include a Storm Water Pollution Prevention Plan (SW3P). A copy of the plans, as approved by the Department of Public Works and any applicable permits must be available for review at the construction site.

Drainage ditches shall be seeded or sodden within 14 days of final grading.

All erosion control measures will be maintained in good working order. Disposal areas and stockpiles shall not be located in any wetland, waterbody, or streambed. The Contractor shall clean pave surfaces as necessary to remove sediment which has accumulated on the roadway.

Denton County reserves the right to inspect any construction site and request changes be made to a SW3P if the site is causing pollution to the environment.

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SECTION IX

CONSTRUCTION REQUIREMENTS

I. **Pre-Construction Meeting**: The Owner or Applicant and the Owner's engineer and constructor shall attend a pre-construction meeting which shall occur after approval of the Preliminary Plat and engineering plans by the Commissioners Court and before any construction of improvements begin. All matters on the Pre-Construction Checklist shall be discussed at said meeting. The Pre-Construction Checklist is attached as an Exhibit to these Regulations and is made a part hereof by reference.

II. **Beginning Construction**: Prior to beginning any construction within the subdivision, the owner shall contact in writing or by facsimile transmission, the Reviewing Engineer. No construction may commence prior to Preliminary Plat and plan approval and the completion of the Pre-Construction Meeting.

III. **Testing**: Testing is required to determine conformance to specifications and shall be performed by a qualified engineering laboratory. The following tests will be required:

A. Subsurface Investigation: A subsurface investigation to evaluate sub-grade characteristics, stabilization requirements, and pavement section thickness is required for a minimum 20 year life.

B. Materials: Pavement materials and mix designs shall be analyzed and evaluated for their suitability for pavement usage.

C. Construction: Materials, engineering testing and inspection services shall conform to Texas Council of Engineering Laboratories (TCEL) recommended scope of services.

1. Soil stabilization (lime & cement), flex- pavement compaction, and concrete testing shall be required for all pavements.

2. The cost of all testing shall be borne by the Owner/Developer of the subdivision.

3. After each phase of construction, certified elevations by Surveyor shall be taken for sub-grade, base, each course of asphalt pavement, and ditch/culvert flow line at one hundred foot (100′) station intervals to verify elevations. These shall be submitted to the Reviewing Engineer for verification prior to beginning construction of the next roadway item. The survey data shall be in a tabular form listing roadway station, proposed elevation, measured elevation and elevation difference. The maximum allowable tolerance for final grade of all plan items shall be 0.10 feet for pavement finished grade and 0.20 feet for ditch and culverts flowlines.

IV. **Project Completion**: Before the project improvements are accepted as complete, a final walk through and inspection shall be completed by the inspector. In all cases regardless of size, 75% grass coverage of all disturbed areas shall be required before the construction activities will be accepted. If the contractor is unable to obtain this coverage with a standard TxDOT winter/summer (rye/Bermuda) mix or by sodding the affected areas, a bond as set forth in Section VI, Subsection 19, 20 and 21, may be posted to insure compliance and conditioned upon reaching compliance with this subsection within 6 months of approval of said bond by Commissioners Court. If the grass has not achieved the 75% coverage over the affected areas the bond may be forfeited by the applicant. The bond shall be in the amount of 120% of $200 per disturbed acre.

EXHIBIT
PER-CONSTRUCTION
OWNER-CONTRACTOR AGREEMENT AND CHECKLIST

1. Owner/Developer will furnish the Reviewing Engineer with a minimum of three (3) sets of the approved construction plans for authorization and distribution to the respective parties at the preconstruction meeting.

2. Owner/Contractor will provide the Reviewing Engineer with a schedule of work to be done.

3. Owner will provide the Reviewing Engineer with a list of vendors where materials for the project will be purchased along with spec sheets showing test results for said materials.

4. Owner will furnish Reviewing Engineer with the name and telephone number of the project representative, contractor, job superintendent and a 24 hour emergency contact number. The Reviewing Engineer will provide the owner with name of the inspector assigned to the project. Before any testing is to be performed, this inspector must be personally notified 48 hours in advance.

5. Proper barricading, traffic control and erosion control will be the responsibility of the contractor in accordance with the plans and /or the minimum required of the Manual of Uniform Traffic Control Devices (MUTCD) For Streets and Highways as published by the U.S Department of Transportation and Federal Highway Administration. All items for each must be in place in accordance with the plans and specifications, prior to beginning any construction activities.

6. As each phase (utility, drainage, sub-grade and paving) of construction is completed, the developer or contractor shall notify the Reviewing Engineer in writing of its completion. **Phone correspondence shall not be sufficient notification under these regulations.**

7. After each phase of construction, certified elevations by a Surveyor shall be taken for sub-grade, base, and each course of asphalt pavement, and ditch/culvert flow-line at one hundred (100′) foot station intervals to verify elevations. These shall be submitted to the Reviewing Engineer for verification prior to beginning construction of the next roadway item. The survey data shall be in a tabular form listing roadway station, proposed elevation and elevation difference. The maximum allowable tolerance for final grade of all plan items shall be 0.10 for pavement finished grade and 0.20 feet for ditch and culvert flow-lines. After the inspection of each phase the Reviewing Engineer will give written notice of any deficiencies. If no deficiencies are found, written notification will be given to proceed with the next phase. In order to ascertain compliance with Denton County construction specifications, the Reviewing Engineer may require copies of test results performed by a certified testing laboratory. If the contractor proceeds without written notification, all work completed must be removed at the owners expense.

8. Upon completion of the final phase of construction, the Reviewing Engineer will perform a thorough walk through of the project and provide the owner / developer and contractor with a detailed final punch list of all deficiencies needed rectification prior to preliminary acceptance.

9. The contractor should be advised that 75% grass coverage of all disturbed areas shall be required before the construction activities will be accepted. If the contractor is unable to obtain this coverage with a standard TxDOT winter/ summer (rye/Bermuda) mix or by sodding the affected areas, a bond, as set forth in Section VI, Subsections 19, 20 and 21, may be posted to insure compliance and conditioned upon reaching compliance with this subsection within 6 months of approval of said bond by Commissioners Court. If the grass has not achieved the 75% coverage over the affected areas the bond may be forfeited by Commissioners Court. The bond shall be in the amount of 120% of $200 per disturbed acre.

10. Upon satisfactory completion of all phases and rectification of deficiencies and re-inspection, the Reviewing Engineer will issue to the owner/developer a written statement of preliminary acceptance of the construction. The data which will be considered the date for the official completion of construction, will be the date Commissioners Court approves the Final Plat.

11. After completion of construction and receipt of preliminary acceptance, the owner may submit a Final Plat.

12. Once a date completion is established, the owner will be responsible for all maintenance until final acceptance of the public improvements. The process shall commence upon the earlier of the sale and built-out of 60% of the Subdivision's lots or two years from the date of completion.

13. Upon notification of any deficiencies and re-inspection, the Reviewing Engineer will provide a recommendation to the Commissioners Court regarding final acceptance of the improvements by Denton County.

14. Upon Commissioners Court approval, the improvements will be accepted by Denton County for maintenance. Until that time, Denton County will not perform any maintenance work of any kind on the subject improvements.

