Engineering Design Manual

City of Boerne, Texas

Adopted April 11, 2023
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<td>07/27/21</td>
<td>Revisions made to the Manual include, but are not limited to, the following:</td>
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<td></td>
<td>1.7.6: Updated development categories from 3 to 4 for stormwater reports</td>
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<td></td>
<td>2.1.14(3)(a): Updated horizontal curve radius from 250’ to 300’ for determination of street change in direction</td>
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<td>2.7: Updated language for waiving requirements for streetlights in Camp Bullis Dark Skies Zone</td>
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<td>2.11.10(A): Updated left turn lane length from speed limit based to street classification based</td>
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<td>2.11.10(D): Added language for maximum cross slope of medians</td>
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<td>3.2.1(8): Added subgrade verification letter requirement</td>
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<td>5.3.1(C): Updated language for detention pond volume requirements</td>
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<td>5.4: Added language for depth of discharge to streets and Drainage crossing sidewalks</td>
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<td>02/22/22</td>
<td>2.1: Clarification on Collector Road requirements</td>
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<td>2.1.6: Added “Access Road” to Vertical curve table</td>
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<td>2.12: Moved internal site circulation requirements from UDC to EDM</td>
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<tr>
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<td>5.14.4 Added more detail on types of flood models</td>
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11.1.2 Added Electric Design Requirements

11.1.3 Added Electric Service Voltage

11.1.4 Added Electric Points of Service

4/26/2022

1.7.7 Revisions to drainage tier requirements

4/11/2023

1.5 Updated Department names

1.7.1 Update to KWU changing to CLWSC, added/revised submittal requirements, added/revised submittal content

1.7.4 Clarified which applications require TIA submittals

1.7.6 Clarified definition of financial assurance

1.7.7 Revised drainage tier thresholds and classifications, and changed zone of influence requirements

2.1.1 Updated street geometry per UDC updates

2.1.15 Added section for substandard streets

2.1.16 Added section for special designs

2.11.9 Added design vehicle requirements for roundabouts

2.11.10 Revised threshold for left turn, right turn, and deceleration lanes

2.12.2 Corrected minimum driveway throat lengths are for all streets

4.1.3 Added rules for TIA longevity

4.2.1 Clarified requirements on PHT Generation Form

4.2.4 Added section for TIA consistency worksheet

4.2.5 Added requirements for scoping meeting and revised threshold for intersection analysis

4.3.1 Clarified TIA mitigation phasing plan requirements

4.5 Clarified rough proportionality requirements

5.1.1 Added reference to UDC section on NRCS flood control dams

5.2 Revised requirements for assumed impervious cover and added clarification on ultimate condition model
5.2.1 Revised requirements for assumed impervious cover, updated impervious cover for zoning categories per UDC updates, and updated runoff coefficients

5.3.1 Revised design requirements for detention ponds and added section for pumped detention systems

5.4 Added requirements for use of streets as drainage facilities and updated Table 5-11 per UDC updates

5.5.5 Revised minimum slope for channels

5.8.3 Added requirement for drainage channel easement width

6.1.4 Clarified when seeding is required

7.2.1 Added language from UDC to clarify water main extension requirements

7.2.2 Revised water main sizing for multi-family

7.2.3 Revised looping requirements

7.2.12 Revised requirements for replacing substandard service lines

8.1 Added language from UDC to clarify sewer main extension requirements

8.6 Added requirements for manholes

8.7 Added requirements for force main design and sizing

9.1 Added language from UDC to clarify reclaimed water main extension requirements

9.3 Revised looping requirements

10.1 Added language from UDC to clarify gas main extension requirements

10.2 Added requirements for sizing gas mains

10.3 Revised looping requirements

11.1.1 Added language from UDC to clarify electric extension requirements

11.1.2 Revised electric looping requirements

12.1 Added requirements and clarifications for LID facilities
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CHAPTER 1 - GENERAL DESIGN REQUIREMENTS

1.1 - PURPOSE AND SCOPE

The purpose of the Engineering Design Manual (EDM) is to establish standard principles and practices for the design and construction within the City of Boerne, Texas, and its extraterritorial jurisdiction (ETJ). The design factors, formulas, graphs, and procedures described in this manual are intended to serve as guidelines. Responsibility for actual design remains with the design engineer. Where there is any conflict between this manual and the current Unified Development Code (UDC), the UDC shall take precedence. The design engineer is responsible for complying with the latest version of this manual and the UDC adopted by the City.

Should conflicts occur between policy and criteria in this manual versus other regulatory authorities with jurisdiction in the same area, such as Texas Commission on Environmental Quality (TCEQ) or Texas Department of Transportation (TxDOT), then the more stringent requirement will apply, and the designer will need to show how both requirements have been met.

1.2 - ENFORCEMENT

These Engineering Design Standards shall be in full force and effect immediately upon adoption or revision. Projects will be required to comply with all requirements. The standards include the various design criteria, technical specifications, and standard construction details which are considered minimum requirements for the design and construction of adequate facilities within the City. The Engineer of record shall bear the sole responsibility for meeting the Engineering standard of care for all aspects of the design and providing a design that’s required by the site-specific conditions and intended use of the facilities, while at a minimum meeting the City’s design and construction requirements.

1.3 - AMENDMENTS

The City Council may amend the Engineering Design Manual (EDM) as described in Chapter 2 of the UDC. To ensure that the Design Engineer has the City’s latest design standards, they are directed to the City’s website to acquire the City’s most current design standards. The Engineering Standards will include a Record of Revisions to identify any revisions to the Engineering Standards.

1.4 - INNOVATIVE AND ALTERNATIVE PRACTICES

Innovative practices, or alternatives to those presented in this section, are not considered or approved by staff on a case-by-case basis. Rather, each year, staff evaluates new technologies and suggestions and determines which practices to formally adopt into the manual. The EDM will then be formally updated by the rules adoption process to allow use of these products/technologies across all appropriate projects. Suggestions or requests for product evaluation should be submitted to the City Engineer.
1.5 - ADMINISTRATIVE EXCEPTIONS

All Administrative Exceptions from the requirements included in the EDM shall be approved by the Director of Engineering & Mobility as described within the UDC, Section 2.6(A)(7)(b).

1.6 - PRE-DESIGN CONFERENCE

A pre-design conference, as required by the City Engineer, prior to the Design Engineer commencing their design of any facilities to be dedicated to the public. It is particularly important for large developments, redevelopments or where special conditions or problems have become apparent during the development review process. The applicant shall consult with City for general information regarding regulations, required procedures, possible drainage problems, and specific submittal requirements for projects.

1.7 - SUBMITTAL REQUIREMENTS

1.7.1 - INFRASTRUCTURE DOCUMENTS LETTER OF CERTIFICATION

A. SUBMITTAL REQUIREMENTS

1. All new construction, reconstruction, modifications, alterations, and improvements of public infrastructure shall be designed in accordance with the City’s Engineering Design Manual.

2. Section 212.009 of the Texas Local Government Code specifies that construction plans are approved by the City unless they are disapproved within 30 days after the plan submittal is deemed administratively complete.

3. Specific submittal requirements for Infrastructure Documents can be found within the Engineering & Mobility Infrastructure Document Checklist. It is the responsibility of the Engineer to ensure that all construction plans submitted for review adhere to the current version of the Checklist. The City reserves the right to specify additional requirements as necessary to facilitate the review.

4. Any projects requiring permits from agencies other than the City (including, but not limited to, TxDOT, Canyon Lake Water Supply Company (CLWSC), SAWS, LCRA, GBRA, Pedernales Electric, Bandera Electric, etc.) shall receive approval from these agencies prior to submittals to the City of Boerne.

5. Projects that may have vested rights as allowed by Section 43.002 of the Texas Local Government code, shall make formal application for Vested Rights Determination prior to submitting for Letter of Certification, see UDC Section 2.4.
B. PROCEDURES FOR SUBMISSION

The developer shall provide the Engineering & Mobility Department the following with their application for Letter of Certification:

1. Completed Infrastructure Documents application form
2. Vested Rights Determination, if applicable
3. City required review fees
4. Design Compliance letter - All design professionals shall be required to sign letters to accompany their documents stating that the “The attached documents comply with the requirements of the City of Boerne Unified Development Code, Engineering Design Manual, Texas Commission on Environmental Quality, the State Health Department, and Texas Insurance Commission.”
5. Construction drawings in compliance with below
6. Opinion of Probable Construction Cost – signed and sealed by the design engineer
7. TIA or TIA compliance letter
8. Geotechnical report – if new streets are proposed
9. Drainage study
10. LID construction plans
11. Fire protection detail plan
12. Tree preservation plan and protection plan
13. Approval from Kendall County for street names
14. TCEQ Letter of Approval, if applicable
15. LCRA Letter of Approval, if applicable, for any easement crossings
16. GBRA Letter of Approval, if applicable, for any easement crossings
17. Electric Provider Letter of Approval, if applicable, for any provider other than City of Boerne
18. TxDOT Driveway Permit, if applicable for any access points to State ROW
19. For water and sanitary sewer systems provided by other than City of Boerne, the following additional requirements shall apply:
   a. Submit Construction Plans and specifications for the subdivision’s water and sanitary sewer system for City approval demonstrating that the water and sanitary sewer system will be built to the standards of this Engineering Design Manual to serve the subdivision.
   b. A will-serve letter from the water and sanitary sewer utility provider for the project to be considered.
   c. A letter from the utility provider verifying that the water design meets the minimum requirements of this manual and the fire code for peak flow conditions.
C. FORM AND CONTENT OF INFRASTRUCTURE DOCUMENTS

The construction documents submitted for all public infrastructure shall meet the following requirements:

1. All design professionals shall include in their plans, the statement “Construction of all facilities to be dedicated to the public shall be performed per the requirements of the City of Boerne, Standard Specifications for Public Works Construction, latest edition”.

2. The Construction plans shall be submitted on either 24” x 36” or 22” x 34” sheets. Each sheet of the construction plans shall contain a title block, including space for the notation if revisions. This space is to be completed with each revision to the plan sheet and shall clearly note a detailed description of the nature of the revision and the date the revision was made.

3. The standard horizontal scale for plan and profile sheets shall be 1” = 50’ or 40’ for the plan view, or as allowed by City Engineer. The vertical scale shall be 1” = 5’ or 4’. The same scale shall be used on all plan and profile sheets of the same type. For sheets other than plan and profile, horizontal scales of 1” =200’, 100’, 50’, 40’, 30’, or 20’ may be used as appropriate.

4. The Construction plans and shall include the following, all in compliance with the specifications and Design Standards of this manual:
   a. Subdivision Plat
      i. Copy of approved or proposed draft subdivision plat (for plans associated with platting) affixed to the front of the plans.
   b. Cover Sheet
      i. Project name, legal description, address or location, and type of plans
      ii. Provide contact information for owner, developer, and engineer/surveyor
      iii. Engineer’s seal with signature and date
      iv. Location map with north arrow and using a scale of 1” =2,000’
      v. Index of sheets with consecutive sheet numbers
      vi. The following note: “Note: The City Engineer’s signature affixed to this document indicates that the City Engineer and City Staff has reviewed this document and has found it to be in general conformance with the City’s Engineering Design Manual, the UDC, or approved variances to the same. The City Engineer, through the acceptance of this document, assumes no responsibility, other than stated above, for the completeness and/or accuracy of this document. Responsibility for the engineering adequacy of the facilities depicted in this document lies solely with the Registered/Licensed Professional Engineer whose seal and signature is affixed to this document.”
      vii. Sequence of Construction (include construction phasing, temporary traffic control and installation and removal of stormwater best management practices)
   c. Master Development Plan (if applicable)
      i. Copy of approved or current master development plan (for plans associated with platting)
   d. General Notes
      i. City of Boerne Engineering & Mobility Construction Plan Notes (latest version on City website)
      ii. Sequence of Construction on cover page (include construction phasing, temporary traffic control and installation and removal of stormwater best management practices)
      iii. Notes required by other regulatory agencies
      iv. Project specific notes as deemed necessary by engineer of record
e. Erosion Control Plan
   i. A permanent erosion control and construction phasing plan, conforming to the requirements of this Code.
   ii. Sequence of construction/phasing
   iii. Existing and proposed drainage infrastructure
   iv. Existing and proposed contours
   v. Staging, storage, and spoils locations
   vi. Erosion control measures: silt fence, inlet protection, rock berms, seeding, temporary construction entrances, etc.
   vii. Limits of disturbed area
   viii. Adequate erosion control measures provided at all locations where runoff leaves the site, around the staging and storage location, pond spillways, pilot channels, and at upstream side of pond discharge locations
   ix. Details and notes
   x. Note stating: PER TPDES REQUIREMENTS, DISTURBED AREAS ON WHICH CONSTRUCTION ACTIVITIES HAVE CEASED (TEMPORARILY OR PERMANENTLY) SHALL BE STABILIZED WITHIN 14 DAYS UNLESS ACTIVITY RESUMES WITHIN 21 DAYS. SEEDING DOES NOT CONSTITUTE AS STABILIZATION.

f. Tree Preservation Plan (if applicable)
   i. See Unified Development Code (UDC), chapter 8 for plan requirements

g. Demolition Plan (if applicable)

h. Street Improvements – Plan and Profile
   i. Plan View
      1. Horizontal alignments with points of curvature, points of tangency and curve data labeled
      2. Existing and proposed contours
      3. Right-of-way width
      4. Street pavement width
      5. Curb radii for curb returns, knuckle sacs, cul-de-sacs, etc.
      6. Spot elevations around cul-de-sacs and along washout crowns
      7. Intersection sight distances at street intersections
      8. Sidewalk layout and construction plan
      9. Pedestrian curb ramp type
      10. Drainage and utility crossing locations
      11. End of roadway markers and header curbs at street stub-outs
      12. Street Light location and type
   ii. Profile View
      1. Vertical alignment including PVC, PVI, PVT, crest/sag location, curve length, algebraic grade difference, and “K” values
      2. Existing ground profile at center line, right-of-way, and proposed top of curb
      3. Drainage and utility crossing locations and elevations
      4. In locations of proposed fill, provide a note referencing compaction density and material requirements.
   i. Street Pavement Plan
   ii. Pavement types and location
   iii. Street cross section
   iv. Right-of-way and Pavement width
   v. Pavement design
vi. Sidewalk location and dimensions  

vii. Note referencing geotechnical report  

viii. Note referencing City geotechnical testing requirements for paving

i. Grading Plan  
   i. Existing contours  
   ii. Proposed contours  
   iii. Minimum finished floor elevations for buildable lots adjacent to local or FEMA floodplains  
   iv. Survey control information: benchmarks, permanent monuments, and control points  
   v. Flow arrows, high points, low points, etc.  
   vi. Existing and proposed drainage features  
   vii. Location of Retaining walls with top and bottom of wall elevations  
   viii. Compaction requirements  
   ix. Additional requirements for mass grading of residential lots as listed in Section 5.11 of this EDM, if applicable.

j. Stormwater Management Features (storm drain, channel, culverts, etc.)  
   i. Impervious cover table  
      1. Breakdown of square footage and percent impervious cover assumed for all lots, open spaces, rights-of-way, etc.

   ii. Plan View  
      1. Existing contours  
      2. Proposed contours  
      3. Right-of-way, easements, etc.  
      4. Horizontal layout of infrastructure  
      5. Inlet/manhole/headwall locations  
      6. Access ramps/paths

   iii. Profile View  
      1. Utility crossings  
      2. Hydraulic and energy grade lines (5- and 100-yr events)  
      3. Slopes  
      4. Flow line elevations  
      5. Profile of existing grade at centerline  
      6. Profile of proposed grade at centerline  
      7. Vertical layout of infrastructure including flowlines  
      8. Cross section or pipe size (indicate depth of channel)  
      9. 5-yr velocity for storm sewer  
     10. Pipe material  
     11. Energy dissipation calculations (on plans)  
     12. Discharge (100-yr events)  
     13. Velocity (100-yr events)  
     14. Flow Depth (100-yr events)

   iv. Detention Plan  
      1. Existing contours  
      2. Proposed contours  
      3. Maintenance access location  
      4. 100-year water surface elevation with freeboard  
      5. Stage, storage, and discharge summary table for the percent annual storms (2-yr, 5-yr, 10-yr, 25-yr, 50-yr and 100-yr events)  
      6. Spillway and outlet details, size, specifications, and location
7. Vegetation requirements
8. Cross sections indicated side slopes
9. Comparison of flow rate, velocity, and water depth to Pre-Development conditions for all design storms (2, 5, 10, 25, 50, and 100 year events)

k. Permanent Water Quality Plan
   i. Calculations for minimum water quality volume, and water quality volume with safety factor
   ii. Flow path for detention filtration
   iii. Orifice details and sizing calculations
   iv. Existing contours
   v. Proposed contours
   vi. Maintenance access location
   vii. Cross sections indicated side slopes

l. Overall Utility Plan
   i. Roadway names and widths
   ii. Lot and block numbers
   iii. Existing and proposed easements
   iv. Streetlight locations and type
   v. The layout, size, and location of the existing and proposed drainage facilities, domestic and reclaimed water mains, sewer mains, gas mains, electric lines
   vi. Location of manholes with venting requirements and note with description of venting method.

m. Domestic Water and Reclaimed Water (if applicable) Improvements Plan
   i. Roadway names and widths
   ii. Locations of curbs or edge of pavement
   iii. Lot and block numbers
   iv. Existing and proposed easements
   v. Size and location of all existing and proposed water mains, service lines, valves, fire hydrants, tracer wire locate boxes, and all other water distribution appurtenances
   vi. Location and method of connecting the proposed mains to the existing system.
   vii. Profile view for all water mains greater than 12 inches in diameter

n. Sanitary Sewer Improvements – Plan and Profile
   i. Roadway names and widths
   ii. Lot and block numbers
   iii. Existing and proposed easements
   iv. Showing by plan and profile the size, location, and the grade of all existing and proposed sanitary trunk lines, laterals, manholes, and services
   v. Location and method of connecting the proposed mains to the existing system.
   vi. Station numbers
   vii. Existing ground line
   viii. Proposed ground line
   ix. Flow line elevations at manholes
   x. Pipe slopes
   xi. Manhole and end of main cleanout locations
   xii. Location of manholes with venting requirements and note with description of venting method.
xiii. Details of how water and sewer separation are being met including showing the separation distance between parallel mains and providing details for how TCEQ and TAC requirements for water and sewer separation are met.

o. Signage Plan and Details (if applicable)
   i. Signs (type, size, TMUTCD code designation, etc.)
   ii. Pavement markings (type, color, size, etc.)
   iii. Sign mounting details
   iv. Sidewalk ramp locations and type
   v. Street Light locations and type

p. Temporary Traffic Control Plan (if applicable)
   i. Traffic Control Plan Sheets
   ii. Channelization device type, locations, and spacing
   iii. Traffic barricades
   iv. Detour routes and signing
   v. Flagger locations
   vi. Message boards

q. Phasing plan

r. Standard Details (Roadway, Drainage, Utilities, etc.)

s. Natural Gas Distribution (if applicable)
   i. Roadway names and widths
   ii. Locations of curbs or edge of pavement
   iii. Lot and block numbers
   iv. Existing and proposed easements
   v. Size and location of all existing and proposed gas mains, service lines, valves, tracer wire locate boxes, and all other appurtenances
   vi. Location and method of connecting the proposed mains to the existing system.

t. Electric
   i. Electric design (City of Boerne does not perform design for primary or secondary electric associated with site development or platting activities
   ii. Existing and proposed easements
   iii. Street lighting
   iv. Primary conductor voltage
   v. Size and location of electric lines, meter pedestals, transformers, etc.
1.7.2 - TRAFFIC IMPACT ASSESSMENT FOR LAND STUDY

A traffic assessment shall be submitted for land studies using the Peak Hour Trip Generation Form to provide the trip generation for the existing conditions of the site. If the site is undeveloped with zero existing trips, a letter may be provided in lieu of the Peak Hour Trip Generation Form.