_____

Signature (Owner)

_____

Signature (Contractor)

_____

Signature (Reviewing Engineer)

V. CONSTRUCTION AND MAINTENANCE BONDS

1. Construction Bonds

All construction shall be complete within 2 years after approval of preliminary plat. To insure roads, streets and required drainage and drainage structures are constructed in a timely manner, and in accordance with the terms and specifications contained in this Order, the developer shall file a Construction Bond, executed by a Surety Company authorized to do business in this State, and made payable to the County Judge of Denton County, Texas or his successor in office.

The bond amount shall be equal to one hundred percent of the estimated cost of construction including drainage structures.

The construction bond shall be presented to the Department of Public Works for submission to the Commissioners Court with the preliminary plat.

The construction bond shall remain in full force and in effect until all the roads, street and drainage and drainage structures in the subdivision have been completed to the satisfaction of the Department of Public Works and the construction bond has been released by a Court Order from the Commissioners' Court.

In the event any or all of the streets, roads, drainage and drainage structures as constructed by the Owner fail to meet the requirements of the foregoing specifications and the said Owner fails or refuses to correct the defects called to his attention in writing by the Department of Public Works, the unfinished improvements shall be completed at the cost and expense of obliges as provided.

2. Maintenance Bonds

To insure roads, streets, and required drainage and drainage structures are maintained to the satisfaction of the Department of Denton County Public Works, a maintenance bond executed by a Surety Company authorized to do business in this state, and made payable to the County Judge of Denton Count. Texas or his successor in office shall be substituted for the construction bond at the time of release of said construction bond.

The bond amount shall be equal to ten percent of the estimated cost of construction including drainage structures.

The conditions of the maintenance bond shall be that the Owner shall guarantee to maintain, to the satisfaction the Department of Public Works, all of the streets, roads, drainage structures and drainage ditches and channels which have been constructed to specification with construction security released by Court Order from Commissioners Court, in a good state of repair for a period of two years from the date of official release of construction security.

Periodical inspection of all the streets, roads, drainage and drainage structure for which maintenance security is held, will be made by the Department of Public Works during period of liability covered by the maintenance bond. In the event any or all of the streets, roads, drainage and drainage structures are not being maintained in a good state of repair, the Owner will be so advised in wiring and, if after a reasonable time, he fails or refuses to repair said items, they shall be maintained at the cost and expense of obliges as in said orders provided.

The release of any bond shall be by order of the Commissioners Court. To request a release the developer who posted the bond in question shall present a written request to release said bond. The request shall contain a statement by the Engineer responsible for the design of said work stating that he has made inspections of such improvements and recommends their acceptance by the County. Attached to his letter shall be one set of "as built" drawings and a diskette containing the "as built" plan sheets in the format and medium specified by the County showing the work to be accepted for use by the County.

3. **Final Inspection**

The Developer, upon completion of drainage, roads, streets and other facilities intended for the use of the public, or purchasers or owners of lots fronting or adjacent there to, shall request from the County a final inspection. The Precinct Commissioner or his designee will inspect the completed work for compliance. The Developer will be notified in writing of any work not found incompliance with Subdivision Regulations.

4. **Irrevocable Letter of Credit (In Lieu of Bond)**

An Irrevocable Letter of Credit may be submitted in lieu of bonds, for the purpose of insuring a developer's promise to construct and maintain the roads and drainage of facilities in a subdivision.

Irrevocable Letters Of Credit in lieu of Bonds are required under the same conditions as Construction and Maintenance Bonds and must be approved by Denton County's District Attorney and Commissioners Court.

VI. **FACILITIES AGREEMENTS**

The Subdivider shall be required to enter into an agreement with County which will govern his subdivision if there are off-site utility extensions, off-site street extensions and/or modifications, perimeter street construction and/or modifications, perimeter street rules responsibilities, pro-rata payments, escrow deposits, multiple phases to the project, construction schedule greater than one (1) year, or variances granted to the project. This agreement shall be based upon the requirements of this section and shall provide the County with specific authority to complete the improvements required in the agreement in the event of failure by the developer and to recover the full legal cost of such measures. The County may subordinate the facilities agreement to the prime lender if provided for in said agreement.

The facilities agreement shall be a legally binding agreement between the County and the developer specifying the individual and joint responsibilities of both the County and the developer. Unusual circumstances relating to the subdivision shall be considered in the facilities agreement such that the purpose of this Order best served for each particular subdivision. Such facilities agreements may stipulate pro-rata share agreements, escrow deposits or other payments for future facilities, variances granted to this Order and other particular aspects of the development. The developer shall include in such agreement a hold harmless indemnity clause agreeing to hold the County harmless against any claim rising out of this developer's subdivision or any actions taken therein.

The developer shall have a continuing responsibility under this facilities agreement after the filing of the final plat and until all facilities and improvements required under this facilities agreement have been completed. When construction of required improvements have proceeded to the point that certain parts of the subdivision are adequately served, the Commissioners Court may release specified portions of the subdivision prior to the completion of all improvements. This shall not be done if the release of such improvements would jeopardize or hinder the continued construction of required improvements, and the facilities agreement shall remain in force for portions of the subdivision for which a release has not been executed.

The facilities agreement shall be approved by the Commissioners Court and recorded in the Denton County Courthouse after the preliminary plat is approved.

SECTION X

SUBDIVISION PLAT CANCELLATION

A. A person owning real property in the County that has been subdivided into lots and blocks or into small subdivisions may apply to the Commissioners Court of the County in which the property is located for permission to cancel all or part of the subdivision, including a dedicated easement or roadway, or to reestablish the property as acreage tracts as it existed before the subdivision. If on the application, it is shown that the cancellation of all or part of the subdivision, or it is shown that the purchaser agrees to the cancellation, the Commissioners Court by order shall authorize the owner of the subdivision to file an instrument canceling the subdivision in whole or in part. The instrument must describe the subdivision or the part of it that is cancelled. The Commissioners Court shall enter the order in its minutes. After the cancellation instrument is filed and recorded in the deed records of the County, the County Tax Assessor-Collector shall assess the property as if it had never been subdivided.

B. The Commissioners Court shall publish notice of an application for cancellation. The notice must be published in a newspaper in the County, in the English language for at least three weeks before the date on which action is taken on the application. The Commissioners Court shall take action on an application at a regular term. The published notice must direct any person who is interested in the property and who wishes to protest cancellation to appear at the time specified in the notice.

C. If delinquent taxes are owed on the subdivision tract for any preceding year, and if the application to cancel the subdivision is granted as provided by this section, the owner of the tract may pay the delinquent taxes on an acreage basis as if the tract had not been subdivided. For the purpose of assessing the tract for a preceding year, the County Tax Assessor-Collector shall back-assess the tract on an acreage basis.

D. On application for cancellation of a subdivision or any phase or identifiable part of a subdivision, including a dedicated easement or roadway, by the owner of 75% of the property included in the subdivision, phase, or identifiable part, the Commissioners Court by order shall authorize the cancellation in the manner and after notice and hearing as provided by Subsections (a) and (b). However, if the owners of at least 10 percent of the property affected by the proposed cancellation file written objections to the cancellation with Court, the grant of an order of cancellation is in the discretion of the Commissioners Court.