1.7.3 - MASTER DEVELOPMENT PLAN (MDP) TRAFFIC IMPACT ANALYSIS CONTENTS

A master development plan level TIA may be prepared for a development at the zoning or Master Development Plan (MDP) stage when precise land uses, quantities, and driveway locations may not yet be well defined. The goal of a master plan level TIA is to evaluate the adequacy of proposed access to adjacent existing or planned roadways and to determine effects the proposed project may have on current and future roadway systems in its study area. While a master plan level TIA has many of the same components as a typical TIA, the master plan TIA permits extended phasing timeframes and requires limited driveway analysis.

The following components shall be included in the master development plan level TIA document:

A. INTRODUCTION
   1. Site and Study Area Descriptions and Boundaries – Include a location map and site plan
   2. Existing and Proposed Site Uses
   3. TIA Parameters:
      a. Build Out Year
      b. Phasing – maximum 5-year increments
      c. Peak Periods for Analysis
      d. Intersection Analysis

B. EXISTING CONDITIONS OVERVIEW
   1. Existing Roadways and Intersections in Study Area:
   2. Roadway configuration and classification (per thoroughfare plan)
   3. Speed limit
   4. Planned/pending improvement projects
   5. Existing Traffic Volumes

C. PROPOSED CONDITIONS OVERVIEW
   1. Roadway Configuration – Identify any changes resulting from addition of development
   2. Site distance evaluation for any proposed intersections with existing streets
   3. Background Traffic Growth
   4. Background Traffic Growth Rate
   5. Other Significant Nearby Development(s)
   6. Background Traffic Volumes (by phase)

D. DEVELOPMENT SUMMARY
   1. Trip Generation
   2. Trip Distribution
   3. Trip Assignment
   4. Projected Traffic Volumes (by phase)
   5. Total Traffic Volumes (by phase)
E. CAPACITY ANALYSIS

1. Existing Conditions Level of Service Determination
2. Background Conditions (by phase) Level of Service Determination
3. Build Out Conditions (by phase) Level of Service Determination
4. Auxiliary Lane Evaluation
5. Roadway Classification Review (see procedure in EDM Chapter 4.4)
6. Mitigation Summary (developed per criteria in EDM Chapter 4.3) by Phase
7. Mitigated Build Out Conditions (by phase) Level of Service Determination

F. CONCLUSION

1. Compliance with Border Street Policy:
   a. Substandard Existing Streets
   b. Thoroughfare Plan Construction
2. Summary of Proposed Mitigation with Exhibit
3. Completed Rough proportionality worksheet

As the phases of a development for which a master plan level TIA was prepared are platted, the applicant must demonstrate that the development is occurring consistent with the original plan. If the number of trips increases by more than 10% or the applicant desires to alter the mitigation plan, an update must be prepared. Driveway turn-lane evaluations will be performed with the conformance review process.

1.7.4 - TRAFFIC IMPACT ANALYSIS CONTENTS

The following components shall be included in the Traffic Impact Analysis (TIA) document submitted with change in Zoning, Master Development Plan, Infrastructure Documents LOC, plats, building permits and/or other applications:

A. INTRODUCTION

1. Site and Study Area Descriptions and Boundaries – Include a location map and site plan
2. Existing and Proposed Site Uses
3. TIA Parameters:
   a. Build Out Year
   b. Phasing (if any) – maximum 5-year increments, 10-year total build out
   c. Peak Periods for Analysis
   d. Intersections for Analysis

B. EXISTING CONDITIONS OVERVIEW

1. Existing Roadways and Intersections in Study Area:
   a. Roadway Configuration and classification (per thoroughfare plan)
   b. Speed limit
   c. Planned/pending improvement projects
2. Existing Traffic Volumes
C. PROPOSED CONDITIONS OVERVIEW

1. Roadway Configuration – Identify any changes resulting from addition of development
2. Sight distance evaluation for proposed intersections with arterial or collector roads
3. Background Traffic Growth:
   a. Background Traffic Growth Rate
   b. Other Nearby Development(s)
4. Background Traffic Volumes (by phase)

D. DEVELOPMENT SUMMARY

1. Trip Generation
2. Trip Distribution
3. Trip Assignment
4. Projected Traffic Volumes (by phase)
5. Total Traffic Volumes (by phase)
6. Summary of required mitigations by phase/traffic volume

E. CAPACITY ANALYSIS

1. Existing Conditions Level of Service Determination
2. Background Conditions (by phase) Level of Service Determination
3. Build Out Conditions (by phase) Level of Service Determination
4. Auxiliary Lane Evaluation
5. Roadway Classification Review (see procedure in EDM Chapter 4.4)
6. Mitigation Summary (developed per criteria in EDM Chapter 4.3) by Phase
7. Mitigated Build Out Conditions (by phase) Level of Service Determination

F. CONCLUSION

1. Compliance with Border Street Policy:
   a. Substandard Existing Streets
   b. Thoroughfare Plan Construction
2. Summary of Proposed Mitigation with Exhibit
3. Summary of Rough Proportionality

1.7.5 - LID CONSTRUCTION PLANS

The construction plans for LID features shall be submitted as provided in the UDC, Section 8.2(B) and shall meet the following requirements:

1. All design professionals shall include in their plans, the statement “Construction of all facilities to be constructed shall be performed per the requirements of the City of Boerne LID Manual.”
2. Complete design of all BMPs shall be included in the construction plans with sections and profiles. These plans shall meet the BMP’s and techniques as identified in the LID Manual.
3. Construction plans as necessary shall include but is not limited to design for storm drains, underdrain connections, overflows, bypasses, cistern details including foundations, permeable pavement structural design, and liner connections and details.
1.7.6 - LID ENGINEERING REPORT

The engineering reports for LID features shall be submitted as provided in the UDC, Section 8.2(B) and shall include the following information:

1. General information and site description
2. Narrative and summary for requested incentives
3. Site planning and environmentally sensitive design methods
4. Grading plan
5. Detailed drainage maps for proposed LID BMPs (existing and proposed)
6. Impervious cover exhibit(s)
7. LID volume and treatment/removal calculations
8. Vegetation plan including establishment plan, if necessary
9. Inspection, maintenance, repair, and retrofit plan
10. Narrative and summary of multiuse benefits, if necessary
11. Financial assurance including an estimated annual cost for maintenance of the features and proof that the maintenance costs will be covered by owner or community association

1.7.7 - DRAINAGE STUDY CONTENTS

The drainage report shall be a stand-alone document. When references are made or assumptions are based on previously approved submitted reports, the drainage report must include the appropriate excerpts, pages, tables, and maps containing the referenced information. Assumptions made in previous reports must be verified and substantiated. All submitted reports should be clearly and cleanly reproduced. Photocopies of charts, tables, nomographs, calculations, or any other referenced material must be legible.

To facilitate development while applying drainage rules, a tier system, as shown in Table 1-1, is established requiring different submittals and different development actions depending on the probable impact on the drainage basin. In all cases, properly sized easements shall be granted across all contiguous property owned by the applicant; and a comprehensive Drainage Plan and Drainage Report shall be provided for all property on the subject plat whether developed by this application or not.

<table>
<thead>
<tr>
<th>Table 1-1: Development Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1 (Exhibit/Resident Letter)</td>
</tr>
<tr>
<td>1. Adding area of impervious cover less than 100 square feet; or</td>
</tr>
<tr>
<td>2. Adding less than 4% of the gross lot size of impervious cover; or</td>
</tr>
<tr>
<td>3. Meets one of the criteria below:</td>
</tr>
<tr>
<td>a. Single family residential: Two or less lots</td>
</tr>
<tr>
<td>b. Multi-family residential: Two or less lots with 2 or less units on each lot</td>
</tr>
<tr>
<td>Tier 2 (Drainage Study)</td>
</tr>
<tr>
<td>1. Meets one of the criteria below:</td>
</tr>
<tr>
<td>a. Single family residential: Four or less lots</td>
</tr>
<tr>
<td>b. Multi-family residential: Four or less lots with 2 or less units on each lot</td>
</tr>
<tr>
<td>c. All other categories:</td>
</tr>
<tr>
<td>i. Single lot with total increase in impervious cover less than 5,000 SF</td>
</tr>
<tr>
<td>Tier 3 (Drainage Study and Downstream Drainage Assessment)</td>
</tr>
<tr>
<td>2. Development does not meet requirements of Tier 1 or 2</td>
</tr>
</tbody>
</table>
FOR ALL TIERS:

1. Amenity structures shall not exceed the impervious coverage limitations outlined in the Unified Development Code Section 4.8(A). Amenity structures include, but are not limited to, structures such as swimming pools, patios, and concrete slabs.
2. Sheds are an accessory structure and shall meet the size and quantity requirements of the Unified Development Code Section 3.5(E).
3. Total Impervious cover shall not exceed the requirements of the Unified Development Code Section 8.2(C).

Incomplete or absent information may result in the report being returned to the preparer without review. The below information, as shown in Table 1-2, shall be supplemented with narrative text describing the watershed and the subdivision, including their general soil conditions, downstream channel conditions, all weather access. In general, all deviations from the City’s requirements shall be included in the narrative with justification for deviation. The drainage study shall be submitted along with the administratively complete design and construction plans, per EDM Section 1.7.1-C, prior to submittal of the final plat.

### Table 1-2: Drainage Study Requirements

<table>
<thead>
<tr>
<th>Category</th>
<th>Site Exhibit &amp; Landowner No-Impact Letter</th>
<th>Drainage Study &amp; Stormwater Management Facilities</th>
<th>Adverse Impact Assessment</th>
<th>Local Floodplain Determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier 2</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Tier 3</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**A. TIER 1 DEVELOPMENT**

Submittals for Tier 1 Developments may be provided by the developer/subdivider and include the following:

1. Site exhibit showing existing and proposed flow arrows for drainage patterns, site boundary, existing structures, proposed improvements. Show adjacent drainageway protection zones, 1% annual chance local and FEMA floodplain, if applicable.
2. A signed letter from the owner/developer stating that the project does not adversely impact adjacent or downstream properties.
3. A Floodplain Development Permit approved by the Engineering & Mobility Department if local or FEMA floodplain is within the platted limits.

Upon review of a Tier 1 Submittal, the City Engineer may require a Tier 2 submittal if the proposed improvements are located in an area with known flooding problems as determined by the City Engineer, or if they are adjacent to a street or drainage structure with known flooding problems. Drainage easements may be required to accommodate future or existing development.
B. TIER 2 DEVELOPMENT

Submittals for Tier 2 applications require a complete Drainage Study for both existing and fully developed conditions, for the entire watershed drainage area upstream of the lowest points(s) in the subdivision. The drainage study shall be prepared by a professional engineer registered in the State of Texas, consisting of the following:

1. GENERAL

   a. Project Location depicted on a 7.5-minute series U.S.G.S. or aerial map.
      i. Include land plan and limit of downstream drainage assessment
      ii. Digital Flood Insurance Rate Map (DFIRM) with site superimposed.
      iii. Onsite Drainage Area Map (to scale) including the following:
         1. Time of Concentration flow paths
         2. Overall drainage areas for the site and indicate area for each
         3. Points of discharge to directly correlate with discharge summary tables
         4. Land use type data
         5. Land plan, when applicable
         6. Two-foot contour intervals
      iv. Provide Overall Drainage Area Map (to scale) including the following, when applicable:
         1. Time of Concentration flow paths
         2. Overall drainage areas for the site and indicate area for each
         3. Points of discharge to directly correlate with discharge summary tables
         4. Approximate location of downstream drainage assessment limit
         5. Land use type data
         6. Land plan, when applicable
         7. Two-foot contour intervals
         8. Provide Soil Type Map (to scale) for the project site, when applicable.
            a. Include project area, land plan, and drainage areas.
   v. Grading Plan (Also required in construction plans).
      1. Lots grading properly, including lot grading type (A, B, C)
      2. All storm drain, channel and/or pond facilities
      3. All proposed drainage easements, including width of easement
   vi. Hydraulic Work Map including the following, when applicable
      1. Land plan
      2. Proposed drainage systems including storm drains, channels, and ponds
      3. Cross sections associated with supporting models
      4. Points of discharge/flow change locations
      5. Appropriate flood plain limits
      6. Approximate location of downstream drainage assessment limit
      7. Two-foot contour intervals
      8. Computer Models:
         a. Provide table with input parameters for all models
         b. In addition to output tables for all models, provide digital copies of all models in native format
2. HYDROLOGY
   a. Detailed Time of concentration/Lag Time calculations.
   b. Surface runoff coefficient calculations.
      i. Soil Type Map to be included when SCS curve number (CN) calculations provided
   c. Detailed calculations for existing/proposed types of impervious cover.
   d. Peak flow summary table including:
      i. Fifty, twenty, ten, four, two and one percent annual chance (2, 5, 10, 25, 50, 100 year) storms.
      ii. Associated rainfall intensity factors, when applicable
   e. Detailed calculations for hydrologic routing as stated in this Section, when applicable.
   f. Table comparing peak flows for specified conditions and storm events

3. HYDRAULICS
   a. 25- and 100-year flow quantities with the 25- and 100-year FEMA and local flood plain limits for the existing and fully developed watershed shown on the preliminary plat.
   b. Preliminary street grades and directional flow paths sufficient to determine high points, low point, and intended drainage patterns.
      i. Provide typical street section
      ii. Provide summary of street capacities with supporting calculations for minimum and maximum grades along all streets proposed
   c. Proposed locations of inlets, storm drains, channels, and culvert along with supporting calculations.
   d. All proposed drainage easements, including width of easement and configuration of channel.
   e. Calculations to determine the volume of proposed detention/retention/sedimentation ponds.
      i. Verify if impoundment qualifies as a Texas Commission of Environmental Quality (TCEQ) impoundment, and if it is required to obtain a permit under the TCEQ Dam Safety Program.
   f. Summary of discharges and velocities at all major outlets, outfall, and at the downstream drainage assessment limit.
      i. Specify proposed energy dissipation type and provide detailed calculations and supporting references

4. STORMWATER MANAGEMENT FACILITIES
   a. Stormwater Detention Pond Volume calculations
   b. Stormwater Detention Pond Outfall calculations
   c. Water quality volume calculations by stage
   d. Calculations showing that permanent Best Management Practices (BMPs) capture and treat the required water quality volume (WQV).
   e. Proposed location of facilities, including inlet calculations, overflow/bypass routes and capacity of overflow grates.
   f. Access locations for maintenance for all permanent facilities.
Upon review of a Tier 2 Submittal, the City Engineer may require a Tier 3 submittal if the proposed improvements are in an area with known flooding problems as determined by the City Engineer, or if they are adjacent to a street or drainage structure with known flooding problems. Drainage easements may be required to accommodate future or existing development.

C. TIER 3 DEVELOPMENT

A Tier 3 application is required for any development or redevelopment that does not qualify as a Tier 1 or Tier 2 Application. Submittals for Tier 3 applications require a complete Drainage Study for both existing and fully developed conditions, for the entire watershed drainage area upstream of the lowest points(s) in the subdivision. The study shall be prepared by a professional engineer registered in the State of Texas, consisting of the following:

1. DRAINAGE STUDY

A Drainage Study as described in Tier 2 shall be provide for all Tier 3 projects.