E. To maintain an active to enjoin the cancellation or closing of a roadway or easement in a subdivision, a person must own a lot or part of the subdivision that:

    1. Abuts directly on the part of the roadway or easement to be cancelled or closed; or

    2. Is connected by the part of the roadway or easement to be cancelled or closed, by the most direct feasible route, to:

a. The nearest remaining public highway, county road, or access road to the public highway or county road; or

b. Any common amenity of the subdivision which has not been cancelled.

F. A person who appears before the Commissioners Court to protest the cancellation of all or part of a subdivision may maintain an action for damages against the person applying for the cancellation and may recover as damages an amount not to exceed the amount of the person's original purchase price for property in the canceled subdivision or part of the subdivision. The person must bring the action within one year after the date of the entry of the Commissioners Court order granting the cancellation.

SECTION XI

SUBDIVISION IMPROVEMENTS ACCEPTANCE PROCEDURE

GENERAL

All conditions of Preliminary Plat and engineer plans must be met. All construction must be in accordance with approved plans and construction standards set forth herein or as may be adopted by Commissioners Court.

PRELIMINARY ACCEPTANCE OF CONSTRUCTION

As each phase of the road, drainage and utility construction is completed, the developer shall notify the County Engineer or designee, in writing and pay the inspection fee for each required inspection.

The County Engineer, or his designee, shall then inspect the improvements and give written notice of any deficiencies. Should it be deemed necessary to ascertain compliance with county construction specifications, the County Engineer or his designee, may require copies of test results performed by a certified laboratory.

Upon rectification of deficiencies and re-inspection, the County Engineer or his designee, shall recommend to the Commissioners Court to issue a statement of preliminary acceptance of construction and to shall establish a date considered to be the date of completion of public improvements. The owner will be responsible for all maintenance until final acceptance of the roads by the Commissioners Court ("the maintenance period").

FINAL ACCEPTANCE OF CONSTRUCTION

No earlier than two years after the date of preliminary acceptance or the occurrence of the sale and completed construction of sixty percent (60%) of all platted lots within the subdivision, the County Engineer or his/her designee, shall inspect the improvements and notify the developer in writing of any deficiencies. Upon rectification of any deficiencies and re-inspection, the County Engineer his/her designee, shall recommend to Commissioners Court that improvements be accepted by Denton County.

Upon Commissioners Court approval, the improvements will be accepted by Denton County for maintenance purposes.

RECORD CONSTRUCTION PLANS

After the subdivision roads, streets and drainage improvements have been completed by the owners or sub-divider, one set of Mylar record construction plans of all underground utilities, street and drainage improvements that have been constructed shall be filed with the County Engineer, or his designee, prior to acceptance of the public improvements.

ACCEPTANCE OF ROADS FOR COUNTY MAINTENANCE

DENTON COUNTY PUBLIC WORKS EX OFFICIO ROAD COMMISSIONER RULES AND ROAD POLICIES

PREFACE

The Denton County Commissioners Court adopted the Ex Officio Road Commissioner system of road administration on May 25, 2003, in compliance with Texas Transportation Code Chapter 252, Subchapter A. All public roads and bridges in the unincorporated areas of Denton County which are determined by the Commissioners Court of Denton County to be County maintained roads ("County Roads") will be maintained by the Ex Officio Road Commissioners in compliance with Texas Transportation Code Chapters 251 and 252, these rules and the directions of the Denton County Commissioners Court.

ROAD POLICY
DIVISION OF PUBLIC WORKS RESPONSIBILITIES

1.1 Under the Ex Officio Road Commissioner System the Public Works Department of Denton County is divided into two separate divisions: Public Works/Planning and Public Works/Engineering.

A. With oversight by the Commissioners Court, the Director of Public Works/ Engineering shall supervise the operations of the Denton County Planning Division. Responsibilities of the Director to include:

1. Subdivision Plat Review.
2. Flood Plain Management.
3. Issuance of Development Permits.
4. Lake Ray Roberts Land Use Ordinance
5. Real Property Information System
6. Storm Water Management Plan
7. Master Plan Space Study / Buildings & Properties

B. With oversight by the Commissioners Court, the Director of Public Works/Engineering shall supervise the operations of the Denton County Engineering Division (Engineering Division). Responsibilities of the Director to include:

1. Engineering plan review and site inspection for Subdivisions in all County precincts.

2. Review of any SWPPP's, erosion control plans or engineering plans that are currently required or may become required for the Denton County Storm Water Program and Denton County Storm Water Policy.

3. Review of all CLOMR's, LOMR's or other engineering submittals required of the developers or entities that submit under the Floodplain Management Program.

4. Engineering design of all County Engineering Projects and Roadway Construction Projects.

5. Issuance of all County Utility construction permits.

6. Management of the Denton County BRINSAP Program with each Director of Public Works having input on those bridges that fall in their respective precincts.

1.2 The Ex Officio Road Commissioners shall oversee the day to day operations of the Road and Bridge Department as they pertain to all the county roads and bridges within each Commissioners' Precinct. Each Officio Road Commissioner shall:

A. Report to the Commissioners Court the condition of the roads in the Commissioners' precincts.

B. Report to Commissioners Court on the character of work to be done on the roads.

C. Direct the manner of grading, draining, and otherwise improving the roads:

1. Ex Officio Road Commissioners for Precincts Three and Four shall make work assignments through the Argyle Branch Road Maintenance Facility with the respective personnel, tools and equipment assigned thereto.

2. Ex Officio Road Commissioners for Precincts One and Two shall make work assignments through the Aubrey Branch Road Maintenance Facility with the respective personnel, tools and equipment assigned thereto.

ROAD POLICY
UPGRADING ROADS

2.1 Initiating Road Paving of Existing Gravel Roads

A. Each Ex Officio Commissioner may select existing unpaved County Roads for upgrade and reconstruction to a paved surface at any time in accordance with these rules. The cost of preparing deeds or easements, surveying work, and fence relocation shall be borne by the County. The Following criteria shall be used to set the priorities as to which County Road shall be selected for paving:

1. The following criteria shall be used to rank the paving order in which Road Projects shall be placed.
    a. 1st Priority
        1. The County Road is utilized as a school bus route;
        2. The County Road has a traffic court of 180 vehicles per day or greater;
        3. The County Road has an 80% or greater of its constituents willing to donate ROW.

    b. 2nd Priority
        1. Has a traffic count of 180 vehicles per day or greater;
        2. Has 80% or greater of its constituents willing to donate ROW.

    c. 3rd Priority
        1. Has 80% or greater of its constituents willing to donate ROW.

B. The adjacent property owners of an unpaved County Roads may request that the County pave the road. The Denton County Subdivisions Rules and Regulations shall set the standards for the proposed improvements. The request shall be made in writing to the Ex Officio Road Commissioner, in whose precinct the County Road is located, and shall be approved by Commissioners Court.

In order for the road to be eligible for paving, the adjacent property owners must do the following:

1. Donate to the County the funds needed to cover the cost of the materials to upgrade the subject road;

2. Donate the Right of Way (ROW) and easements determined to be required by the Engineering Division prior to the beginning of the project;

3. Bear the cost of preparing ROW deeds or easements, survey work and fence and utility relocation, when the utility companies are not required by law for such relocation; and

4. Make payment to the County Treasurer a sum of money, as determined by the Engineering Division, required to complete all elements of the project prior to the commencement of the project;

2.2 Right of Way Request and Road Qualification Process:

A. A County Road that is identified as potentially being able to meet the requirements of Section 2.1 A. or B., the Ex Officio Commissioner shall send a letter to the owners of property adjacent to the County Road requesting that they state their willingness to donate for the project. The minimum acceptable ROW width shall be 60 feet unless a greater width is needed to properly construct and maintain the road, or the minimum width is waived in accordance with Section 2.2 B. If ROW is donated, the form of a transfer of the right-of-way shall be agreed upon between the County and the Owner. If the ROW is purchased, the County shall seek title in fee for the ROW. If the ROW is taken through condemnation, title shall be taken as authorized by law.

B. The Ex Officio Commissioner may elect to waive the 60' minimum ROW width stipulated above, if any of the following conditions are met:

1. It is determined that additional ROW is not necessary for drainage purposes. In this case, it will not be necessary to convey the 100-year storm in the roadside ditches, but the paving of the roadway may not cause increased drainage problems, nor may significant drainage problems be ignored or left unremedied.

2. It is determined that there are significant trees lining the roadway that must be removed to accommodate the 60' minimum ROW requirement. This will particularly apply if the existing trees are primarily in the fence line, and their removal would eliminate the entire tree buffer between the roadway and the adjacent property (as opposed to a heavily wooded area where removal of trees along the ROW would leave a wooded buffer).

3. It is determined that the existing ROW is acceptable for safe roadside conditions, including adequate clear space from obstructions, reasonable ditch slopes, and acceptable sight distances.

4. Significant existing utilities will require relocation at the expense of the County in order to accommodate the minimum 60' ROW width.

5. The cost of acquisition of the remaining ROW (beyond the required ROW donation) exceeds the estimated cost of paving the roadway.

C If adjacent property owners of either 80% or more of the total lineal distance of the frontage on a county road or 80% of the residents along the road indicate a willingness to dedicate ROW, the project may proceed with approval of Commissioners Court. The purchase of the remaining 20% of the ROW may be negotiated with the owners with approval of Commissioners Court. If after the

negotiation to purchase the ROW an agreement cannot be reached, the remaining ROW may be obtained through condemnation proceedings, if approved by Commissioners Court. If the Commissioner Court does not approve condemnation proceedings, the project must be placed on hold.

D. If less than 80% are willing to dedicate the following three options are available:

1. The Ex Officio Road Commissioner may direct that additional letters be sent out and the request reasserted in an attempt to gain more positive responses.

2. The required ROW may be purchased from the adjacent property owners still unwilling to donate with approval of the Commissioners Court and under the direction of the Ex Officio Road Commissioner, provided funds are available.

3. If the requested ROW can not be obtained by donation or purchase from the owners, the Commissioners Court must authorize the initiation of any condemnation procedure.

2.3 Plan Preparation and ROW Acquisition Process:

A. Once a County Road is determined to meet the criteria and is prioritized for paving, the Engineering Division, with the prior approval of the Ex Officio Road Commissioner, will then make arrangements for preparation of legal descriptions of the existing ROW, the ROW to be acquired, topographic surveys and construction staking services.

B. After the surveys are complete the Engineering Division shall have construction plans prepared and will determine if additional easements beyond the 60-foot of ROW will be required for drainage improvements. All Engineering plans shall be prepared in accordance with the requirements and processes set forth in the Denton County Subdivision Rules and Regulations.

C The Ex Officio Road Commissioner shall cooperate with the Denton County District Attorney's Office Civil Division in the preparation of all ROW donation and condemnation documents.

D. The construction plans, the ROW donation, and/or condemnation documents shall be forwarded to the Ex Officio Road Commissioner once complete, for review. The documents pertaining to the parcels of land of owners that are willing to donate their ROW will then be sent out for execution. Condemnation proceedings will begin for the remainder of the parcels when such action is approved by the Commissioners Court.

E. Once all ROW has been obtained the Ex Officio Road Commissioner shall be responsible for the following:

1. The Ex Officio Road Commissioner may direct the Director of Public Works to:

    a. Oversee the day to day construction activities of the maintenance and construction crews from start of project to its finish.

    b. Ensure that the project is constructed in accordance with the plans and construction staking and ensure that the work meets all County policies and guidelines.

    c. Provide inspection services throughout the project and maintain copies of all material testing or density test reports.

    d. Inform the Engineering Division of any deficiencies cited in the test reports.

    e. Report all field changes to the Engineering Division for inclusion in as-built plan sets.

2. Under the direction of the Ex Officio Road Commissioner, the Engineering Division shall:

    a. Ensure that all erosion control measures are in place prior to the beginning of construction activities.

    b. Arrange all construction staking with the firm retained by the County for surveying services.

    c. Answer any questions pertaining to the plans and provide technical assistance throughout the project.

    d. Prepare as-built plans upon completion of construction activities.

    e. Ensure materials for Road Construction will conform to the most current TXDOT Standard Specifications.

    f. Receive input and final decision making from the Ex Officio Road Commissioners, provided these decisions are within policy.

ROAD POLICY FOR ACCEPTANCE OF PUBLIC ROADS IN A SUBDIVISION FOR MAINTENANCE BY DENTON COUNTY

3.1 Denton County can only maintain public roads in a subdivision when the following criteria have been met:

1. The roads have been dedicated to the public for public use by plat, re-plat or deed; and

2. The roads have been formally accepted for maintenance by the Denton County Commissioners Court. For purposes of this Policy, the term "county public road" refers to a public road that has been accepted for maintenance by Denton County.

Denton County cannot perform any construction or maintenance on private roads nor expend any public funds on private roads. Before a public road in a subdivision can be accepted as a county public road, there must be a written recommendation for this action to the Denton County Commissioners Court by the Ex Officio Road Commissioner for the Commissioner Precinct where the public road is located and from the County Engineer. Denton County can not perform any construction or maintenance on a public road until it has been accepted for maintenance by Denton County as a county public road as defined above.

There are two means by which a public road in a subdivision may be accepted as a county public road.

I. Acceptance under Texas Transportation Code Chapter 253

A public road in a subdivision may be accepted as a county public road when all of the requirements of Texas Transportation Code Chapter 253 have been met.

II. Alternative Acceptance Procedure

A public road in a subdivision may be accepted as a county public road by formal action of the Denton County Commissioners Court when all of the following requirements have been met:

A. The subdivision where the road is located must have been constructed prior to February 17, 2009. For purposes of this policy, the term "subdivision" is limited to subdivisions constructed prior to that date.

B. The road has been expressly dedicated to public use by a properly prepared and submitted plat, re-plat or deed to Denton County, Texas.

C. A person or entity requesting acceptance of the road as a county public road, hereinafter "the Applicant(s)," must submit an application to the Ex Officio Road Commissioner for the Commissioner Precinct in which the road is located. Any surveying, platting or legal expenses that are required in order for the road to be accepted as a county public road shall be borne by the Applicant. The Applicant is

also responsible for making all engineering, design and construction improvements to the road which are required in order to bring the road up to minimum County standards prior to the road being accepted for maintenance. Denton County shall not perform any construction or maintenance on the road until it meets minimum County standards and has been accepted for maintenance.