2. STORMWATER MANAGEMENT FACILITIES

Stormwater Management facilities as described in Tier 2 shall be provide for all Tier 3 projects.

3. ADVERSE IMPACT ASSESSMENT

An adverse impact assessment shall extend from the outfall of the subdivision to a point downstream, determined by one of two methods:

Zone of Influence – Point downstream where the discharge from a proposed development no longer has a significant impact upon the receiving stream or storm drainage system.

Adequate Outfall – Location of acceptable outfall, as approved by City Engineer, that does not create adverse flooding or erosion conditions downstream.

These methods recognize the fact that a structural control providing detention has a “zone of influence” downstream where its effectiveness can be felt. Beyond this zone of influence the storm water effects of a structural control become relatively small and insignificant compared to the runoff from the total drainage area at that point. Based on studies and master planning results for a large number of sites, a general rule of thumb is that the zone of influence can be considered to be the point where the drainage area controlled by the detention or storage facility comprises 10% of the total drainage area. This is known as the 10% Rule. As an example, if a structural control drains 10 acres, the zone of influence ends at the point where the total drainage area is 100 acres or greater.

The adverse impact assessment shall include the following steps:

a. Determine the outfall location of the site and the pre- and post-development site conditions.

b. Using a topographic map, determine a preliminary lower limit of the zone of influence using the 10% Rule or 2,000 feet downstream, whichever is greater.
c. Using a hydrologic model determine the pre-development peak flows and velocities at each junction beginning at the development outfall and ending at the next junction beyond the preliminary lower limit of the zone of influence (10% point). Model off-site areas as ultimate development condition with any undeveloped off-site assumed to be “fully built-out” without providing on-site detention, for both the pre- and post-development analyses. Use the City of Boerne Master Plan to determine future land uses for the model. Evaluate discharges and velocities for the fifty, twenty, ten, four, two and one percent annual chance (2, 5, 10, 25, 50, 100 year) storms. Use storm durations equal to 24-hours.

d. Change the land use on the proposed subdivision site to post-development conditions and rerun the model.

e. Evaluate interim conditions (phasing of units, soil disturbances during construction, etc.) based on the Curve Numbers in National Engineering Handbook Chapter 630. Compare interim and post-development conditions to determine which condition has the highest potential adverse impact.

f. Compare the pre- and post-development peak discharges and velocities at the downstream end of the model. If the post-developed flows are higher than the pre-developed flows for the same frequency event, or the post-developed velocities are higher than the allowable velocity of the downstream receiving system, extend the model downstream. Repeat steps 3 and 4 until the post-development flows are less than the pre-developed flows, and the post-developed velocities are below the allowable velocity. Allowable velocities are given in Table 5-13 of this article.

g. Add proposed storm water management facilities to the model designed so that the model shows that adverse effects are mitigated. Adverse effects can be shown to be mitigated if flooding is not increased off site, velocities do not exceed the greater of Table 5-13 allowable maximum velocities or pre-development velocities, and that the peak flow at the downstream limit of the zone of influence is not increased.

4. ADVERSE IMPACT TIMING

The timing of releases from storm water facilities can be critical to the proper functioning of overall drainage systems. Storm water control structures reduce the peak discharge and increase the duration of flow events. While this is the desired result for flow tributary to an individual storm water facility, this shifting of flow peak times and durations in some instances may cause an adverse effect downstream.

If the adverse impact study determines that providing on-site detention increases the peak flow rate for the fifty, twenty, ten, four, two and one percent annual chance (2, 5, 10, 25, 50, 100 year) storms, the City Manager may grant an exception for providing on-site detention, if all of the following exception requirements are met:

a. Total watershed acreage at the downstream limit of the zone of influence is less than 10,000 acres such that rainfall depth is consistent across the entire watershed.

b. Project location is directly adjacent to one of the City’s major drainageways (Cibolo Creek, Frederick Creek, Menger Creek, Ranger Creek, Curry Creek, Browns Creek, etc.)

c. Project acreage is less than or equal to 1/100th of the total watershed acreage at the downstream limit of the zone of influence.
d. All on-site drainage system design, and their drainage easements, are provided for the City’s ultimate development watershed model for both the project site and future development in the upstream drainage areas.

e. All downstream drainage systems, and their drainage easements, are provided for the City’s ultimate development watershed model from the project site to a point 2,000’ feet downstream, OR the downstream limit of the zone of influence calculation point, whichever is greater. The Developer may propose modifications to the downstream drainage system and/or acquisitions of off-site drainage easements, to comply with this requirement. However, it is the Developer’s responsibility to acquire landowner permission, design and construct the drainage modifications, and establish drainage easements to make these off-site accommodations.

f. Water Quality Best Management Practices (BMP’s) are designed to be offline drainage structures and sized to capture an increased depth of rainfall (2.35 inches) as required for areas within the water supply protection zone as described in the UDC.

g. Developer to construct off-site drainage improvements, at location approved by City Engineer, within the same watershed as the project site, or the developer shall provide a contribution toward regional stormwater improvements to be constructed by City at later date. Determination of value of off-site construction costs or contribution costs shall be determined using an Opinion of Probable Construction Cost (OPCC) for providing on-site detention. OPCC shall include all costs necessary to design and construct a detention pond, including the value of land the pond is to be located within. The OPCC shall be prepared and sealed by licensed professional engineer and shall be submitted to the City Engineer for review.

If all exception requirements are not met, the owner or agent may make application to the Planning and Zoning Commission for a variance from the storm water detention requirement. The application shall be filed with the City Manager, accompanied by the appropriate fee established by City Council.

5. LOCAL FLOODPLAIN DETERMINATION

A Local floodplain, as defined in Chapter 8 of the UDC, determination shall be made to verify location and depths of Local floodplain. Base flood elevation data shall be generated for all local floodplains and submitted to the Floodplain Administrator for review with any proposed development.
CHAPTER 2 - STREET DESIGN REQUIREMENTS

2.1 - STREET GEOMETRY STANDARDS

2.1.1 - GENERAL REQUIREMENTS

The design of all streets in a subdivision shall conform to the standards of street geometry in the following table:

Table 2-1: Street Geometry Standards

<table>
<thead>
<tr>
<th>Street Functional Classification</th>
<th>Pavement Crown or Cross Slope</th>
<th>Minimum Grade</th>
<th>Maximum Grade</th>
<th>Centerline Minimum Horizontal Curve Radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial</td>
<td>Min. 6&quot; or 2%</td>
<td>0.5%</td>
<td>6%</td>
<td>1,000'</td>
</tr>
<tr>
<td>Collector</td>
<td>6&quot; or 2%</td>
<td>0.5%</td>
<td>8%</td>
<td>600'</td>
</tr>
<tr>
<td>Neighborhood Collector</td>
<td>5&quot; or 2%</td>
<td>0.5%</td>
<td>8%</td>
<td>400'</td>
</tr>
<tr>
<td>Local</td>
<td>5&quot; or 2%</td>
<td>0.5%</td>
<td>10%</td>
<td>300'</td>
</tr>
<tr>
<td>Residential Alley</td>
<td>7&quot;</td>
<td>0.5%</td>
<td>10%</td>
<td>50'</td>
</tr>
<tr>
<td>Commercial Alley</td>
<td>7&quot;</td>
<td>0.5%</td>
<td>10%</td>
<td>50'</td>
</tr>
</tbody>
</table>

2.1.2 - STREET CROSS SECTIONS

Street Cross Sections shall be as established as set forth in the UDC Section 7.2(F).

2.1.3 - REVERSE CURVES

Reverse curves shall be separated by a minimum tangent of 100 feet, except that the City Engineer may waive this requirement for Local streets where an exception is justified by the topography of the site and by the sight distance, right-of-way width, setbacks, and other features of the subdivision design.
2.1.4 - SUPERELEVATION

When superelevation is used, the maximum allowable rate of superelevation for roadways is 2.0%. Superelevation must be designed consistent with the guidelines in AASHTO’s current edition of *A Policy on Geometric Design of Highways and Streets*. City Engineer may waive this requirement, up to 4.0% superelevation, when justified by topography or other site-specific features.

At any location that the typical crowned crown cross section cannot be provided, the pavement superelevation shall be 2.0% from the opposite curb to any required drainage openings.

2.1.5 - INVERTED CROWN

Inverted Crowns are not allowed in public rights-of-way. The City Engineer may waive this requirement where the inverted crown is used in conjunction with a center median being used for an earthen channel or other natural stormwater facility.

2.1.6 - VERTICAL CURVATURE

A gradual transition from one roadway grade to another shall be accomplished by means of a vertical parallel curve connecting two intersecting tangents. Vertical curve alignment shall also provide stopping sight distance (SSD) in all cases. The minimum length of vertical curve shall be computed from the following formula and table:

**Equation 2-1:**

\[ L = KA \]

Where:
- \( L \) = the length of vertical curve in feet
- \( K \) = a constant related to sight distance and geometry of a parabolic curve
- \( A \) = the algebraic difference in grades in percent.

A vertical curve is not required for when the algebraic difference between grades is as follows:

- 1.5 percent or less for design speeds equal to or less than 45 mph
- 0.5 percent or less for design speeds greater than 45 mph

**Table 2-2: Design Values for Constant "K" Vertical Curve**

<table>
<thead>
<tr>
<th>Street Classification</th>
<th>&quot;K&quot; Crest Curves</th>
<th>&quot;K&quot; Sag Curves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Thoroughfare</td>
<td>84</td>
<td>96</td>
</tr>
<tr>
<td>Arterial</td>
<td>61</td>
<td>79</td>
</tr>
<tr>
<td>Collector</td>
<td>44</td>
<td>64</td>
</tr>
<tr>
<td>Local</td>
<td>19</td>
<td>37</td>
</tr>
<tr>
<td>Access Road</td>
<td>12</td>
<td>26</td>
</tr>
</tbody>
</table>
2.1.7 - VERTICAL CURVE AT INTERSECTIONS

1. To determine K-value at intersections the design engineer shall use the AASHTO’s current edition of A Policy on Geometric Design of Highways and Streets for stopping sight distance (SSD) to determine the vertical curve requirements:

2. For local street intersections, where the K-value is on the street that has a stop sign control, a minimum design speed of 15 mph may be used.

3. For local street or driveway intersections connecting to a Collector Street or higher, where the K-value is on the street that has a stop sign control and does not have the potential of begin signalized, a minimum design speed of 20 mph may be used.

2.1.8 - STREET WIDENING

1. When widening of existing streets is required, the design engineer shall provide a plan sheet with cross sections at every 50’ station and any location with changes in the vertical or horizontal geometry.

2.1.9 - PARTIAL/HALF STREETS

1. When widening of existing streets is required, the design engineer shall provide a plan sheet with cross sections at every 50’ station and any location with changes in the vertical or horizontal geometry.

2. Partial right-of-way dedications of thoroughfares shall be prohibited, except when essential to the reasonable development of a property in conforming with the requirements of the UDC, and where the Engineering & Mobility Director finds that it will be practical to require the dedication of the other portion of the street when the adjoining property is developed.

3. Where a partial right-of-way is being dedicated along a common property line where no roadway currently exists, the first dedication of right-of-way shall be of an adequate width so that the Developer shall be responsible for a minimum of twenty-seven (27’) of pavement, containing at least two 11’ wide travel lanes, including a 5’ wide on-street bicycle facility, if applicable, as considered necessary by the City Engineer.

4. On collectors and arterials where a full right-of-way is being dedicated, the initial roadway shall be a minimum of twenty-seven (27’) of pavement, containing at least two 11’ wide travel lanes, including a 5’ wide on-street bicycle facilities if applicable.

2.1.10 - CUL-DE-SACS

1. All dead-end streets shall have a turn-around unless otherwise allowed in Street Stubs section below. Turn-arounds (cul-de-sacs) at the end of dead-end streets shall have a circular driving surface that has a minimum diameter of 96 feet and a street right-of-way that has a minimum diameter of 120 feet.

2. The maximum length of a dead-end street with a turn-around (cul-de-sac) shall be six hundred feet (600’), measured from the right-of-way line of the intersecting street to the center point of the turn-around. If a dead-end street has another dead-end street branching off, the total combined length of the main dead-end street and its branch(es) cannot exceed the maximum length described above and the total number of lots fronting onto the combined dead-end streets cannot exceed twenty-five (25).

3. A temporary turn-around must be built at the end of a street more than 150 feet long that will be extended in the future. The temporary turn around shall meet the requirements of Fire Apparatus Access Road, per current Fire code. The following note shall be placed on the plat: “cross-hatched area in a temporary easement for turn-around purpose until the street is extended to the (direction) on a recorded plat.”

4. Medians or islands in cul-de-sac’s require approval of the Fire Marshall.
2.1.11 - STREET STUBS
Street Stubs, as required for external connections in UDC chapter 7.2(E), shall be provided to connect to future subdivision on adjacent tracts as follows:

1. The length of the street stub shall not exceed the depth of the adjacent lot or length as allowed by fire code.
2. A residential stub street shall also have a 24”x30” sign prominently posted at its terminus with black letters on a white background that state, “NOTICE – This street will be extended as part of a future development.”

2.1.12 - CLEAR ZONE
A clear zone shall be provided for all streets in accordance with AASHTO’s current edition of *Roadside Design Guide*. In general, a minimum clear zone of 4 feet shall be provided from the face of curb on tangent sections and a minimum clear zone of 6 feet shall be provided from the face of curb on curved sections. For roads without curbs, a minimum clear zone of 7’ is required for local streets and 10’ for collectors. Where clear zone requirements cannot be met, a guardrail or other type of barrier shall be required. Horizontal clearance for 1.5 feet behind the face of curb shall be provided for all streets.

2.1.13 - VERTICAL CLEARANCE
No point within pavement surface area shall have a vertical clearance less than 15.5-feet from any bridge, structure, and utility. The vertical clearance for trees shall be 15.5-feet from all vehicular pavement plus a minimum of 5 feet behind back of curb.

2.1.14 - STREET LENGTHS

1. Collector and arterial thoroughfares (except for neighborhood collectors) have no street length restrictions. Residential streets (local thoroughfares in a single-family, duplex, or townhome neighborhood) shall have street length restrictions to discourage speeding and cut-through traffic.
2. A residential street (local thoroughfares in a single-family, duplex, or townhome neighborhood) that intersects with a collector or arterial thoroughfare and has residential lots fronting onto any portion of the street shall not exceed a maximum length of six hundred feet (600’) measured from the collector or arterial thoroughfare ROW line.
3. Residential streets (local thoroughfares in a single-family, duplex, or townhome neighborhood) that do not intersect with a collector or arterial thoroughfare shall not exceed one thousand two hundred feet (1,200’) in length before changing direction. A change in direction occurs when one of the following elements is used:
   a. A horizontal curve radius of three feet (300’) that changes the course of the street between ninety (90°) and one hundred twenty degrees (120°). A tangent that is a minimum of one hundred feet (100’) long shall be provided between reverse curves.
   b. A street offset using two elbow intersections, each between ninety (90°) and one hundred twenty degrees (120°). The minimum distance between reverse elbows shall be one hundred fifty feet (150’).
c. A roundabout is used to start a new section of roadway which is angled or curved away from the alignment of the preceding street. If roundabouts are used to create a continuous route through a neighborhood that would otherwise be considered a residential collector, no homes shall front any part of that route.

### 2.1.15 - SUBSTANDARD STREETS

Where the existing street is substandard in width, or a material other than concrete or asphalt, or a pavement surface not adequate for the proposed traffic, the existing street shall be improved. The proposed street improvements must meet the minimum standards of the street cross sections as provided in Table 7-1 of the UDC, the Major Thoroughfare Plan, or at least 26 feet of clear pavement width whichever is greatest.

### 2.1.16 - SPECIAL DESIGNS


### 2.2 - CURBS

1. All streets shall have concrete curbs extending seven and one-half inches above the pavement surface and shall be reinforced with 1- #4 continuous longitudinal reinforcing bar (minimum) centered in the curb section.
2. The minimum total curb height shall be shown on Standard Detail included within the City of Boerne, Standard Specifications for Public Works Construction, latest edition. Compacted backfill shall be placed on all the rights-of-way behind curbs to a minimum elevation equal to the top of the curb.
3. Continuously reinforced Header curbs (minimum total depth of 9 inches) shall be provided at driveway areas.
4. Header curbs are required on streets using the Character Preservation Type as shown in Chapter 7 of the UDC.

### 2.3 - SIDEWALKS

1. Sidewalks, the width set forth in UDC Chapter 7, shall be installed in the appropriate location adjacent to all properties fronting a street at such time as that lot is developed in the City limits or in the ETJ of the City of Boerne. This includes all lots/tracts or parcels that front any portion of IH-10 right-of-way.
2. Sidewalks, including portions within any driveway aprons, shall meet all local, state, and federal standards.
3. Locations of sidewalks within State right-of-way shall be as directed by TxDOT and a sidewalk permit must be approved by TxDOT, prior to construction within State right-of-way.
4. Sidewalks shall be located on both sides of bridges and culverts. A combination or pedestrian rail, as approved by the City Engineer, protecting the sidewalk shall be provided on the outside edge of the bridge/culvert.
5. An accessible sidewalk or trail shall be provided connecting the public sidewalk to the main entrance of the main building.
6. Sidewalks with potential fall hazards (vertical drop greater than 12”, grade steeper than 3:1 slope, etc.) within 5 feet from the edge of the sidewalk shall have edge protection provided such as a curb or pedestrian railing.
7. Unless otherwise approved by City Engineer due to topography or other issues, a public sidewalk, 5’ minimum width, shall be provided between any permanent street cul-de-sac and adjacent streets, trails, parks, or school sites. All screening and/or fencing requirements shall be met in addition to this requirement.