D. The Denton County Commissioners Court must make the following formal findings in a Court Order accepting a public road as a county public road:

1. A "significant public interest" exists that warrants acceptance of the public road as a county public road; and

2. Acceptance of the road as a county public road meets a "public purpose" in that it is necessary for the health, safety and welfare of the citizens of Denton County, Texas.

E. The road shall contain a minimum of at least sixty feet (60') of right-of-way expressly and unambiguously dedicated to public use and be clear of all obstructions in accordance with Denton County Subdivision Rules and Regulations § III(C)(1). The Denton County Commissioners Court may accept a road with less than sixty feet (60') of right-of-way only if the criteria set forth in Ex Officio Road Commissioner Policy § 2.2(B)(1)-(5) are met.

F. At least six inches (6") of suitable base material, regardless of paving surface, must be present on the road in the subdivision prior to acceptance as a county public road. This requirement is the "minimum county standard" for a public road to be accepted as a county public road.

G. When an application is submitted under this Policy, the County Engineer shall inspect the road and determine if there is any need for drainage improvements, utility relocation or any other changes or improvements that he deems appropriate (hereinafter "work"). The County Engineer shall report these findings to the Ex Officio Road Commissioner in the Commissioner Precinct in which the road is located and the Ex Officio Commissioner shall submit the report to the Denton County Commissioners Court as a part of the formal acceptance of the road as a county public road by the Commissioners Court. All engineering, technical or other professional services, labor, work, materials and any other costs required to meet County standards and any work deemed necessary by the County Engineer under this subsection to meet the minimum County standard shall be borne entirely by the Applicant(s) seeking to have the road accepted as a county public road, prior to acceptance of the road for maintenance as a county public road.

H. The County Engineer shall issue a written report summarizing his findings, including a description of the specific improvements that must be made by the Applicant(s) in

order to bring the substandard road to the minimum County standard as defined in subsection (F) and (G) above. The Applicant(s) then must bring the road to the minimum County standard before it can be accepted for maintenance as a county maintained road.

I. Once the road has been accepted for maintenance, Denton County shall only maintain the road to the minimum County standard as defined in subsection (F) of this policy. All upgrades of the road from the minimum County standard must be in accordance with the criteria set forth in Ex Officio Road Commissioner Policy §§ 2.1, 2.2 and 2.3.

J. If the road has a dead end, the road shall have sufficient dedicated right-of-way for construction and maintenance of a cul-de-sac in accordance with the Denton County Subdivision Rules and Regulations.

In reviewing an application submitted pursuant to Section II of this Policy (Alternative Acceptance Procedure), Denton County shall consider only the facts, circumstances and conditions available to the Denton County Commissioners Court at the time such application is heard. No acceptance or denial of any public road as a county public road shall be used as a basis of support or a reason for denial of any future application, and the acceptance or denial of any public road as a county public road shall not create or limit any rights of future applications hereunder. Each application shall be determined solely upon the merits of that application, the factors set out above, the judgment of the Ex Officio Road Commissioner and the formal action of the Denton County Commissioners Court.

Upon denial by Denton County of an application submitted pursuant to Section II of this Policy (Alternative Acceptance Procedure), an applicant shall not be eligible to re-apply for acceptance of a subdivision road as a county public road for at least one (1) calendar year from the date of denial by the Commissioners Court.

Rule Applicable to Roads Accepted Pursuant to this Policy (Either Method):

Acceptance of roads as county public roads pursuant to this Policy shall not obligate Denton County to upgrade road surfaces, routes, profiles or curvature other than that required for normal maintenance.

Revised By: Commissioners Court Date: 07/28/2009

ROAD POLICY
DUST CONTROL

4.1 The Commissioners Court of Denton County authorizes the expenditure of County funds to lay Recycled Asphalt Product (RAP) under the following conditions:

A. An Ex Officio Road Commissioner may direct the application of RAP with the following restrictions:

1. Dust control will cover 250 feet in each direction from the center of the place of residence of the person making the request.

2. Dust Control requests will only be honored if someone lives on the property and their primary residence is within 500 feet of the centerline of the road.

B. Under the direction of the Ex Officio Road Commissioner with the following stipulations:

1. Dust control will cover 250 feet in each direction from the center of the place of residence.

2. Dust Control requests will only be honored if someone lives on the property and their primary residence is within 500 feet of the centerline of the road.

3. An Ex Officio Road Commissioner may request up to 1.5 miles of roadway per fiscal year be covered in RAP.

ROAD POLICY
POSTING SPEED LIMITS & WEIGHT LIMITS

5.1 A public hearing is necessary for the posting of all regulatory road signs, i.e. speed limits and weight limits.

5.2 Advisory signs, such as curve signs and children playing signs, do not require a public hearing and shall be posted as needed by the Ex Officio Road Commissioner in accordance with the Texas Manual on Uniform Traffic Control Devices.

5.3 Roads are categorized as follows:

CATEGORY	DESIGNATION M.T.P.	SUGGESTED SPEED LIMIT
Dead End Local Subdivision Roads		30 M.P.H*
Local Subdivision Roads	RR 2	30 M.P.H.*
Collector/Paved	RC 2	45 M.P.H.
Collector/Unpaved	RC 2	35 M.P.H.
Arterial/Paved	RA 2	50 M.P.H.
Arterial/Unpaved	RA 2	45 M.P.H.

* A speed limit lower than 30 M.P.H. must be set by Commissioners Court Order after a public hearing and supported by an engineering and traffic investigation.

5.4 Weight limits on all county roads shall not exceed 25 tons (50,000 lb. Gross Weight).

5.5 Where there is a load posted bridge (BRINSAP) on a dead end road, the road limit shall not exceed the bridge load limit.

ROAD POLICY
TREE PRESERVATION & TREE TRIMMING

6.1 Intent

The intent of the Denton County Tree Trimming/Removal Policy is to preserve the natural resources of the trees and shrubs within the ROW, but recognizing the legal duty of the County to maintain its roads so as to provide for the safe use for all travelers.

6.2 Tree Removal

A. Trees that prevent the construction of drainage ditches, prevent sight distance per most recent TxDOT specifications, or that present a safety hazard for the travelers and users of Denton County roads shall be removed from ROW/easements.

B. In cases where additional ROW/easement is required (per approved Road Policy), trees may be removed to allow for road improvements.

6.3 Tree Trimming

A. Trees that remain in the ROW/easements will be trimmed back.

B. Property owners wishing to trim their own trees along the frontage of their property may do so with the following stipulations:

1. Trimming must be completed in no less than three (3) days from notification and must meet Denton County specifications.

2. Trees that are not trimmed to specifications and in the time allotted will be trimmed by Denton County.

ROAD POLICY
DRIVEWAY/CULVERT PERMIT
Rev. 4/1/08

7.1 Intent of Policy

Denton County approved a culvert policy in 1995 and revised it in 2003 to better control illegal and improperly sized culverts along County roads which often create safety and drainage problems. This policy allows the County to require uniformity and inspection of culverts to maintain proper drainage flows.