2.4 - SIDEWALKS TIMING

1. Ramps and landings shall be installed as well as sidewalks along common areas prior to acceptance. However, to avoid undue damage to sidewalks, the subdivider, developer, or builder may construct the sidewalk located on local and neighborhood collector roads on each lot as it is developed. However, sidewalks on collector and arterial roadways shall be constructed with the roadway.

2. In no case will a Certificate of Occupancy be issued for a building until the required sidewalks have been constructed.

3. In areas, sites, or other portions of streets where no building will be constructed and sidewalks are required by these regulations, the sidewalks shall be constructed with other required street infrastructure.

4. Sidewalks, or trails in lieu of sidewalks, that are on a main thoroughfare as depicted in the Major Thoroughfare Plan shall be constructed with the street improvements to provide safety and connectivity within the development.

2.5 - DRIVEWAYS

Driveway aprons in the public right-of-way shall be constructed of concrete and according to all local, state, and federal standards. Driveways shall be located per the minimum separation requirements of UDC Section 7.5.

2.6 - TRAFFIC CONTROL SIGNS AND STREET SIGNS

All traffic control signs shall be provided and installed by the subdivider and shall conform with the Texas Manual on Uniform Traffic Control Devices (TMUTCD). All street signs shall be provided and installed by the subdivider and/or developer and meet the City's standard specifications and sign patterns.

2.7 - STREET LIGHTING

Street lighting on local roads shall be provided, according to the city design standards, by the developer/subdivider at the entrance, all intersections, street alignment changes greater than 45 degrees, mid-block between intersections longer than 900 feet and at the beginning of any cul-de-sac or other disconnected street permitted. Streetlights shall not be installed on the same corner of an intersection that contains a fire hydrant or signpost.

On arterial and collector - roadways streetlights shall be provided in the medians with spacing not to exceed 250 feet. On arterial and collector - thoroughfares without medians, the streetlights shall be placed on alternate sides of the parkway, between the curb and sidewalk, with spacing not to exceed 250 feet. When partial thoroughfares are constructed, the electric infrastructure shall include stub-outs for future streetlights.

To prevent light trespass from streetlights, all proposed light fixtures shall comply with International Dark Association (IDA). Fixtures shall be required to be fully shielded and to minimize the amount of blue light in the nighttime environment.
For areas within the Camp Bullis Dark Skies Zone, the City Engineer may waive the requirement for the streetlight spacing requirements listed above, based upon an illumination plan showing compliance with Kendall County’s lighting requirements.

2.8 - TRAFFIC CONTROL

All permanent and temporary traffic control shall be in accordance with TxDOT’s current edition of TMUTCD and this section.

2.9 - ACCESS RESTRICTED ENTRANCE DESIGN STANDARDS

2.9.1 - ACCESS STANDARDS

1. If an overhead, or lift-up, barrier is used, it must rise to a minimum of fourteen feet (14) in height above the road surface, and this clearance height shall be extended for a minimum distance of fifty feet (50) in front of and behind the location of the device.
2. All gates and cross arms must be of a breakaway design. Breakaway design must allow for the gate or cross arms to break away when struck and automatically shut down the gate operator. The system must be capable of resetting by snapping the gate or cross arms back into place.
3. A traffic study for the development shall determine the stacking length such that no vehicles will queue into the public street or shared private driveway. The minimum vehicle stacking distance of sixty (60) feet shall be provided from the right-of-way line of the public road from which the private street subdivision or multi-family development is accessed to the first vehicle stopping point, which point is usually an access request keypad, a telephone, and/or a guard’s window.
4. Adequate distance shall be provided between the access request point(s) and the entry barrier, or gate, to accommodate a vehicle turnaround as described in Section 2.9.2 below.
5. All gates extending across a fire apparatus road shall meet the requirements as described in Section 2.10 below.

2.9.2 - TURNAROUND REQUIREMENTS

1. A paved turnaround space must be located in front of (i.e., prior to passage through) any restricted access entrance barrier, between the access request device and the barrier or gate, to allow vehicles that are denied access to safely exit onto public streets without having to back up, particularly into the public street upon which the entrance is located.
2. The design and geometry of such turnaround shall be of sufficient pavement width and having such inside turning radius that it will accommodate smooth, single-motion U-turn movements for WB-40 design vehicles as defined in the TXDOT Roadway Design Manual or by the types of service and utility trucks that typically visit or make deliveries to neighborhoods that are similar to the proposed private street development including by way of reference and not limitation utility service vehicles, postal or UPS delivery trucks, and two- to three-axle flatbed or box-type trucks used by contractors and moving companies.
3. The City Engineer may require submission of additional drawings, plans or exhibits demonstrating that the proposed turnaround will work properly, and that vehicle turnaround movements will not compromise public safety on the entry and/or exit roadway or on the adjacent public street(s).
2.10 - GATE REQUIREMENTS

1. All gates extending across a fire apparatus access road shall be automatic opening and must meet design and installation standards described in Appendix D, Section D103.5, of the City Fire Code Ordinance. Said design shall be reviewed and approved by the Fire Marshall prior to installation.

2. Electric gates shall be equipped with an SOS (Siren Operated System), Knox key switch mounted on the access panel (keypad) and a manual means of opening the gate by fire department personnel in the event there is loss of electric power to the gate.

3. Emergency opening devices shall be approved by the fire code official.

4. Gate components shall always be maintained in an operative condition and replaced or repaired when defective by property owner’s association or the private landowner.

5. Electric gate openers, where provided, shall be listed in accordance with UL 325.

6. Gates intended for automatic operation shall be designed, constructed, and installed to comply with the requirements of ASTM F 2200.

2.11 - INTERSECTION DESIGN

Intersections for streets and driveways shall be designed to balance safe and direct connections for vehicles and pedestrians.

2.11.1 - ALIGNMENT

Local Streets intersections shall be either aligned directly, or off-set at least 200’ from edge of pavement to edge of pavement. Collector roadways, or greater, that have offset intersections must have a minimum spacing as defined by current TxDOT access spacing criteria for functional median spacing. Only intersections of two streets shall be permitted except for roundabouts for the intersection of two or more local streets. Roundabouts for street intersections classified above a local street is subject to approval by the City Engineer. All intersections shall be as near to 90-degree angles as practical and shall always be between 80 degrees and 100 degrees.

2.11.2 - CURB RADII

To minimize crossing distances for pedestrians and limit high-speed vehicle turning movements, curb radii shall be limited to the greatest extent possible considering the appropriate balance of pedestrian and vehicle needs. In general, curb radii at intersections shall be as specified in the intersection requirements Table 2-3, below:

2.11.3 - ROW LINE RADII

Radii at intersections shall be provided at corners between two or more right-of-way. This radius aids in street intersection visibility as well as provides sufficient room for sidewalks, curb ramps, and other street facilities. If the radius is within the sight visibility line, all sight distance requirements must be maintained. In general, radii dimensions at intersections shall be as specified in the intersection requirements Table 2-3, below:
Table 2-3: Intersection Requirements

<table>
<thead>
<tr>
<th>Intersection Type</th>
<th>Curb Radii*</th>
<th>ROW**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local / Local</td>
<td>25’</td>
<td>13’ radius</td>
</tr>
<tr>
<td>Local / Collector</td>
<td>25’</td>
<td>30’ x 30’ corner clip</td>
</tr>
<tr>
<td>Collector / Collector</td>
<td>35’</td>
<td>30’ x 30’ corner clip</td>
</tr>
<tr>
<td>Collector / Arterial</td>
<td>35’</td>
<td>50’ x 50’ corner clip</td>
</tr>
<tr>
<td>Arterial / Arterial</td>
<td>40’</td>
<td>50’ x 50’ corner clip</td>
</tr>
</tbody>
</table>

* In such cases, areas where slower vehicle speeds are desired or high pedestrian traffic is expected, the City Manager may allow smaller turning radii. In areas where large vehicles will make frequent turning movements, the City Manager may require greater turning radii. The City Manager requirement shall be based on the advice of the City Engineer and upon consideration of all design solutions that effectively balance the interests of all users of the street. Actual centerline turning movements of typical vehicles, lane locations, intersection angles, or other geometric configurations of the specific intersection may be justifications for larger or smaller requirements.

**The City Engineer may determine ROW radii requirements based on the ultimate intersection type. The ROW radii shall have the same dimension on all corners of the intersection, based on the largest classification roadway at the intersection.
2.11.4 - ROW FLARES AT INTERSECTIONS

ROW flares at intersections shall be required to accommodate left and right turn lanes for any intersection with divided and undivided collectors and arterials. In addition, ROW flares at arterial intersections shall accommodate dual left turn lanes. ROW flares at all other intersections shall accommodate a single left turn lane with 12’ additional ROW. ROW tapers shall occur with respect to left and right turn lane tapers and median widening (if applicable) as shown in Figure below.

2.11.5 - FIRE APPARATUS ROAD RADII

The required inside turning radius of a fire apparatus access road shall be 30 feet. This requirement may be waived by the Fire Marshall in the event the requirement is impractical or prohibitive. Where this requirement may be impractical or prohibitive, it may be waived by the fire code official. If adjacent roadway travel lanes are 12’ or greater the following equation may be used to calculate an acceptable reduced radius:

\[
\text{Driveway Curb Radius} = 30' - (\text{Existing Lane Width} - 12')
\]

2.11.6 - SLOPE RESTRICTIONS

Intersections where perpendicular pedestrian crossings are required, by local or federal requirements, shall maintain a maximum roadway travel slope of two percent (2%) for a minimum distance of fifty feet (50’) upstream and downstream of any pedestrian crossing.

2.11.7 - PEDESTRIAN FACILITIES

1. Curb ramps meeting accessibility standards shall provide a direct, non-diverted approach from the sidewalk along the block, into the pedestrian crossing area.
2. All pedestrian crossings must meet accessibility standards.
3. A minimum of two pedestrian crossings with curb ramps must be provided at tee intersections. A minimum of three pedestrian crossings with curb ramps must be provided at cross intersections.

4. Pedestrian crossings of a Collector Street classification, or higher, shall have a crosswalk differentiated from the finished street surface by any combination of textured or colored paving, decorative pavers, paint, or other alternative material subject to approval by the City Manager.

5. Cross walks at mid-block locations shall be required for any block face that exceeds 600 feet.

6. Curb extensions shall be provided where pedestrian facilities cross multi-lane streets in high-pedestrian areas, to shorten pedestrian crossings and define on-street parking areas, or center pedestrian refuge islands where applicable.

7. Unless otherwise required by state/federal requirements, where pedestrian access routes are contained within a street right-of-way, the grade of pedestrian access routes shall not exceed the general grade established for the adjacent street. Where pedestrian access routes are not contained within a street or highway right-of-way, the grade of pedestrian access routes shall be five percent (5%) maximum.

8. All plans and specifications for construction of pedestrian facilities shall be in accordance with Texas Accessibility Standards (TAS), Americans with Disabilities Act (ADA), and Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-Of-Way (PROWAG) regulations. If the accessibility standards conflict with each other, the more restrictive standards shall govern.

9. The City of Boerne considers a sidewalk to be an “accessible route” as specified in Section 4.3 of the Texas Accessibility Standards (TAS) and considers a public sidewalk a “facility” under the TAS and the U.S. Department of Justice Americans with Disabilities Act (ADA) regulations at 28 C.F.R. Part 35. Sidewalks are subject to the requirements of Chapter 469 of the Texas Government Code as a City-funded public ROW project for Texas Department of Licensing and Registration (TDLR) inspection purposes (per 16 Texas Administrative Code, Chapter 68).

10. Enhanced pedestrian devices at crosswalks shall be provided for intersections within 1,500 feet of an elementary school or a middle school, a park, a senior center, or where the City Engineer deems necessary to provide for the enhanced safety of pedestrians at a crosswalk. A list of associated devices can be found in the TMUTCD and FHWA’s Guide for Improving Safety at Uncontrolled Crossing Locations, July 2018 or as amended.

2.11.8 - TRAFFIC SIGNALS

Traffic control signals should not be installed unless one or more of the signal warrants in the Texas Manual on Uniform Traffic Control Devices (TMUTCD) are met. The satisfaction of a warrant or warrants is not in itself justification for a signal. Information should be obtained by means of engineering studies and compared with the requirements set forth in the warrants. The engineering study should indicate the installation of a traffic signal will improve the overall safety and/or operation of the intersection. If these requirements are not met, a traffic signal should neither be put into operation nor continued in operation (if already installed).

Warrant Criteria - To justify the installation of a traffic signal, Part IV in the TMUTCD shall be followed. Part IV describes the warrants for a traffic signal installation and provides guidelines and requirements for the actual design and operation of a traffic signal.

Traffic Signal Spacing – Signal spacing is an important factor in being able to provide progressive flow for a platoon of traffic. Traffic signal spacing less than 1,300’ requires approval of the City Engineer.
Traffic Signal Design – All traffic signal designs shall at a minimum meet the guidelines in TxDOT’s current editions of TMUTCD; Traffic Signals Manual; Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges; and Traffic Standard Sheets.

Cost of Traffic Signal Installation - Traffic signals where a private driveway or a public street intersects with an Arterial or Collector thoroughfare – The developer is responsible for the total cost of designing and constructing a traffic signal that would only be warranted based on the full build out traffic generated by the development. The developer shall escrow funds for the construction cost of the traffic signal and the City shall construct the traffic signal at the time of development or when the development reaches a certain level of activity, as determined by the City Engineer.

Illuminated Street Name Signs - Illuminated Street Name Signs (ILSN) shall be used for every signalized intersection. An ILSN shall be installed on each dedicated street leg. Standard ILSN size is 10-foot by 18-inches and shall be installed on either a 30-foot signal pole or a 24-foot signal pole.

Roundabouts in lieu of traffic signals - The City reserves the right to install a roundabout in lieu of a traffic signal at any location referenced in Subsection above. In that case, any funds escrowed for a traffic signal according to Subsection above shall be used for the roundabout.

All traffic signal mast arm poles, pedestal poles, push button station poles, and APS push button assemblies shall be powder coated. The powder coat paint shall be “Traffic Black” or City Engineer approved equal.

Number of Heads – There shall be a signal head for each thru lane and right turn heads for any overlaps.

2.11.9 - ROUNDABOUTS

A. ROUNDABOUT DESCRIPTION

Roundabouts are circular intersections that create counterclockwise traffic movements around a central island with entering traffic yielding to circulating traffic. Every roundabout is unique but usually contain the following features shown below.

B. ROUNDABOUT DEFINITIONS

Central Island – The central island is the raised area in the center of the roundabout around which traffic circulates.

Splitter Island – The splitter island is a raised or painted area on an approach used to separate entering traffic from exiting traffic, to deflect and slow entering traffic, and to allow pedestrians to cross the road in two stages.

Circulatory Roadway – The circulatory roadway is the roadway that follows the traffic path adjacent to the Central Island. Flow of traffic in the circulatory roadway is counterclockwise.

Apron – An apron is the traversable portion of the central island adjacent to the circulatory roadway that may be needed to accommodate the wheel tracking of longer vehicles. The curb line is mountable, and the apron is typically reinforced stamped colored concrete.
Entrance Lane – The entrance lane is the point of entry from connecting roadways to the circulatory roadway. Entrance lane traffic must yield to circulatory roadway traffic coming from the left.

Accessible Pedestrian Crossing – In general, pedestrian crossings at roundabouts are discourage unless otherwise approved by the City Engineer. If pedestrian crossings are allowed, the crossing will use a two-step approach utilizing a splitter island. The crossing shall be setback from the entrance line and utilize an opening in the splitter island. The crossing must meet accessibility standards.

Landscaping Strip – A landscaping strip between the back of curb and the sidewalk shall be provided. The landscaping strip shall include a two-foot-wide colored stamped reinforced concrete mow strip adjacent to the curb and a six feet minimum wide landscape strip. The curb and gutter within the roundabout shall be surmountable.

Figure 2-1: Typical Roundabout

C. ROUNDABOUT DESIGN

The design of a roundabout is an iterative process considering multiple objectives and design elements including safety, operations, cost, uses, right of way, traffic volumes and other such items. Normally each roundabout will be unique in some way, so a standard roundabout is not included in the manual. Also, the various analysis and design considerations are beyond the scope of this manual. The resources shown in this section should be used when designing a roundabout. In addition to the resources shown, the roundabout design shall include the following design review process with the City Engineer and City Staff:
1. Have a pre-development meeting on the project which will include a separate meeting with the City Engineer for proposed roundabout design considerations.
2. Develop Preliminary layout of roundabout considering TIA and Pre-development meetings.
3. Preliminary Design review meeting with City Engineer.
4. Develop roundabout design based upon comments from the City Engineer.
5. City of Boerne fire truck (Smeal Aerial RM 105ft) shall be the design vehicle used to check function of roundabout without the use of the apron.
6. Roundabouts on intersections of collector or arterial roads shall be designed for apron width to accommodate a WB—67 truck.

D. ROUNDABOUT RESOURCES


2.11.10 - LEFT TURN, RIGHT TURN, DECELERATION LANES & MEDIANS

A. LEFT TURN LANES

At all intersections of Arterial and Collector thoroughfares, a separate left-turn lanes shall be constructed at the time of development, except where precluded by the proximity of a roundabout. Left turn lanes at site access points are required when projected turning movements are 5 vehicles or more per hour, as described in Section 4.2.3

1. Left-turn lanes are required for each street, or driveway, that connects to a median opening. The design of median openings and left-turn lanes shall accommodate potential future left-turn lanes that might serve undeveloped land.
2. All single left-turn lanes constructed on divided thoroughfares of ultimate cross section width shall be a minimum of eleven feet (11') wide for design speeds less than or equal to 40 mph. Where double left-turn lanes are provided, each left-turn lane shall be a minimum of ten feet (10') wide.
3. Minimum storage length is 150 feet for non-signalized intersections and 100 feet for signalized intersections. Storage requirements may be increased, or decreased, by the City Engineer based upon actual and projected traffic volumes or TIA storage demands of the properties that will be served by the left-turn lane.
4. Minimum taper length is 100 feet when located on collectors or arterials and 50 feet for all other roadways.
5. At a minimum, the length of the left turn lane shall be the combined length of the storage and deceleration lengths. The City Engineer may require additional length based on traffic volumes or TIA storage requirements discussed in the TIA.
6. Dual left turn lanes shall be required for all arterial/arterial intersections when peak hour turning volumes exceed 300 vehicles.
7. The radii at the beginning and end of the taper section shall be symmetric reverse curves with a minimum radius of 250 feet.
8. Deceleration length shall be based upon design speed as follows:

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Deceleration Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>300</td>
</tr>
<tr>
<td>30</td>
<td>400</td>
</tr>
<tr>
<td>40</td>
<td>500</td>
</tr>
<tr>
<td>50</td>
<td>600</td>
</tr>
<tr>
<td>60</td>
<td>700</td>
</tr>
</tbody>
</table>

Table 2-4: Left Turn Deceleration Length
### B. RIGHT TURN LANES

At all intersections of Arterial and Collector thoroughfares, a separate right-turn lane shall be constructed at the time of development, except where precluded by the proximity of a roundabout. Right turn lanes are required at street intersections at time of platting when projected turning movements are 50 vehicles or more per hour, as described in Section 4.2.3.

1. All right-turn storage areas shall be eleven feet (11’) wide.
2. Additional ROW shall be required adjacent to right-turn lanes so that there is typical parkway width per the road classification.
3. Minimum storage length is 30 feet.
4. Minimum deceleration length shall be same as that for a left-turn lane.
5. Minimum taper length is 100 feet when located on arterials and 50 feet for all other roadways.
6. The radii at the beginning and end of the taper section shall be a minimum of 515 feet.
7. A minimum tangent section of thirty feet (30’) shall be provided between the preceding driveway or cross street curb return and the taper of a right-turn lane.

### C. DECELERATION LANES

Deceleration lanes are required at any site access point when projected turning movements are 50 vehicles or more per hour, as described in Section 4.2.3. Deceleration lanes are also required at all non-residential and multi-family driveways located on Arterial and Collector thoroughfares with only one single lane in the direction of travel, except where precluded by the proximity of a roundabout.

1. All deceleration lane storage areas shall be eleven feet (11’) wide.
2. In locations where there will be less than ten feet (10’) of ROW adjacent to the deceleration lane, a street easement shall be dedicated such that the combination of ROW and street easement extends at least ten feet (10’) from the back of curb of the deceleration lane. Street easements shall extend along the street a minimum of forty feet (40’) beyond the far edge of the driveway to allow for utility connections.
3. Minimum storage length is 100 feet. Storage requirements may increase based upon actual and projected traffic demands.
4. Minimum taper length is 100 feet.
5. The radii at the beginning and end of the taper section shall be a minimum of 280 feet.
6. Where several successive driveways require exclusive deceleration lanes, and the driveway spacing is not adequate to avoid encroachment of the right turn lane on another driveway, a continuous right turn lane shall be used.
7. A minimum tangent section of thirty feet (30’) shall be provided between the preceding driveway or cross street curb return and the taper of a deceleration lane.
8. A tangent section is not required when a deceleration lane is immediately downstream from an intersecting Arterial or Collector thoroughfare.
9. Permitting for access points on TxDOT is at the discretion of TxDOT officials. Requirement for deceleration lanes for driveways located on TxDOT roadways may be waived if City receives notice from TxDOT that deceleration lane is not required.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Deceleration Length (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>215</td>
</tr>
<tr>
<td>Collector</td>
<td>275</td>
</tr>
<tr>
<td>Arterial</td>
<td>345</td>
</tr>
</tbody>
</table>
10. **Roundabout Exceptions** – On an approach to a roundabout, a deceleration lane shall not be installed for a driveway whose edge is less than two hundred eighty feet (280') upstream from the roundabout’s yield line. On a departure from a roundabout, a deceleration lane shall not be installed for a driveway whose edge is less than two hundred twenty feet (220’) downstream from the roundabout’s crosswalk. If the driveway’s edge is between two hundred twenty feet (220’) and two hundred seventy feet (270’) downstream from the roundabout’s crosswalk, a deceleration lane shall be installed with a storage of one hundred feet (100’) and a taper of seventy feet (70’).

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D. **MEDIANS**

1. Median openings shall be a minimum of 20 feet wider than the width of the driveway/street/access point throat width which they are serving. Regardless of driveway width, the minimum length of a full median opening shall be 60 feet and shall accommodate all the turning maneuvers of the design vehicle for which the driveway is designed.

2. The minimum length of a full median opening shall be of sufficient length so that concurrent turning maneuvers from exclusive left turn lanes serving the driveways on each side of the roadway do not conflict with each other.

3. The maximum length of a full median opening shall be limited so that the median opening serves only a single driveway on each side of the roadway. Turning movements of design vehicle shall be shown plan submittal.

4. The distance between medians along collector or arterial roadways shall comply with the spacing as defined by current TxDOT access spacing criteria for functional median spacing.

5. To accommodate for future turn lanes or median openings, the maximum cross slope across the median shall be 2% from the curb elevations. In areas where there is no future need for a median opening, the City Engineer may allow greater differential between median curb elevations.

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2.11.11 - **INTERSECTION VISIBILITY**

1. Proper lines of sight shall be maintained at all intersections. The proper line of sight shall be an unobstructed view from the stopping point to all points between thirty inches (30”) and nine feet (9’) above the centerline of the intersected street for a distance based on that streets design speed.

2. This sight distance is provided using Sight Line Triangles. Sight Line Triangles shall be provided where a driveway, an alley, or a stop-controlled thoroughfare intersects an uncontrolled thoroughfare and on any signalized intersection approach where right turn on red operation is permitted. No fence, wall, screen, sign, structure, utility box, foliage, hedge, tree, bush, shrub, berm, driveways, parking, drive aisles, or any other item, either man-made or natural shall be erected, planted, or maintained in a position that will obstruct or interfere with a driver’s clear line of sight within a sight line triangle. Power poles and streetlights are excluded from this restriction provided they maintain visibility. Sight Line Triangles that extend outside of the ROW shall be identified and dedicated as Visibility, Access, and Maintenance (VAM) Easements on the plat using City-approved VAM language.

3. The City has the right to prune or remove any vegetation within City right-of-way, including VAM easements, to abate a safety hazard and/or a nuisance.

4. Sight visibility triangles calculations shall assume the driver is 15 feet behind the curb line of the intersecting street; at-grade intersection with approaches of 3.0% or less; driver eye height is 3.5 feet above pavement; and, both drivers can see each other. AASHTO’s current edition of A Policy on Geometric Design of Highways and Streets shall be used to determine the sight visibility triangles.
5. The Intersection Sight Distance Table below provides the clear distances:

Table 2-5: Intersection Sight Distances

<table>
<thead>
<tr>
<th>Street Classification</th>
<th>Intersection Sight Distance (measured in feet along the centerline of intersecting street)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>335</td>
</tr>
<tr>
<td>Collector</td>
<td>445</td>
</tr>
<tr>
<td>Arterial</td>
<td>500</td>
</tr>
</tbody>
</table>

2.12 - INTERNAL SITE CIRCULATION REQUIREMENTS

All internal site circulation shall be designed and constructed in a way that preserves the health, safety, and welfare of the Public, as determined by the Director of Engineering & Mobility. This applies to all private and public infrastructure intended for the movement of pedestrians and all types of vehicles (including, but not limited to, cars, trucks, buses, trains, golf carts, bicycles, scooters, etc.).

2.12.1 - DRIVE-THRU FACILITIES AND STACKING SPACE

1. A drive-thru lane shall be a separate lane from the circulation routes and aisles necessary for ingress to or egress from the property or access to any off-street parking spaces.
2. Drive-thru restaurants and businesses shall be designed so that traffic queued up to use the business shall not block a fire lane, block required parking spaces, interfere with traffic circulation for other businesses, block a driveway entrance to the shopping center, nor back up into a public street.
3. All business uses containing an automobile drive-thru type ordering or service facility, whether manned or unmanned, shall provide automobile stack space in conjunction with the drive-in facility.
4. Required stack spaces shall not be on any street rights-of-way or alley, any necessary maneuvering area for parking spaces within the general traffic circulation pattern of a parking lot, or in a designated fire lane.
5. Stack space may be situated in a straight alignment or in a curved pattern with functional radii, which shall be measured along the centerline from the point of entry or the beginning of a drive-thru lane, to the center of the farthest service window area.
6. Drive-thru lanes shall be oriented to the ordering and pick-up or service area.
7. All stack space requirements shall be in addition to all parking spaces and loading requirements.
8. Off-street stacking spaces shall be a minimum of 10 feet by 20 feet in size and may not impede on- or off-site traffic movements or movements into or out of off-street parking spaces.
9. Off-street stacking spaces shall be provided as indicated in the following table:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Minimum Spaces</th>
<th>Measured From</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank Teller Lane</td>
<td>4</td>
<td>Teller or Window</td>
</tr>
<tr>
<td>Automated Teller Machine (ATM)</td>
<td>3</td>
<td>Teller or Window</td>
</tr>
<tr>
<td>Restaurant drive-thru</td>
<td>6</td>
<td>At or before order station</td>
</tr>
<tr>
<td>Restaurant drive-thru</td>
<td>4</td>
<td>between order station and pick-up window</td>
</tr>
<tr>
<td>Restaurant drive-thru</td>
<td>1</td>
<td>after last transaction window</td>
</tr>
<tr>
<td>Auto service facility stalls; vehicle repair and body shop stalls</td>
<td>2</td>
<td>entrance to stall</td>
</tr>
<tr>
<td>Car wash stall, self-service</td>
<td>3 per drying area and/or vacuum island</td>
<td>entrance to wash bay</td>
</tr>
<tr>
<td>Car wash stall, automatic</td>
<td>traffic queuing and circulation study, see note 13 below</td>
<td></td>
</tr>
<tr>
<td>Gasoline pump island</td>
<td>2</td>
<td>pump island</td>
</tr>
<tr>
<td>Daycares and School (public or private)</td>
<td>traffic queuing and circulation study, see note 14 below</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Determined by City Engineer</td>
<td></td>
</tr>
</tbody>
</table>

10. The Director of Engineering & Mobility may increase the amount of stacking spaces required on site based on the proposed development use. Proposed retail uses and drive-thru with historically high traffic volumes may have additional requirements to prevent congestion and backing up on the adjacent thoroughfare.

11. If the drive-thru has two (2) transaction windows, the required stacking distance between the order box and pick-up window shall be split between each of the windows.

12. An escape lane, with minimum of ten (10) foot width, shall be provided for any use containing a drive-thru facility. Escape lane shall provide access around the drive-thru facility.
13. All development requests and/or specific use permit requests for an automatic car wash shall include, at a minimum, a traffic circulation and queuing study. This study shall state the rate at which the car wash tunnel can process cars (per lane and total) and the rate at which the pay station can process cars (per lane and total), the smaller of which shall be the constraining service rate for the facility. The stacking spaces will be determined by a queuing analysis. The design of the site and the circulation plan shall ensure that car wash traffic does not back up onto any public street. The study shall provide two circulation plans that show how cars will enter, circulate, and leave the site (including the use of any detailing or vacuum stations). One circulation plan will be created for normal operations and another circulation plan will be created for peak operations when vehicles begin to stack up in a fire lane. The traffic circulation study shall include a statement that the owner and/or operator of the car wash agrees to operate the facility in accordance with the approved circulation plans. The circulation plans must be approved by the Director of Engineering & Mobility before the development request or the specific use permit can be approved.

14. All development requests and/or specific use permit requests for a daycare, Montessori school, private school, charter school, or public school shall include, at a minimum, a traffic circulation and queuing study. This study shall include the estimated maximum peak hour trip generation of the facility, the planned circulation of inbound and outbound traffic during drop-off and pick-up operations, and the estimated length of the queue of cars waiting to pick up students. The design of the site and the circulation plan shall ensure that school traffic does not back up onto any public street. The traffic circulation study shall include a statement that the owner and/or operator of the daycare or school agrees to operate the facility in accordance with the approved circulation plan. The circulation plan must be approved by the Director of Engineering & Mobility before the development request, or the specific use permit can be approved.
2.12.2 - THROAT LENGTH

1. Driveway length is important for safe and efficient traffic operation on the site and the adjacent roadway. The driveway throat needs to be of sufficient length so that the vehicles may enter, exit, and circulate on the site without interference with each other or with through traffic on the adjacent roadway.

2. Throat length shall be designed in accordance with the anticipated storage length for entering and existing vehicles to prevent vehicles from backing into the flow of traffic on the public street or causing unsafe conflicts with on-site circulation. Traffic volumes for the Peak Hour trips (PHT) should be assigned to the applicable driveways and the highest lane volume should be accommodated. In the absence of adequate traffic volumes and trip generation data, the minimum throat length, as measured from the ROW/property line to the first conflict or intersection with a parking aisle, shall not be less than the following table:

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Minimum Throat Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shopping Centers &gt; 200,000 GLA</td>
<td>200’ or as required by TIA</td>
</tr>
<tr>
<td>Or</td>
<td></td>
</tr>
<tr>
<td>Non-residential developments &gt; 400 PHT per driveway</td>
<td></td>
</tr>
<tr>
<td>Non-residential developments between 200 and 400 PHT per driveway</td>
<td>75’ or as required by TIA</td>
</tr>
<tr>
<td>Non-residential developments less than 200 PHT per driveway</td>
<td>40’</td>
</tr>
<tr>
<td>Or</td>
<td></td>
</tr>
<tr>
<td>Other driveways</td>
<td></td>
</tr>
<tr>
<td>Gated Residential (Private)</td>
<td>See EDM section 2.9 &amp; UDC section 7.5</td>
</tr>
</tbody>
</table>

3. The throat length may be reduced to no less than twenty (20) feet measured from the outside of the right-of-way by the City Manager by administrative exception if both the following items are met; driveways with less than 50 Peak Hour trips (PHT) and not located on an Arterial or Collector Roads.
3.1 - STANDARDS FOR PAVEMENT DESIGN

1. Pavements shall be designed using site specific soil and geologic design considerations to assure reasonable durability and economy of maintenance.
2. Proper documentation of the engineering and design techniques, and performance and maintenance data must be shown.
3. Approval of these designs shall be subject to the review of the City Engineer.

3.2 - MINIMUM PAVEMENT DESIGN STANDARDS

The pavement of all streets and alleys shall meet the minimum specifications in the following table:

Table 3-1: Minimum Pavement Design Standards (Over Compact Subgrade)

<table>
<thead>
<tr>
<th>Street Classification</th>
<th>Type D HMAC Surface Course (in.)</th>
<th>Crushed Limestone (in.); or</th>
<th>Asphalt Treated Base Course (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial</td>
<td>3 in.</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Collector</td>
<td>3 in.</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Local</td>
<td>2 in.</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Residential Alley</td>
<td>1.5 in.</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Commercial Alley</td>
<td>3 in.</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Bikeway / Path</td>
<td>Bikeway PATHS shall be, six (6) inches of cement stabilized crushed limestone base (2,500 – 3,000 psi), 1 ½ inches of asphaltic concrete over 6” crushed limestone base, or 4” of concrete over 2” crushed limestone base.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.2.1 - SOILS INVESTIGATION

1. The developer/subdivider shall, at his/her own expense, cause to be made a soils investigation by a qualified and independent geotechnical engineer licensed to practice in the State of Texas. The field investigation shall include test borings within the rights-of-way of all proposed streets. The number and locations of such borings shall be subject to the approval of the City Engineer, but in no cases will the spacing exceed 750 linear feet.

2. Atterberg limits and moisture contents shall be determined for all significant boring samples. The method used for these determinations shall be the same as that used by the Texas Department of Transportation using their latest Manual of Testing Procedures, 100-E Series test methods.

3. The results of the soils investigation shall be presented to the City Engineer in written report form.

4. Included as a part of the report shall be a graphical or tabular presentation of the boring data giving Atterberg limits and moisture contents, a soil description of the layers of different soils encountered in the profile of the hole, their limits in relation to a fixed surface datum, and such other information as needed to complete the soils investigation for pavement design purposes.

5. Minimum depth of soil profile boring holes shall be 10 feet unless solid rock formations are encountered sooner. Where cuts are required that exceed the minimum bore depth, bores will be continued to a depth of 5 feet below proposed roadway subgrade. Record the coordinates of the location and the surface elevation where the soil boring is being taken.

6. Bore holes must be filled or plugged to prevent injury to livestock or people in the area and to minimize the entry of surface water into the bore hole. If surface contamination of lower aquifers or cross contamination is a concern, the backfill material will be bentonite pellets or grout. Where borings penetrate asphalt and/or concrete, the borings must be patched with similar materials.

7. Any geotechnical activity within existing City of Boerne Right-of-Way (ROW) requires an approved ROW permit prior to commencing geotechnical investigation activities.