7.2 Application Procedures:

A. Culvert Permit Application – The Property Owner will complete the culvert permit application and pay the required fee. The property owner may not begin installation of the culvert until the application is approved by the Road & Bridge Precinct and the requirements of Sections 7.3 A, and 7.3 B are satisfied. If it is determined a culvert is to be constructed in a Flood Safety Hazard Zone, a Development Permit will also be required. The culvert permit will not be granted until the requirements set forth in the application have been met.

B. Sizing will be conducted by the Road & Bridge Precinct utilizing acceptable engineering practices and taking into consideration the constraints of ROW, extent of downstream grading required, finished floor elevation of proposed residential structures and existing structures, and the overall lay of the land for the best end result.

C. Culvert Permit – Once the requirements of the permit application have been met the Road & Bridge Precinct will issue a Culvert Permit (Exhibit A).

D. Double driveway permits are considered one location. However, both culverts must be completed prior to final acceptance.

7.3 Special Requirements and Conditions

A. The property Owner is responsible for placing a stake to mark the proposed location of the driveway/culvert. After the stake has been set the property owner/contractor is responsible for notifying the Road & Bridge Precinct so the location can be researched so proper sizing of the culvert may proceed. The culverts and/or safety ends are not allowed to cross property lines without a written agreement between both property owners.

B. Within 10 working days of this notification, the assigned Denton County Inspector shall provide the Property Owner with the size and number of culverts to be installed and shall place grade stakes at the culvert location site marking the new culvert centerline and the depth of cut or fill for the flow-line of the culvert ends. It is the

responsibility of the Property Owner to insure that his or her contractor install the culvert at those grades. Any culvert not place in accordance with the required grades will be removed and the applicant will be required to reinstall it at their own expense.

C. All culverts shall be corrugated steel only (CMP). The length shall in no case be less than 20 feet or more than 60 feet (not inclusive of the length of the safety ends). Driveways for gas well access may use reinforced concrete pipe (RCP).

D. The Owner is required to call 48 hours in advance for inspections during the following stages of the culvert installation process:

1. After the culvert has been laid at established grade and backfilled to a depth equal to half of the pipe diameter;

2. After the culvert safety ends (4:1 sloped ends) have been formed and are ready for inspection (reinforcing steel and form work are complete) per the County detail and the remaining backfill has been placed;

3. Once the culvert and safety ends are complete with all concrete poured and the site cleaned of form work and debris, the Property Owner shall call for a final inspection.

E. Septic Permits will not be issued until the final inspection has been approved by the Road & Bridge Precinct and the Culvert Permit issued.

F. "Temporary" driveway/culverts are not permitted on County Roads without permission being requested in writing and granted by the Road & Bridge Precinct.

7.4 Existing Culverts

Existing Culverts that are in good condition and that do not have any blockages or other restrictions will be allowed to remain in the "as-is" condition. Culverts over 24" in diameter and/or with a flow line depth of 3 feet or more below the edge of pavement will be required to have safety end treatments (SET's) installed in accordance with the culvert policy section 7.3. If the existing culvert does have safety ends a culvert permit will be issued without changes to the existing culvert.

Replacement of Existing Culverts: Culverts that are to be replaced due to re-grading of bar ditches and road repair issues by County forces will be sized appropriately and installed to an as good or better condition that of the original culvert. If the existing culvert is adequate and undamaged then the culvert can be reused and installed per the new specifications as adopted herein.

7.5 County Enforcement of Policy

A. As stated above in Section 7.3, culverts will not be approved and Septic Permits will not be issued until the final inspection has been approved by the Road & Bridge Precinct and a culvert permit has been issued.

B. If the culvert is not installed within 60 days from the date the application was approved, the application will expire, fees will not be reimbursed, and the property owner must reapply for a culvert permit. A one-time 60 day extension may be granted by the Road & Bridge Precinct when circumstances warrant.

C. Modifications after the permit has been approved and installation accepted will not be permitted and the property owner may be required to remove and replace the driveway/culvert at their own expense.

7.6 Permit Fees

A. Fees for the all culverts shall be $15.00

ROAD POLICY
UTILITY SPECIFICATIONS

8.1 Authority

The Denton County Commissioners Court hereby authorizes the Director of Public Works/Engineering to review and approve utility requests.

8.2 An application for development permit must be completed with the Department of Public Works/Planning. With this application a written request detailing the utility installation and specific location must be submitted first to the Department of Public Works/Planning and then forwarded to the Department of Public Works/Engineering. A schematic of the proposed installation is required along with a profile view of the bore if applicable to your request. Please include with your request, a map outlining the county road in which the utility will be located.

8.3 Specifications for utility installations within County ROW are set forth from the Texas Practice, County and Special District Law Section 40.14 Utility lines.

8.4 Authorization for utility installation is also based on the requesting company adhering to the policies stated in the Denton County Subdivision Rules and Regulations," Utility Installation Specifications."

8.5 Traffic control devices i.e. signs, cones, etc. must be used when work is being performed in the count ROW.

8.6 All utility lines shall be installed as near as practical to the outside limits of the County road ROW. This is also to include above ground installation and the setting of utility poles. No ditching machinery shall be operated upon the crown of any roadway unless specifically permitted.

8.7 All utility lines shall be buried at a depth of not less than forty two (42) inches from the lowest point of a minimum design bar ditch depth of thirty (30) inches at top of conduit below the existing grade line of the area of installation.

8.8 All utility lines crossing a county road **shall be bored and encased with a minimum schedule 40 steel and the ends shall be sealed with end caps** . On gravel roads an open cut trench will be permitted, the utility line **shall be encased with minimum schedule 40 steel**. All boring shall be inspected by the assigned Department Inspector prior to being back filled/covered.

8.9 At all points where excavations and boring are made in public ROW, the applicant will replace and recompact the subgrade and will restore the road way section to the same or better condition as existed prior to the excavation and bore.

8.10 The applicant will remove and relocate its utility lines should it become necessary in order to accommodate widening, realigning, and/or improving County roads at no cost to Denton County.

8.11 The applicant shall, from the commencement of the installation of utility lines and thereafter for a period of twelve (12) months from the date the installation is completed and accepted, assume all responsibility for damages resulting to the landowner to any other person caused by the installation of the utility lines and shall hold Denton County harmless from any obligation or claim or damages that may be alleged or result from such utility construction or operation. Applicant agrees to indemnify Denton County for any costs or expenses including, but not limited to, reasonable attorney's fees, which Denton County may be legally required to pay, resulting from damages caused by the installation. The indemnity by the applicant shall cover claims occurring during the twelve (12) month period. The applicant shall also reimburse Denton County for its costs and expenses in repairing a cut bore during the twelve (12) month period, when the applicant cannot repair same, and, in the judgment of the Commissioner of the Precinct wherein the road is located, the cut or bore must be immediately repaired, or when the applicant has been requested to repair same and either refuses or fails to repair same within three days from the date of the requested repair.

8.12 A copy of the applicant's Letter of Approval must be on location at each job site at all times.

8.13 Before commencing any work on County roads or County ROW under the authority of this Letter of Approval or by any other claimed authority (including such work as trimming and/or cutting trees, and/or ROW, etc.), the applicant Company shall notify the Department of Public Works/Engineering of the approximate time that work will commence, which notice shall be at least forty-eight (48) hours prior to commencing said work.