8. A subgrade verification letter is required to be provided by the Geotechnical Engineer following excavation activities. This letter shall state if the subgrades encountered during construction are consistent with the subgrades anticipated in the geotechnical report.
3.3 - PAVEMENT DESIGN LOADS

Pavement design shall be in accordance with the American Association of State Highway and Transportation Officials (AASHTO) Guide of Design of Pavement structures, latest approved edition. A table of minimum values is shown in Table 3-2, but the pavement designer shall increase the expected ESAL’s based on the results of a traffic study.

Table 3-2: Minimum Pavements Load Standards

<table>
<thead>
<tr>
<th>Street Classification</th>
<th>Total Equity 18 Kip Single Axle Load Applications</th>
<th>Reliability Level</th>
<th>Minimum Pavement Structure</th>
<th>Maximum Pavement Structure</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial</td>
<td>3,000,000</td>
<td>95</td>
<td>SN = 4.80</td>
<td>SN = 5.70</td>
<td>0.45</td>
</tr>
<tr>
<td>Primary/Secondary Collector</td>
<td>2,000,000</td>
<td>95</td>
<td>SN = 4.50</td>
<td>SN = 5.40</td>
<td>0.45</td>
</tr>
<tr>
<td>Neighborhood Collector</td>
<td>1,000,000</td>
<td>90</td>
<td>SN = 3.90</td>
<td>SN = 4.80</td>
<td>0.45</td>
</tr>
<tr>
<td>Neighborhood Local</td>
<td>500,000</td>
<td>80</td>
<td>SN = 3.20</td>
<td>SN = 4.10</td>
<td>0.45</td>
</tr>
<tr>
<td>Alley/Access</td>
<td>100,000</td>
<td>75</td>
<td>SN = 2.02</td>
<td>SN = 3.18</td>
<td>0.45</td>
</tr>
</tbody>
</table>

1. A written report containing pavement design data and recommendations based on the soils investigation shall be prepared at the subdivider’s expense by a qualified geotechnical engineer licensed to practice in the State of Texas and shall be presented to the subdivider and to the City Engineer. The soil investigation shall be submitted with the initial submittal of the infrastructure construction documents.
2. The design service life shall be a minimum of twenty (20) years.
3. The initial serviceability ($p_i$) shall be 4.2 for flexible pavements.
4. The terminal serviceability ($p_t$) shall be 2.0 for local street and 2.5 for collector and arterial streets.
5. The report shall state the load criteria and the soil classifications used.
6. Where the plasticity index of the sub grade soil (regardless of if the soil is in-situ or fill material) on which the street is to be built is in excess of 20, the pavement design shall include lime subgrade stabilization, unless approved otherwise by the City Engineer.
7. When sub grade soils are stabilized the minimum depth of stabilization shall be eight (8) inches unless otherwise approved by the City Engineer. In the stabilization of swelling clay soils, the stabilizer used shall be hydrated lime. Application rate of lime shall be determined based upon laboratory testing. The lime shall be applied to the sub grade soil in slurry form unless otherwise approved by the City Engineer.
8. Base material and the stabilized layer, if used, shall extend at least 18 inches behind of the back of the curb.
9. Where the roadbed is in a milled rock excavation a "structural layer" within the pavement design calculations can be used that is equivalent to a structural layer for lime stabilized subgrade. If a roadbed structural layer is used in the pavement calculation for rock subgrade an engineering report will be provided to City Engineer addressing the consistency of the subgrade prior to base placement.
10. Geogrid (Tensar Tx-5 or equal, as approved by City Engineer) layers may be used, however, if the subgrade’s PI is greater than 20, lime treatment is still required. A structural credit may be given to the aggregate base course that is mechanically stabilized with tri-axial geogrid material.

11. Pavement sections shall be designed in accordance with the above listed criteria and at no time shall the street structural layers be less than the following:
   a. Dense-Graded wearing (Surface) Course HMAC (TxDOT item 340, type “D”) (Sc = 0.44)
   b. Crushed Limestone Base (Sc = 0.14)
   c. Crushed Limestone Base with tri-axial geogrid base reinforcement (Sc = 0.17)
   d. Asphalt Treated Base Course (TxDOT item 292, Grade 1) (Sc = 0.38)
   e. Lime Subgrade Stabilization (Sc = 0.08)

### 3.4 - PAVEMENT SUB-SURFACE DRAINAGE

Moisture and soil subgrade support play an important role in asphalt concrete (flexible) pavements, since they are flexible pavements that transmit much greater stresses to the subgrade.

Additional roadway sub-surface drainage design is required in areas such as median and landscape islands within the travel lanes, roadways adjacent to residential or greenbelts with irrigation systems, stormwater facilities adjacent to roadways, or natural springs. Geotechnical Engineer shall address this condition in their report and propose alternate moisture/root barrier that is acceptable to the City Engineer.

These items to minimize sub-surface water into the pavement section include the following available options:

1. Curbs that penetrate thru the base section a minimum of six (6) inches.
2. Sub-surface drainage systems
3. Edge drains
4. Vertical moisture barriers
CHAPTER 4 - TRAFFIC IMPACT ANALYSIS REQUIREMENTS

4.1 - TRAFFIC IMPACT ANALYSIS – PROCESS AND DEFINITIONS

No Master Development Plan, subdivision plat, development plat, Infrastructure Documents, change in zoning, Planned Unit Development (PUD) submission, or building permit application, shall be approved unless a Traffic Impact Analysis (TIA) or peak hour trip (PHT) generation form is completed and approved.

If the TIA indicates that traffic volumes will significantly impact the capacity and/or safety of the transportation network, it may be necessary of the development to obtain ROW for off-site, abutting, and internal thoroughfares to support new development at the time of platting or development of the land.

4.1.1 - TIA THRESHOLD AND CATEGORIES

TIA Thresholds and Categories are defined in Chapter 2.8 of the UDC.

4.1.2 - TIA PROCESS OVERVIEW

A summary of the process is shown in Figure 4-1.

Figure 4-1: TIA Process Flow Chart
4.1.3 - IMPACT AREA

The impact area is the area within which any analysis is conducted to determine compliance with the level of service standards. This area shall be based on the distribution patterns of the PHTs projected to be generated by the proposed development. The specific intersections for analysis will be established in coordination with City staff during the scoping process as outlined in Section 4.2. The impact area is defined as those intersections within two (2) miles of the boundary of the site, measured along the roadway network (e.g., travel path).

Figure 4-2 presents an example site distribution exhibit.

Figure 4-3 presents an example site trip assignment exhibit that demonstrates the study intersection selection process.
Figure 4-2: Site Distribution Example
Figure 4-3: Site Trip Assignment Example

[Diagram showing a site trip assignment example with labeled intersections and turning movements.]

<table>
<thead>
<tr>
<th>Land Uses</th>
<th>Amount</th>
<th>Units</th>
<th>ITB Code</th>
<th>Daily One-Way Trips</th>
<th>AM Peak Hour One-Way Trips</th>
<th>PM Peak Hour One-Way Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Use Name</td>
<td>100</td>
<td>Units</td>
<td>000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Trips</td>
<td>2,832</td>
<td></td>
<td></td>
<td>96</td>
<td>169</td>
<td>222</td>
</tr>
</tbody>
</table>

TRIP ASSIGNMENT
4.1.4 - TIA LONGEVITY

If a development is being incrementally implemented in general conformance with the TIA, a TIA will remain valid for five (5) years beyond the projected build out year of the last phase of the development, provided significant changes in the development proposal or surrounding conditions have not occurred. General conformance is defined as trip generation characteristics that do not increase by more than 10% than the uses originally proposed.

At the discretion of the City Engineer, the TIA shall be revised if the proposed land use is changed by type or size, if existing conditions have changed enough to invalidate the TIA results, or if the initial TIA assumptions are no longer valid.

4.2 - TIA SCOPING PROCESS

The purpose of the TIA scoping process is to establish the TIA requirements in accordance with generally accepted practice, as described in the most recent edition of Transportation Impact Analysis for Site Development: An ITE Recommended Practice.

Prior to the preparation of the TIA, the property owner or their representative shall coordinate with City staff to determine whether a TIA will be required and, if required, to establish the scope of the TIA.

To determine if a TIA is required the applicant shall complete the Peak Hour Trip Generation Form using the current edition of the ITE Trip Generation Manual.

If the development generates less than 100 peak hour trips and does not have 5 or more inbound vehicles during the peak period, the applicant should complete the Border Street Worksheet and submit it and the Peak Hour Trip Generation Form to the City for review. A TIA is not required.

If the development generates less than 100 peak hour trips and has 5 or more inbound vehicles during the peak period, the applicant should complete the Turn Lane Evaluation Worksheet and Border Street Worksheet and submit these two documents along with the PHT Generation Form to the City for review. A TIA is not required.

If the development generates more than 100 peak hour trips a TIA is required and the applicant should complete the TIA Scoping Meeting Worksheet. TIA Scoping Meeting Worksheet provides a framework for establishing the parameters of the TIA. Including:

1. Build Out Year
2. Proposed Phasing
3. Background Traffic Growth Rate
4. Peak Periods for Analysis
5. Proposed Trip Distribution
6. Proposed Trip Assignment
7. Intersections for Analysis

Additional detail on the forms and worksheets identified above can be found in this section.
4.2.1 - PEAK HOUR TRIP (PHT) GENERATION FORM

Complete the PHT Generation Form using the most recent edition of the ITE Trip Generation Manual. Typically, the peaks for evaluation will be AM and PM peak periods of the adjacent road. If the subject tract or driveway includes developed property, include all existing and proposed trips shown in separate categories on the form.

The other peak period section on the worksheet should be utilized if the two highest peaks for the development are not traditional AM and PM peak periods. For example, retail uses typically experience the greatest peak on Saturday. Therefore, the analysis peaks for a use that was primarily retail would be PM and Saturday peak hours. Analysis for a school should include the AM peak and PM peak hour of the generator (corresponding with the afternoon school release).

An example of a completed PHT Generation Form is included as Figure 4-4. A trip generation form is available on the City of Boerne website and in the appendix of this document. Appendix D contains a quick reference of trip generation rates for the most common land uses to aid in completion of this form.

4.2.2 - BORDER STREET WORKSHEET

The purpose of the border street worksheet is to aid the applicant in determining right-of-way (ROW) and border street construction requirements that may apply. A border street worksheet should be prepared for each adjacent street – existing or designated on the Major Thoroughfare Plan (MTP).

An example of a completed Border Street Worksheet is included as Figure 4-5. A blank Border Street Worksheet is available on the City of Boerne website and in Appendix E.

4.2.3 - TURN LANE EVALUATION WORKSHEET

A right or left turn lane is required when projected turning movements are 5 vehicles or more per hour to facilitate the turning movement with limited impact to through traffic. It is possible that a development that does not require the preparation of a TIA might still necessitate the construction of a turn lane. To determine if a turn lane is required the applicant shall prepare a sketch indicating the location of the proposed site access and perform a distribution and assignment of site trips.

An example of a completed Turn Lane Evaluation Worksheet is included as Figure 4-6. A blank worksheet is available on the City of Boerne website and in Appendix E.

4.2.4 - TIA CONSISTENCY WORKSHEET

If a Traffic impact Analysis was previously approved and the proposed peak hour trips is less than or equal to the amount assumed in the original TIA, a Consistency Worksheet shall be provided. The Consistency Worksheet is attached as an exhibit to this manual and an example is included as Figure 4-7.
**4.2.5 - TIA SCOPING MEETING WORKSHEET**

If a TIA is required, the applicant shall complete a TIA scoping meeting worksheet to summarize the proposed parameters of the TIA which are described below:

1. **Build Out Year.** The maximum allowable single phase buildout year is five (5) years from the existing traffic scenario. If the development will take longer than five (5) years to build out, interim phases must be analyzed.
2. **TIA Phasing.** If a development will take longer than five (5) years to build out interim phases must be established in increments of five (5) years or less.
3. **Background Traffic Growth Rate.** The background traffic growth rate will be established based on an average of five (5) years of TxDOT traffic count data collected at a location near the site. If the City provides specific development information as submitted in other TIAs for nearby development, the background traffic growth rate may be reduced.
4. **Peak Periods for Analysis.** The TIA shall analyze the two (2) peak periods in which the development generates the greatest peak hour trips. While this will typically be the AM peak period (one hour between 7AM and 9AM) and PM peak period (one hour between 4PM and 6PM) that corresponds with a traditional “rush hour,” for land uses with a heavy retail component this could be a Saturday midday peak period (12PM – 2PM). For special land uses such as a church or event center, the peak period of concern shall be identified during the scoping process. Traffic counts may not be collected on weeks that include a school holiday, or the summer unless approved by the City Engineer.
5. **Trip Distribution.** The applicant shall propose a trip distribution consistent with area traffic patterns and present the information graphically as part of the TIA scoping process.
6. **Trip Assignment.** Based on the trip distribution the peak hour trips associated with the development shall be assigned to the roadway network. Trip assignment should be presented graphically for all collector or higher classification intersections through which site trips travel within two (2) miles of the boundary of the project site along the roadway network.
7. **Intersections for Analysis.** Intersections for analysis will be those where there are 75 or more site trips (inbound and outbound combined) on any single signalized approach or 50 or more trips on a stop-controlled approach. This will be determined using the Site Trip Assignment figure.
8. **City Engineer may choose to waive TIA requirements if no off-site intersections are identified within the study limits.** A turn lane evaluation worksheet shall be submitted for the site.

Figures depicting the trip distribution and assignment shall be submitted with the TIA scoping meeting worksheet.

A blank worksheet is available on the City of Boerne website and in Appendix E.
**PEAK HOUR TRIP GENERATION FORM**  
City of Boerne, Texas

Complete this worksheet as requirements for Zoning, Master Plan, Infrastructure Documents LOC, and Building Permit submittals. If trips exceed the thresholds provided in the Engineering Design Manual, a Traffic Impact Analysis (TIA) or other traffic documents must be prepared. Prior to preparing a TIA, contact Engineering and Mobility to schedule a TIA Scoping Meeting.

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Example Site</th>
<th>Preparer Name:</th>
<th>Engineer Name</th>
<th>Preparer Email:</th>
<th>Engineer Email</th>
<th>Preparer Phone #:</th>
<th>Engineer Phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal Description:</td>
<td>Legal Description</td>
<td>Date:</td>
<td>03/20/23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Type of Application:** Infrastructure Documents LOC

<table>
<thead>
<tr>
<th>ITE Code</th>
<th>Land Use</th>
<th>Variable</th>
<th>Density</th>
<th>AM Peak Hour Rate</th>
<th>AM Total Trips</th>
<th>AM In</th>
<th>AM Out</th>
<th>PM Peak Hour Rate</th>
<th>PM Total Trips</th>
<th>PM In</th>
<th>PM Out</th>
<th>Other Peak Hour Rate</th>
<th>Other Total</th>
<th>Other In</th>
<th>Other Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>710</td>
<td>General Office Building</td>
<td>1,000 SF</td>
<td>20</td>
<td>1.16</td>
<td>23</td>
<td>20</td>
<td>3</td>
<td>1.15</td>
<td>23</td>
<td>4</td>
<td>19</td>
<td>0.53</td>
<td>11</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

| Proposed |                  |          |         |                   |                |       |        |                   |                |       |        |                     |            |         |          |
| 930      | Fast Casual Restaurant | 1,000 SF | 5       | 2.07              | 10             | 7     | 3      | 14.13             | 71             | 39    | 32     | 14.02               | 170        | 94      | 77       |

| Total     |                  |          |         |                   |                |       |        |                   |                |       |        |                     |            |         |          |
| 34        | 27               | 7       | 94      | 43               | 51             | 181   | 99     | 81               |                |       |        |                     |            |         |          |

**Peak Period:** SAT/SUN  
**Peak Hour Trips:** 181  
**TIA Required:** YES  
**Turn Lane Evaluation Required:** YES
Border Street Worksheet
City of Boerne, Texas

Project Name: Project Example
Preparer Name: Engineer Name
Legal Description: Legal Description Example
Preparer Email: Engineer Email
Date: 03/20/23
Preparer Phone #: Engineer Phone

Type of Application: Master Plan

Adjacent Street Name: Street A
MTP Classification: Collector

Development Frontage?
Yes
No

Centerline

Pavement Width
30'

Right-of-way Width
34'

Pavement Widening (ft)
4'

ROW Dedication (ft)
7'

Reviewed By

Worksheet Last Updated: 3/20/2023
## Turn Lane Evaluation Worksheet

City of Boerne, Texas

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Example Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legal Description:</td>
<td>Example Legal Description</td>
</tr>
<tr>
<td>Date:</td>
<td>March 20, 2023</td>
</tr>
<tr>
<td>Preparer Name:</td>
<td>Engineer Name</td>
</tr>
<tr>
<td>Preparer Email:</td>
<td>Engineer Email</td>
</tr>
<tr>
<td>Preparer Phone #:</td>
<td>Engineer Phone</td>
</tr>
<tr>
<td>Type of Application:</td>
<td>Master Plan</td>
</tr>
</tbody>
</table>

| Peak Period: | AM |
| Land Use(s): | Single-Family Residential, Attached, General Office |
| Total PHT: | 58 |
| Inbound Volume: | 82 |

Provide depiction of turning movements:

![Diagram of Turning Movements](image)

Reviewed By

Worksheet Last Updated: 3/20/2023
**TIA CONSISTENCY WORKSHEET**

City of Boerne, Texas

Complete this worksheet as requirements for Zoning, Master Plan, Infrastructure Documents LOC, and Building Permit submittals. If trips exceed the thresholds provided in the Engineering Design Manual, a Traffic Impact Analysis (TIA) must be prepared. Contact Engineering and Mobility to schedule a TIA Scoping Meeting.