8.14 Should Commissioners Court find it necessary to employ an inspector or inspectors to enforce these provisions, a charge will be made by the County to the applicant to pay the costs of, or a portion of the costs of, employing said inspector or inspectors.

8.15 The contractor is required to coordinate the subject installation with the Department of Public Works/Engineering (940-349-3250), at least forty-eight (48) hours prior to beginning any construction. All boring shall be inspected by the County prior to being back filled/covered. Also, after completion of installation, notification must be given to the Department of Public Works/Engineering for final inspection.

8.16 Upon the request of any utility company the Department of Public Works/Engineering will provide the utility requirements outlined in this section of the Road Policy in the form of the "Utility Request Specifications" document attached to this policy as exhibit "B". This document will be updated as necessary to reflect future changes in the Road Policy.

CULVERT PERMITS

The County retains authority during the maintenance period to require owners and purchasers of lots to make application for and acquire a driveway culvert permit prior to the construction, installation or placement of any driveway access improvements within the right-of-way dedicated to the County. The following statement must appear on the face of each Final Plat to which this section applies.

A driveway culvert permit must be obtained, from the Denton County Road and Bridge Department, by the owner of each lot prior to the construction, installation, or placement of any driveway access improvements within the dedicated right-of-way.

SECTION XII

VARIANCES

VARIANCES GRANTED

Variances may be granted by the Commissioners Court upon recommendation from the DSC.

A. A variance may be granted when the Commissioners Court finds:

1. That there are special circumstances or conditions applying to the land or building for which the variance is sought, circumstances or conditions are peculiar to such land or building and do not apply generally to land or building in the same district or neighborhood, and that said circumstances or conditions are such that the strict application of the provisions of these Rules and Regulations would deprive the applicant of the reasonable use of such land or building; and

2. The granting of such variance will not be detrimental to the public welfare or injurious to the property or improvements in such district or neighborhood in which the property is located; and

3. The granting of the variance is necessary for the reasonable use of the land or building and that the variance as granted by the Court is the minimum variance that will accomplish this propose; and

4. The literal enforcement and strict application of the provisions of these Rules and Regulations will result in an unnecessary hardship inconsistent with the general provision and intent of these Rules and Regulations and that in granting such variance the spirit of these Rules and Regulations will be preserved and substantial justice done.

B. In granting any variance under the provisions of this section, the Commissioners Court may designate such conditions in connection therewith which, in its opinion, will substantially secure the purpose and intent of these Rules and Regulations.

C. The Commissioners Court may permit such variance where the literal enforcement of these provisions would result in an unnecessary hardship, and where such variance is necessary to permit a specific parcel of land which differs from other parcels of land in the same district by such restricted area, shape or slope that it cannot be developed in a manner commensurate with the development permitted upon other parcels of land in the same district.

D. A variation from the standards established by these Rules and Regulations shall not be granted to relieve a self-created or personal hardship, nor for financial reason only, nor shall such modification be granted to permit any person a privilege in developing a parcel of land not permitted by these Rules and Regulations to other parcels of land in the district.

SECTION XIII

ENFORCEMENT

A. **COMMISSIONERS COURT AUTHORITY:** The Commissioners Court of Denton County shall have the authority to refuse to approve and authorize any map or plat of any such subdivision, unless such map or plat meets the requirements as set forth in these Subdivision Rules and Regulations.

B. **REQUEST FOR PROSECUTION**: At the request of the Commissioners Court of Denton County, the Criminal District Attorney or other prosecuting attorney representing the County may file an action in a court of competent jurisdiction to:

1. Enjoin the violation or threatened violation of a requirement established by or adopted under these Rules and Regulations; or

2. Recover damages in an amount adequate for the County to undertake any construction or other activity necessary to bring about compliance with a requirement established by or adopted under these Rules and Regulations.

3. A person commits an offense if the person knowingly or intentionally violates a requirement established by or adopted under this Act by the Commissioners Court. An offense under this subsection is a Class B misdemeanor.

4. A requirement that was established by or adopted under Chapter 435, Acts of the 55th Legislature, Regular Session, 1957, as amended (Article 6626a, Vernon's Texas Civil Statutes), or Chapter 151, Acts of the 52nd Legislature, Regular Session, 1951 (Article 2372k, Vernon's Texas Civil Statutes), before September 1, 1983, and that, after that date, continues to apply to a subdivision of land is enforceable under subsection (a). Knowing or international violation of these requirements are an offense under subsection (c).

SECTION XIV

SEVERABILITY

If any provision of these Rules and Regulations or the application thereof to any person or circumstances is held valid, the validity of the remainder of the Rules and Regulations and the application thereof to other persons and circumstances shall not be affected.

APPROVED this the _____ day of _____, _____

_____
Denton County Judge

_____
Commissioner Precinct No. 1

_____
Commissioner Precinct No. 2

_____
Commissioner Precinct No. 3

_____
Commissioner Precinct No. 4

ENGINEERING PLANS CHECKLIST

DENTON COUNTY SUBDIVISION RULES AND REGULATIONS

(Below are some of the highlighted items to be addressed when preparing engineering plans for developments in Denton County. The entire manual must be referenced for the complete approval of plans. When submitting plans, please include this checklist with all items verified if certain items do not apply, a written explanation is needed on the reason.)

1. Floodway and floodplain encroachments must be in accordance with FEMA regulations. Construction will not begin until FEMA has given approval.

2. Plans must conform to AASHTO and ITE standards. Transportation and geotechnical engineers must design the geometric alignments, roadway width and roadway depths based on these national standards. These types of engineers shall design the road section base on projected traffic and soil conditions to comply with the performance criteria. A 20 year life should be planned for both development and perimeter roads.

3. A grading plan should be submitted to cover all areas in which soils will be disturbed on the entire site. Finish floor and pad elevations should be included. Lots 1 acre and smaller should not drain on each other.

4. Paving and drainage plan and profiles should be 1 inch = 40 ft. horizontal and 1 inch = 4 f vertical. Site plans and grading plans shall be 1 inch = 30 ft or less. The drainage plan/map shall be 1 in = 200 ft unless otherwise addressed by the Subdivision Rules and Regulations (SRR). The following plans should be included or addressed: On and Offsite Drainage Plan, Paving and Drainage Plan-and-Profile, Storm Water Detention Plan, Erosion Control Plan, Traffic Control Plan and Detail Sheets.

5. Perimeter paving and drainage should be addressed for existing county roads also using AASHTO and ITE standards. Traffic studies should be used for the design of the impact of the new development.

6. Driveway culverts must be CMP; cross-culvert must be RCP. Additionally the proposed locations and elevations of the culverts must be shown in plan-and-profile view of the Paving and Drainage Plan and Profile Sheets.

7. For the open drainage channel section, the side slopes should be 4:1. The maximum permitted mean velocity in the channel shall be in accordance with those specified in the SRR. Provide plan and profile sheets as well as cross-sectional drawings for the actual elevations on each of these.

8. No utilities should be placed in the right-of-way. All extra- width ditches should be totally contained in an expanded right-of-way or in the drainage and utility easement with fences placed on the easement lines.

9. Including any permits required from TxDOT, TCEQ, EPA, etc. The TxDOT permit should include any work connecting to a state highway. TCEQ and EPA permits should address the Storm Water Pollution Prevention Plan.