**Project Name:** Project Example  
**Legal Description:** Legal Description Example

| Date | 2/20/2023 |

**Title on Previously Approved TIA:** TIA for Example Project  
**Date on Previously Approved TIA:** 3/1/2019

**Preparer Name:** Engineer Name  
**Preparer Email:** Engineer Email  
**Preparer Phone #:** Engineer Phone

<table>
<thead>
<tr>
<th>ITE Code</th>
<th>Land Use</th>
<th>Variable</th>
<th>Density</th>
<th>AM Peak Hour Rate</th>
<th>AM Total Trips</th>
<th>AM In</th>
<th>AM Out</th>
<th>PM Peak Hour Rate</th>
<th>PM Total Trips</th>
<th>PM In</th>
<th>PM Out</th>
<th>Other Peak Hour Rate</th>
<th>Other Total</th>
<th>Other In</th>
<th>Other Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>210</td>
<td>Single-Family Detached Housing</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>400</td>
<td>0.74</td>
<td>333</td>
<td>83</td>
<td>250</td>
<td>0.99</td>
<td>446</td>
<td>281</td>
<td>165</td>
<td>0.93</td>
<td>419</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TOTAL ALLOWED TRIPS = 333</td>
<td>83</td>
<td>250</td>
<td>446</td>
<td>281</td>
<td>165</td>
<td>419</td>
<td>226</td>
<td>193</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>TOTAL EXISTING TRIPS = 260</td>
<td>56</td>
<td>130</td>
<td>267</td>
<td>168</td>
<td>99</td>
<td>251</td>
<td>138</td>
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<td>TOTAL PROPOSED TRIPS =</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td>ALLOWED = 333</td>
<td>83</td>
<td>250</td>
<td>446</td>
<td>281</td>
<td>165</td>
<td>419</td>
<td>226</td>
<td>193</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td>EXISTING + PROPOSED = 274</td>
<td>68</td>
<td>205</td>
<td>366</td>
<td>231</td>
<td>136</td>
<td>344</td>
<td>186</td>
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<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TRIPS REMAINING = 55</td>
<td>15</td>
<td>44</td>
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<td>23</td>
<td>74</td>
<td>40</td>
<td>34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Does the existing + proposed trips exceed the allowed trips by 10%?  No

<table>
<thead>
<tr>
<th>Description of Mitigation</th>
<th>Unit</th>
<th>Total Pct</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Left Turn Lane on Example Road</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>2. Traffic Signal on Example Road</td>
<td>5</td>
<td>300</td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reviewed/Approved by (City of Boerne): 

File Reference: Last Updated March 2023
4.3 - MITIGATION REQUIREMENTS

Roadways and intersections, within the study area, that are expected to operate at level of service D, E, or F, under traffic conditions including projected traffic plus site-generated traffic must be identified and viable recommendations made for raising the traffic conditions to level of service C or better. If the existing level of service is already below LOS C, the intersection must be mitigated to within 10% of the projected background delay value. For signalized intersections this is quantified as the overall intersection level of service. For unsignalized intersections, delay is measured by approach.

Traffic mitigation tools include, but are not limited to, pavement widening, turn lanes, median islands, access controls, curbs, sidewalks, traffic signalization, traffic signing, pavement markings, etc.

4.3.1 - PHASING OF MITIGATION

For projects where the required mitigation will not be constructed entirely with initial phase, a detailed mitigation phasing plan shall be provided within the report that lists the proposed mitigation items and the trip volume that generate each mitigation item.

Plats for project phases after a phase for which a traffic improvement is required may be approved only if the traffic improvements are completed.

4.3.2 - LIMITATIONS ON TRAFFIC IMPACT MITIGATION

Voluntary effort beyond those required to mitigate traffic impacts are encouraged as a means of providing enhanced traffic handling capabilities to users of the land development site as well as others.

If the City finds that there is little opportunity to expand transportation capacity in the established central core of the City, without destroying the city's historic built environment, the development may be exempt from certain provisions of this manual. This exemption may also apply outside the historic core if there are no viable improvements possible at a study intersection.

4.4 - ROADWAY CLASSIFICATION AND CAPACITY

The internal site roadways shall be sized appropriately to support the trips associated with the development. Roadway capacities and other roadway design characteristics are outlined in Chapter 7 of the Unified Development Code. Where projecting streets provide connectivity to an adjacent parcel, engineering judgement shall be used to establish an estimated amount of traffic that would utilize that connection and thereby the internal street network of the development. The following series of figures demonstrates the roadway classification and capacity determination process. A similar series of figures should be prepared as part of the TIA process.
Figure 4-7: Roadway Classification Example – Unit Density Distribution

Figure 4-8: Roadway Classification Example – Assignment of Trips
4.5 - ROUGH PROPORTIONALITY

If the City requires as a condition of approval that the developer bear a portion of the costs of infrastructure improvements, the developer’s portion of the costs may not exceed the amount required for infrastructure improvements that are roughly proportionate to the proposed development. Improvements that are for the specific project (project driveways, required turn and/or deceleration lanes at project driveways, etc.) and not for the benefit of the overall transportation network shall not be included within the rough proportionality determination.

To facilitate the calculation of the proportionate share, the City has developed a worksheet. That worksheet is available on the City website and was developed based on the methodology outline below.

A developer who disputes the determination may appeal to the City through the City Manager within 30 days of the rough proportionality determination. A developer may further appeal the determination of the City Manager to the City Council. At the City Council appeal, the developer may present evidence and testimony under procedures adopted by the City Council. After hearing any testimony and reviewing the evidence, the City Council shall make the applicable determination within 30 days following the final submission of any testimony or evidence by the developer.
4.5.1 ROUGH PROPORTIONALITY METHODOLOGY

Traffic generation of new development impacts the area roadway system by using available capacity. To measure system impacts, an analysis using vehicle-miles of travel in the PM peak hour is conducted. Using vehicle-miles of travel, the capacity provided by roadway improvements can be compared with the traffic generated by a proposed development. For roadway improvements, supply (vehicle-miles) is determined by multiplying the length of the facility by its available capacity. Capacity values are based on generalized criteria from the Highway Capacity Manual (HCM). For site traffic generation, demand (vehicle-miles) is determined by multiplying an appropriate trip rate for a specific use by an average trip length associated with such use. Trip generation rates and resulting trip estimates are found in the Institute of Transportation Engineers (ITE) publication entitled Trip Generation, 10th Edition. Trip length information is derived information from a data that analyzes Home-Work trips as well as aerial photography determining route choice.

Using this supply and demand information, a comparison can be made to determine the rough proportional impact. The analysis consists of four steps:

**Step 1: Identify Proposed Development and Roadway Improvements**

*Proposed Development:* Based upon information provided by the applicant, the proposed development will ultimately consist of the following land use:

*Proposed Roadway Improvements:* The proposed roadway improvements for the development consist of the following (based upon the currently adopted Major Thoroughfare Plan):

**Step 2: Demand Calculation**

*Projected Demand of Proposed Site*

The projected vehicle-miles of demand are calculated by multiplying the proposed size of development by its appropriate trip rate and trip length. The PM peak hour trip rate per XXX land use is XXX vehicles per hour. This trip rate results in approximately XXX PM peak hour trips for the facility. No additional reduction was applied for pass-by trips.

Trip length data from the XXXXXXX represents that the average home to work trip is XXXX miles, however, this was adjusted to account for the trip end associated with the site and limited to travel on city roadways. The resulting average trip length is approximately XXX miles (average trip length to/from XXXXXX).

**Step 3: Supply Calculation**

This calculation determines the vehicle-miles of supply provided by the proposed roadway improvements and is based on length of improvement and hourly roadway capacity values. Capacity values are based on an area type of suburban residential resulting in hourly capacity values of XXX vehicles per hour per lane (vphpl).

**Step 4: Calculate Rough Proportional Impact**

The calculation determines the rough proportional impact of the proposed development on the roadway system.
Step 4: Proportionality Calculation Results

A comparison of projected demand of the site relative to the roadway supply being provided reveals that the projected demand exceeds the capacity supplied.

\[ XXXX \text{vm}_d > \text{or} < XXXX \text{vm}_s \text{[~XXX%]} \]

The purpose of this evaluation is to assess the impacts of the proposed development on the City roadway system and to determine the roughly proportional supply of roadway capacity necessary to address the added demand. The analysis reveals that the City is OR is not justified in having the developer construct.

4.5.2 - ROUGH PROPORTIONALITY WORKSHEET

The City of Boerne developed a spreadsheet-based tool to facilitate the rough proportionality determination process. The current version of the worksheet is based on the 10th Edition of the Institute of Transportation Engineers Trip Generation Manual and the roadway cross sections and thoroughfare plan designations, current edition. The City will provide periodic updates to the worksheet and post the most recent version on City website for easy access.
CHAPTER 5 - DRAINAGE DESIGN REQUIREMENTS

5.1 - GENERAL

This section contains the minimum storm drainage design criteria to be followed in the design of storm drainage facilities and demonstrates the design procedures to be used on drainage projects in the City of Boerne.

Drainage facilities shall be provided and constructed in accordance with the City Drainage Design Standards and Construction Specifications.

The design factors, formulas, graphs, and procedures described are intended to serve as guidelines. Responsibility for the actual design remains with the Engineer.

It is the responsibility of the Engineer to provide all necessary calculations and designs described herein. The Engineer shall provide the City the data, calculations, and designs necessary to demonstrate the design does not adversely impact the surrounding or downstream property and meet local, state, and federal rules, regulations, and requirements.

The Engineer shall use available (FEMA, SARA, City) base models updated with Atlas 14 rainfall data for development along local or FEMA floodplain areas. If a model is not available, the Engineer shall be required to provide a floodplain model in accordance with city standards and guidelines.

5.1.1 - NRCS FLOOD CONTROL DAMS

There are several Natural Resources Conservation Service (NRCS) assisted watershed dams and lakes within the extraterritorial jurisdiction of the city. These dams and lakes were constructed to NRCS (previously Soil Conservation Service) and TCEQ standards. See UDC Section 8.1(D)(8)) for requirements for projects that impact or are impacted by these NRCS dams.

5.2 - DETERMINING DESIGN DISCHARGE

Impervious cover assumptions for all sites shall use the maximum allowed impervious cover per zoning category or land use category as provided in Section 8 of the UDC for all drainage calculations regardless of the site plan being known or unknown.

The method of computing runoff shall be the Rational Method for watersheds of 25 acres or less that do not require detention or timing considerations. For watersheds with an area greater than 25 acres, or where routing of hydrographs is required, or building drainage-related facilities on major drainage courses, a unit hydrograph prepared with computer model, as described below, shall be used.

In all cases, average antecedent conditions shall be assumed unless otherwise determined by the City Engineer.

Proposed conditions watershed areas must be based upon proposed grading patterns.
Ultimate condition runoff computations shall be based upon fully developed watershed conditions in accordance with the future land use projections in the City’s Comprehensive Plan. The Engineer shall size drainage facilities by disregarding the detention effects of upstream property and calculating the runoff as if the off-site property was developed without any detention. If an existing NRCS regional detention facility is upstream the Engineer may size downstream drainage facilities based on consideration of the detention effects of the existing regional facility.

5.2.1 - RATIONAL METHOD

The following parameters shall be used for runoff calculations by the Rational Method:

The Rational Method shall use the following formula:

\[
Q = CC_f IA
\]

Where:

- \( Q \) = the flow at the discharge of the watershed, cubic feet per second (cfs).
- \( C \) = the runoff coefficient, dimensionless, from Table 5-1 or Table 5-2
- \( C_f \) = runoff coefficient adjustment factor from Table 5-3.
- \( I \) = rainfall intensity, inches per hour, from Table 5-6
- \( A \) = watershed area, acres.

A. RUNOFF COEFFICIENTS

All sites shall use runoff coefficients based on specific land use established by the Zoning Districts according to Table 5-1 below.

A composite runoff coefficient for pre-existing condition shall be based on the percentages of different types of surfaces in the drainage area according to Table 5-2 below.

Runoff coefficients given in Table 5-1 are valid for storms up to and including the 10-year storm. Use the adjustment factor in 2 for other storm frequencies.

Runoff coefficients based on Hydrologic Soil Group given in 3 shall be used for areas where LID features are incorporated in the site design.
<table>
<thead>
<tr>
<th>Zoning District</th>
<th>Impervious Cover (%) (UDC 8.2)</th>
<th>Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Up to 2%</td>
</tr>
<tr>
<td>RAG</td>
<td>10</td>
<td>0.31</td>
</tr>
<tr>
<td>Agricultural and Rural Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMA</td>
<td>25</td>
<td>0.40</td>
</tr>
<tr>
<td>Manor Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RE</td>
<td>45</td>
<td>0.51</td>
</tr>
<tr>
<td>Estate Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1-L</td>
<td>45</td>
<td>0.51</td>
</tr>
<tr>
<td>Low Density Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R1-S</td>
<td>60</td>
<td>0.60</td>
</tr>
<tr>
<td>Medium Density Residential</td>
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<td></td>
</tr>
<tr>
<td>R2-N</td>
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<td>0.60</td>
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<tr>
<td>Neighborhood Residential</td>
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<td></td>
</tr>
<tr>
<td>R2-M</td>
<td>60</td>
<td>0.60</td>
</tr>
<tr>
<td>Moderate Density Residential</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R3-A</td>
<td>85</td>
<td>0.74</td>
</tr>
<tr>
<td>Attached Residential</td>
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<td></td>
</tr>
<tr>
<td>R3-D</td>
<td>50</td>
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<tr>
<td>Duplex Residential</td>
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<tr>
<td>R3-M</td>
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<td>0.66</td>
</tr>
<tr>
<td>Multi-Unit Residential</td>
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<td></td>
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<td>R-4B</td>
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<td>0.66</td>
</tr>
<tr>
<td>Bungalow Courts</td>
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<td></td>
</tr>
<tr>
<td>R4-H</td>
<td>75</td>
<td>0.69</td>
</tr>
<tr>
<td>Horizontal multi-Family</td>
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<td></td>
</tr>
<tr>
<td>R4-L</td>
<td>85</td>
<td>0.74</td>
</tr>
<tr>
<td>Low Density Multifamily Residential</td>
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<td></td>
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<tr>
<td>R4-U</td>
<td>85</td>
<td>0.74</td>
</tr>
<tr>
<td>Urban Multifamily Residential</td>
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<td>RMHC</td>
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</tr>
<tr>
<td>Manufactured Home Communities</td>
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<td></td>
</tr>
</tbody>
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Table 5-1: Rational Method Runoff Coefficients by Zoning District
<table>
<thead>
<tr>
<th>Code</th>
<th>District Type</th>
<th>Average</th>
<th>S</th>
<th>0.66</th>
<th>0.69</th>
<th>0.71</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Neighborhood Commercial</td>
<td>75</td>
<td></td>
<td></td>
<td>0.69</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>Transitional Commercial</td>
<td>80</td>
<td></td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3</td>
<td>Community Commercial</td>
<td>85</td>
<td></td>
<td>0.74</td>
<td>0.76</td>
<td>0.77</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>Regional Commercial</td>
<td>85</td>
<td></td>
<td>0.74</td>
<td>0.76</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>O1</td>
<td>Community Office</td>
<td>75</td>
<td></td>
<td>0.69</td>
<td>0.71</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O2</td>
<td>Office Park</td>
<td>80</td>
<td></td>
<td>0.71</td>
<td>0.73</td>
<td>0.75</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>O3</td>
<td>Industrial Office</td>
<td>85</td>
<td></td>
<td>0.74</td>
<td>0.76</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I1</td>
<td>Storage and Transportation</td>
<td>85</td>
<td></td>
<td>0.74</td>
<td>0.76</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I2</td>
<td>Craft Industry</td>
<td>85</td>
<td></td>
<td>0.74</td>
<td>0.76</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>I3</td>
<td>Light Industrial</td>
<td>70</td>
<td></td>
<td>0.66</td>
<td>0.69</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I4</td>
<td>General Industrial</td>
<td>70</td>
<td></td>
<td>0.66</td>
<td>0.69</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CIV</td>
<td>Civic and Institutional</td>
<td>70</td>
<td></td>
<td>0.66</td>
<td>0.69</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOL</td>
<td>Interim Holding</td>
<td>10</td>
<td></td>
<td>0.31</td>
<td>0.40</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Notes:
1. Average expected impervious cover is indicated, if impervious cover of development will differ because of overlay zoning or other conditions, alternative factors may be used when justified to the satisfaction of the City Engineer in the drainage report.
2. Areas included within parks, green belts, or local/regulatory floodplains shall be considered to remain undeveloped per this table.
3. Pavement and sidewalks within public right-of-way (ROW) are not included within these values.
<table>
<thead>
<tr>
<th>Character of Surface</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Developed Areas</strong></td>
<td></td>
</tr>
<tr>
<td>Asphaltic</td>
<td>0.81</td>
</tr>
<tr>
<td>Concrete or Roof</td>
<td>0.83</td>
</tr>
<tr>
<td>Planted – Poor Condition (grass cover on less than 50% of the area)</td>
<td></td>
</tr>
<tr>
<td>Less than 2% Slope</td>
<td>0.37</td>
</tr>
<tr>
<td>2 – 7% Slope</td>
<td>0.43</td>
</tr>
<tr>
<td>More than 7% Slope</td>
<td>0.45</td>
</tr>
<tr>
<td>Planted – Fair Condition (grass cover on 50% to 75% of the area)</td>
<td></td>
</tr>
<tr>
<td>Less than 2% Slope</td>
<td>0.30</td>
</tr>
<tr>
<td>2 – 7% Slope</td>
<td>0.38</td>
</tr>
<tr>
<td>More than 7% Slope</td>
<td>0.42</td>
</tr>
<tr>
<td>Planted – Good Condition (grass cover on more than 75% of the area)</td>
<td></td>
</tr>
<tr>
<td>Less than 2% Slope</td>
<td>0.25</td>
</tr>
<tr>
<td>2 – 7% Slope</td>
<td>0.35</td>
</tr>
<tr>
<td>More than 7% Slope</td>
<td>0.40</td>
</tr>
<tr>
<td><strong>Undeveloped Areas</strong></td>
<td></td>
</tr>
<tr>
<td>Cultivated Land</td>
<td></td>
</tr>
<tr>
<td>Less than 2% Slope</td>
<td>0.36</td>
</tr>
<tr>
<td>2 – 7% Slope</td>
<td>0.41</td>
</tr>
<tr>
<td>More than 7% Slope</td>
<td>0.44</td>
</tr>
<tr>
<td>Pasture or Range Land</td>
<td></td>
</tr>
<tr>
<td>Less than 2% Slope</td>
<td>0.30</td>
</tr>
<tr>
<td>2 – 7% Slope</td>
<td>0.38</td>
</tr>
<tr>
<td>More than 7% Slope</td>
<td>0.42</td>
</tr>
<tr>
<td>Forest or Wooded Land</td>
<td></td>
</tr>
<tr>
<td>Less than 2% Slope</td>
<td>0.28</td>
</tr>
<tr>
<td>2 – 7% Slope</td>
<td>0.36</td>
</tr>
<tr>
<td>More than 7% Slope</td>
<td>0.41</td>
</tr>
</tbody>
</table>
B. RUNOFF COEFFICIENT ADJUSTMENT FACTORS

Runoff coefficients adjustment factor may be calculated according to Table 5-3 below:

Table 5-3: Runoff Coefficient Adjustment Factors for Rational Method

<table>
<thead>
<tr>
<th>Storm Frequency</th>
<th>( C_f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>4% (25-year)</td>
<td>1.1</td>
</tr>
<tr>
<td>2% (50-year)</td>
<td>1.2</td>
</tr>
<tr>
<td>1% (100-year)</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Note: Use \( C_f = 1.0 \) for ten percent (10-year) storm frequency or less.