10. Show drainage channels and their easements carrying water off-site on plan profile sheets.

11. Provide the following chart near the roadway cross-section on the plans concerning sub grade/density control.

Description	**Density Percent**	**Moisture**
Non-swelling soils with Plasticity Index less than 20	Not less than 98	
Swelling soils with Plasticity Index of 20 to 35	Not less than 98 nor more than 102	Not less than optimum
Swelling soils with Plasticity Index greater than 35	Not less than 95 nor more than 100	Not less than optimum

12. Drainage channels and their easements should not be split by lot lines.

13. Provide detail sheets for single and multiple culvert installation, headwalls, utility line embedment, etc. Specify safety-end-treatments for driveway culverts.

14. Testing of the sub-grade, base and HMA and/or concrete should be provided by qualified engineering laboratory.

15. Benchmarks should be noted on the plans. There should be at least two (2) benchmarks provided in the development itself. A total of one benchmark shall be placed for each 20 acres of site area.

16. A note on the plans should be provided stating the developer's engineer or surveyor will verify controlling alignments and elevations during and after construction.

17. A note on the plans should be provided stating these are construction plans with as-built to follow after completion.

18. A note on the plans should be provided stating a superintendent or foreman is required on the development at all times while construction is ongoing.

19. Provide the following note the plans: The governing technical specifications for construction in Denton County will be the latest edition of TxDOT Standard Specifications for Construction of Highways, Streets and Bridges, plus any other TxDot specifications

referenced therein and the North Central Texas Council of Governments Public Works Manual, latest edition.

20. Provide a quantity takeoff sheet.

21. Traffic control and street signs should be denoted in the plans.

22. Provide an erosion control and seeding plan for this project as per the SRR.

23. Include street cross-section every one hundred (100′) feet. These cross-sections should maintain 4:1 front and back slopes. If 4:1 is not possible in a sixty (60′) foot right-of-way, the right-of way may need to be extended or the slopes can be extended into the drainage and utility easements with fences on the easement lines, not on the right-of-way line.

24. Provide all utility line plan-and-profiles in these plans. Provide a note on the plans specifying boring with schedule forty (40) steel (min.) casing for all underground utilities at road crossing with at lease forty two (42″) inches of cover.

25. Include plans for detention on any extra amount of runoff in a pre-developed vs. post-developed situation. Analysis and calculations should be provided supporting the theory if detention is or isn't needed. Design should be based on 2, 5, 10, 25, 50 and 100 year release rates with zero impact on neighboring properties.

26. Provide an MUTCD Traffic Control Plan for work at the intersection of existing and proposed roads and perimeter improvements.

27. Provide a note on the plat and engineering plans where the County will not maintain drainage channels going off-site from the right-of-way nor detention ponds in the development. However associations should be held responsible for these areas.

28. Provide a Preliminary Plat in the engineering plans.

29. Provide a general notes sheet.

30. Provide two culvert sizes when two streets front two sizes of a lot.

31. Where multiple culverts are used in driveways, a flat bottom ditch should be used.

32. Show contour numbers on drainage maps.

33. Provide sizing for driveway culverts on all lots. Culverts should be at least twenty (20′) feet in length and fifteen (15″) inches in diameter.

34. Show on the profile the depth of the ditches remembering you need to allow for at least six (6″) inches of cover to be placed above all new culverts below the lowest bank of the ditch

on the driveway and cross culverts using a 100 year design storm frequency on both the culvert and roadside ditch.

35. Safety ends or headwalls shall be constructed at the ends of all crossing culverts to protect the embankment from erosion and culvert displacement. The safety ends or headwalls shall be constructed in accordance with TxDOT standards as required by the physical conditions of the particular installations. Rock rip-rap or other suitable erosion control may be required at each location as supplement protection.

36. Denote drainage and utility easements on all plan sheets.

37. Show cross-sections of all utility lines and culverts and how they are to be installed and compacted.

38. If the development is in an ETJ, the city may have to approve the engineering plans. If they do, they must approve these plans before the County will review.

39. All work should be submitted in standard roadway and drainage study format (8½″x 11″ report form) with work done on 24″x36″ sheets.

40. Include engineering and inspection fees as follows:

    - Engineering review fees – 2% of total construction costs for project. (Not including water and sewer utilities construction costs).
    - Inspection fees – 3% of total construction costs for project (Not including water and sewer utility construction costs).

41. An additional entrance may be required into the subdivision in order to provide for the public safety.

42. Please show hydraulic information including backwater effects in all profiles.

43. Provide a cost estimate for the project fee calculation purposes.

44. Provide a North Arrow indicating the direction of north on all plan sheets.

45. Note that minimum grade for all ditches and channels shall be 0.50%.

46. All streets extending further than one thousand (1,000) feet shall provide an emergency vehicle turn-around at least every one thousand (1,000) feet.

47. All stationing shall begin at an intersecting roadway centerline.

48. Station and elevation references shall be provided on plan and profile sheets at PT's, PC's, PI's centerline intersections, VPT's VPC's, VPI's culvert crossings and other locations deemed necessary.

49. Station and elevation shall be provided at the bottom of each profile at each one hundred (100) feet station mark.

50. Roadside ditches shall maintain thirty (30) inches of depth or greater.

51. Provide a scale for all plan sheets.

52. A Mass Grading Plan shall be included in the engineering plan set for all roads and drainage improvements when large areas of cut or fill shall be constructed and that fall outside the right-of-way lines of new roads or over lot lines.

53. Place a note on the general notes sheets stating all roads shall be designed and constructed according to the specifications required in the SRR and subject to inspection as required by Section IX, Construction Requirements in the SRR.

54. Place a note on the general notes sheet stating all street signs, posts and mounting hardware shall be furnished by the developer, applicant or owners (at his or hers expense).

55. All cul-de-sacs shall provide access to all lots, and a turn-around shall be provided at the closed end, with an outside right-of- way radius of at least fifty (50) feet and an outside edge of pavement radius of at least forty (40) feet.

56. Provide dimensions of all roadside ditches and channels in plan view.

57. Provide a note on the general notes sheet stating 75% grass coverage must be obtained prior to the acceptance of construction by Denton County

58. For concrete lined channel sections and rip-rap lines channel sections the paved slopes shall be 2:1 max.

59. Provide a note on the general notes sheet stating drainage easements adjusted to roadways may not be fenced and must be left clear so that access can be obtained for maintenance purposes.

Applicant	Development Engineer	Director of Public Works/Engineering
_____	_____	_____
Sign/Date	Sign/Date	Sign/Date

ATTACHMENTS

DENTON COUNTY PLANNING DEPARTMENT
EXTRA TERRITORIAL JURISDICTION (ETJ) AFFIDAVIT

I_____ DO HEREBY SWEAR OR AFFIRM THAT THE

PROPERTY WITHIN THE_____

SUBDIVISION IS, TO MY KNOWLEDGE:

WITHIN THE TERRITORIAL JURISDICTION OF _____
(CITY NAME)

NOT WITHIN THE EXTRA TERRITORIAL JURISDICTION OF ANY CITY.

SWORDN TO AND SUBSCRIBED BEFORE ME THIS_____DAY OF _____, _____.

NOTARY PUBLIC, _____COUNTY TEXAS.