C. RAINFALL INTENSITY

Rainfall intensity shall be calculated as function of the time of concentration. The time of concentration (Tc) is the amount of time required for surface runoff to travel from the most hydraulically remote point within the drainage basin to the drainage point under consideration. The most hydraulically remote drainage point refers to the route requiring the longest drainage travel time and not necessarily the greatest linear distance. The flow routes used in determining the time of concentration must take into consideration fully developed conditions as proposed by thoroughfare plans, zoning maps, etc.

The time of concentration shall be calculated based on its component parts and summed to determine the total time of concentration. Flow shall be assumed to begin as sheet flow, develop into shallow concentrated flow until the flow enters a drainage system where it becomes pipe flow or channel flow. Sheet flow shall not exceed a length of 100 feet. Shallow concentrated flow shall be the total between the end of the sheet flow and the beginning of a defined channel or concentrated flow.
Unless otherwise approved by City Engineer, the following equations shall be used to calculate travel time for sheet flow and shallow concentrated flow, respectively:

**Equation 5-2**

\[ T_{\text{Sheet}} = \frac{L_n}{42S^{0.5}} \]

**Equation 5-3**

\[ T_{\text{Shallow}} = \frac{L_n}{60S^{0.5}} \]

Where:

- \( T_{\text{Sheet}} \) = Sheet flow travel time, minutes.
- \( T_{\text{Shallow}} \) = Shallow concentrated flow travel time, minutes.
- \( L \) = Flow length, feet, maximum feet for sheet flow.
- \( N \) = Manning’s roughness coefficient from Table 5-5
- \( S \) = Slope of ground, ft/ft.

Where hydraulic calculations can be performed to calculate the velocity in the drainage system, the calculated velocity shall be used to determine the time of concentration in the drainage system. In other cases, use Manning’s equation with the roughness coefficients given below to calculate the velocity in the drainage system.

**Table 5-4: Runoff Coefficients for Open Space Areas by Hydrologic Group**

<table>
<thead>
<tr>
<th>Hydrologic Soil Group</th>
<th>Woods, No Grazing</th>
<th>Pasture (Lawns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.06</td>
<td>0.10</td>
</tr>
<tr>
<td>B</td>
<td>0.13</td>
<td>0.20</td>
</tr>
<tr>
<td>C</td>
<td>0.16</td>
<td>0.25</td>
</tr>
<tr>
<td>D</td>
<td>0.20</td>
<td>0.30</td>
</tr>
</tbody>
</table>
Table 5-5: Manning’s Roughness Coefficients for Sheet Flow and Shallow Concentrated Flow

<table>
<thead>
<tr>
<th>Manning’s “n”</th>
<th>Condition</th>
</tr>
</thead>
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<tr>
<td>0.016</td>
<td>Concrete (rough or smoothed finish)</td>
</tr>
<tr>
<td>0.02</td>
<td>Asphalt</td>
</tr>
<tr>
<td>0.1</td>
<td>0-50% vegetated ground cover, remaining bare soil or rock outcrops, minimum brush, or tree cover</td>
</tr>
<tr>
<td>0.2</td>
<td>50-90% vegetated ground cover, remaining bare soil or rock outcrops, minimum-medium brush or tree cover</td>
</tr>
<tr>
<td>0.3</td>
<td>100% vegetated ground cover, medium-dense grasses (lawns, grassy fields etc.) medium brush or tree cover</td>
</tr>
<tr>
<td>0.6</td>
<td>100% vegetated ground cover with areas of heavy vegetation (parks, green-belts, riparian areas etc.) dense under-growth with medium to heavy tree growth</td>
</tr>
</tbody>
</table>
D. RUNOFF INTENSITY

Use the total calculated time of concentration as the duration to determine the critical rainfall intensity from Table 5-6 below. Use a minimum time of concentration of 5 minutes.

Table 5-6: Intensity-Duration-Frequency Rates for Various Frequencies

<table>
<thead>
<tr>
<th>Duration (Minutes)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-year (Inches/hr)</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>5</td>
<td>6.36</td>
</tr>
<tr>
<td>6</td>
<td>6.04</td>
</tr>
<tr>
<td>7</td>
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<td>8</td>
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<td>12</td>
<td>4.70</td>
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<td>13</td>
<td>4.54</td>
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<td>14</td>
<td>4.39</td>
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<td>15</td>
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<td>4.13</td>
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<td>28</td>
<td>3.10</td>
</tr>
<tr>
<td>29</td>
<td>3.04</td>
</tr>
<tr>
<td>30</td>
<td>3.00</td>
</tr>
<tr>
<td>Duration (Minutes)</td>
<td>Frequency</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td>2-year (Inches/hr)</td>
</tr>
<tr>
<td>31</td>
<td>2.93</td>
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<td>32</td>
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<td>2.11</td>
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<td>55</td>
<td>2.09</td>
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<td>56</td>
<td>2.06</td>
</tr>
<tr>
<td>57</td>
<td>2.04</td>
</tr>
<tr>
<td>58</td>
<td>2.02</td>
</tr>
<tr>
<td>59</td>
<td>2.00</td>
</tr>
<tr>
<td>60</td>
<td>1.97</td>
</tr>
</tbody>
</table>
5.2.2 - COMPUTER MODELS

Computer models shall be prepared using the HEC-HMS software developed by the US Army Corps of Engineers Hydrologic Engineering Center. Parameters for the model shall be determined as described herein. Rainfall and runoff relationships shall be based on the methodology and parameters provided in the National Engineering Handbook Part 630 (NEH-630) published by the Natural Resource Conservation Service (NRCS) except as modified herein. All published Hydrology and Hydraulic models shall be used if available (FEMA, San Antonio River Authority).

A. RUNOFF

The NEH-630 methodology shall be used for runoff calculations in HEC-HMS. Curve numbers shall be determined from the values given in NEH-630 or pre-approved references by the City Engineer. In addition, impervious cover values shall be estimated from aerial photos for existing conditions. For post-development conditions, the maximum anticipated impervious cover shall be used with the appropriate curve number for the development. An assumption that the initial abstraction is equal to 0.2 times the maximum soil retention per NEH-630 shall be used unless calibration data is available to justify other figures to the satisfaction of the City Engineer.

For sites that incorporate LID features to capture and treat the required water quality volume, the volume stored in the LID BMPs can be modeled as additional initial abstraction.

B. RAINFALL

Values shall be used to calculate the rainfall depth-duration-frequency relationships for the model. Rainfall distribution shall be based on the Type II distribution per NEH-630.

Table 5-7: Boerne Rainfall Depths for Various Durations and Frequencies

<table>
<thead>
<tr>
<th>Duration (Minutes)</th>
<th>2-year (Inches)</th>
<th>5-year (Inches)</th>
<th>10-year (Inches)</th>
<th>25-year (Inches)</th>
<th>50-year (Inches)</th>
<th>100-year (Inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.53</td>
<td>0.66</td>
<td>0.78</td>
<td>0.94</td>
<td>1.06</td>
<td>1.19</td>
</tr>
<tr>
<td>10</td>
<td>0.84</td>
<td>1.06</td>
<td>1.24</td>
<td>1.50</td>
<td>1.70</td>
<td>1.90</td>
</tr>
<tr>
<td>15</td>
<td>1.06</td>
<td>1.33</td>
<td>1.55</td>
<td>1.86</td>
<td>2.10</td>
<td>2.35</td>
</tr>
<tr>
<td>20</td>
<td>1.24</td>
<td>1.56</td>
<td>1.81</td>
<td>2.16</td>
<td>2.44</td>
<td>2.73</td>
</tr>
<tr>
<td>30</td>
<td>1.50</td>
<td>1.87</td>
<td>2.18</td>
<td>2.60</td>
<td>2.93</td>
<td>3.27</td>
</tr>
<tr>
<td>45</td>
<td>1.82</td>
<td>2.27</td>
<td>2.65</td>
<td>3.16</td>
<td>3.56</td>
<td>3.98</td>
</tr>
<tr>
<td>60</td>
<td>1.97</td>
<td>2.47</td>
<td>2.89</td>
<td>3.47</td>
<td>3.92</td>
<td>4.40</td>
</tr>
<tr>
<td>120</td>
<td>2.43</td>
<td>3.09</td>
<td>3.69</td>
<td>4.56</td>
<td>5.28</td>
<td>6.06</td>
</tr>
<tr>
<td>180</td>
<td>2.70</td>
<td>3.48</td>
<td>4.20</td>
<td>5.28</td>
<td>6.20</td>
<td>7.23</td>
</tr>
<tr>
<td>240</td>
<td>2.91</td>
<td>3.79</td>
<td>4.60</td>
<td>5.85</td>
<td>6.94</td>
<td>8.15</td>
</tr>
<tr>
<td>360</td>
<td>3.16</td>
<td>4.14</td>
<td>5.09</td>
<td>6.53</td>
<td>7.79</td>
<td>9.22</td>
</tr>
<tr>
<td>720</td>
<td>3.63</td>
<td>4.81</td>
<td>5.95</td>
<td>7.71</td>
<td>9.24</td>
<td>11.00</td>
</tr>
<tr>
<td>1440</td>
<td>4.13</td>
<td>5.53</td>
<td>6.88</td>
<td>8.95</td>
<td>10.80</td>
<td>12.80</td>
</tr>
</tbody>
</table>
C. UNIT HYDROGRAPH

Unless otherwise approved by City Engineer, the unit hydrograph development shall be based on the Snyder-Clark Synthetic Unit Hydrograph. The following equations and parameters shall be used unless a more precise calibration is provided and approved by the Floodplain Administrator.

Use the following to compute the duration of the Unit Hydrograph:

**Equation 5-4**

\[ t_r = \frac{t_{lag}}{5.5} \]

Where:

- \( t_r \) = Unit hydrograph duration (hours).
- \( t_{lag} \) = basin lag time (hours).

Use the following to compute the basin lag time developed by the Tulsa District Corps of Engineers and used by the San Antonio River Authority in the hydraulic modeling of the Cibolo Creek Watershed:

**Equation 5-5**

\[ t_{lag} = C_t \left( \frac{L \cdot L_{ca}}{\sqrt{S}} \right)^{0.39} \]

Where:

- \( t_{lag} \) = basin lag time (hours).
- \( L \) = Length of longest flow path in the watershed (miles).
- \( L_{ca} \) = Length to the centroid along the longest flow path (miles).
- \( C_t \) = Coefficient, based upon level of watershed development in the watershed.
- \( S \) = average slope of the longest flow path (foot/mile)
The $C_t$ coefficient is defined based on the percentage of development within the watershed by:

**Equation 5-6**

$$C_t = 1.4224e^{-0.0088x}$$

Where:

$x$ = is the percentage of development (in percent form)

The peak discharge of the unit hydrograph shall be calculated by:

**Equation 5-7**

$$q_p = 380t_{lag}^{-0.92}$$

**Equation 5-8**

$$C_p = \frac{q_p t_{lag}}{640} \text{ or } C_p = 0.594t_{lag}^{0.08}$$

Where:

$q_p$ = peak discharge of the unit hydrograph (cfs).

$C_p$ = Snyder’s peaking coefficient.

$A$ = watershed size (sq. mi.).

$t_{lag}$ = basin lag time (hours).

<table>
<thead>
<tr>
<th>Watershed Type</th>
<th>Average Watershed Slope</th>
<th>$C_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>$S \leq 0.5%$</td>
<td>0.55</td>
</tr>
<tr>
<td>Moderate</td>
<td>$0.5% \leq S \leq 1.5%$</td>
<td>0.61</td>
</tr>
<tr>
<td>Rolling</td>
<td>$1.5% &lt; S \leq 3.0%$</td>
<td>0.71</td>
</tr>
<tr>
<td>Steep</td>
<td>$S &gt; 3.0%$</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Modified Puls methodology shall be used when detailed hydraulic models are available, but Muskingum-Cunge may be used for all other methods.

For watersheds greater than 10 square miles, the effects of storm centering must be considered. Consult with city staff prior to completing the model. Watershed delineation for hydrologic models must include at a minimum the subareas delineated in the current San Antonio River Authority (SARA) hydrology model for Cibolo Creek. In addition, subareas shall be added to the model to effectively isolate the subject development.
5.3 - HYDRAULIC CALCULATIONS

The purpose of hydraulic calculations shall be to determine the depth, velocity, and width of flow in drainage systems. Small systems may be designed based on normal depth calculations using Manning’s equation. Large systems must be modeled using acceptable computer software. Closed systems must include calculations for inlet capacity, pipe capacity, hydraulic grade line and energy grade line. Flow depths and hydraulic grade lines shall be plotted on construction plans.

5.3.1 - OPEN SYSTEMS

Open systems include channels, swales, detention ponds and other open forms of drainage conveyance and/or storage. Boerne requires that open systems be safe and maintainable and strongly encourages aesthetically pleasing systems that are viewed as community assets rather than liabilities.

A. SMALL SYSTEMS:

Small systems have a maximum normal depth of 3.0 feet and serve a watershed smaller than 25 acres. Normal depth calculations shall be used for design based on the Manning’s equation:

\[
V = \frac{1.486}{n} R^{2/3} S^{1/2}_f
\]

Where:

- \( V \) = average flow velocity in feet per second.
- \( N \) = Manning’s roughness coefficient.
- \( A \) = flow area in square feet.
- \( R \) = hydraulic radius = \( \frac{A}{WP} \) in feet.
- \( S_f \) = Friction slope in feet per foot, assumed equal to channel slope.
- \( WP \) = wetted perimeter in feet.

The average flow velocity and flow area are related to the discharge flow rate as follows:

\[
Q = VA
\]

Where \( Q \) = discharge flow rate in cubic feet per second.
B. LARGE SYSTEMS:

Large systems either have a normal depth greater than 3.0 feet or serve a watershed of 25 acres or more. These systems require that a backwater model be prepared to show the depth of flow and velocity in the system. Natural channels shall be modeled using HEC-RAS computer software developed by the US Army Corps of Engineers Hydrologic Engineering Center. Other channels may also be modeled using HEC-RAS. Uniform cross-section channels may be modeled using the standard step procedure in hand calculations or other software programs acceptable to the City Engineer. Both methods shall make use of the Manning’s equation for channel friction losses. For natural channels, Manning’s n values should be estimated using experienced judgment and information presented in publications such as the Guide for Selecting Manning’s Roughness Coefficients for Natural Channels and Flood Plains, FHWA-TS-84-204, 1984, FHWA HEC-15, 1988, or Chow, 1959. Some of these values are given in Table 5-9 below. Use the values in Table 5-10 below for artificial channels.
## Table 5-9: Roughness Coefficients (Manning’s N) For Natural Channels

<table>
<thead>
<tr>
<th>Channel Description</th>
<th>Manning’s n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MINOR NATURAL STREAMS</strong></td>
<td></td>
</tr>
<tr>
<td>Fairly regular section</td>
<td></td>
</tr>
<tr>
<td>1. Some grass and weeds; little or no brush</td>
<td>0.030</td>
</tr>
<tr>
<td>2. Dense growth of weeds, depth of flow materially greater than weed height</td>
<td>0.035</td>
</tr>
<tr>
<td>3. Some weeds, light brush on banks</td>
<td>0.035</td>
</tr>
<tr>
<td>4. Some weeds, heavy brush on banks</td>
<td>0.050</td>
</tr>
<tr>
<td>5. Some weeds, dense willows on banks</td>
<td>0.060</td>
</tr>
<tr>
<td>For trees within channels with branches submerged at high stage, increase above values by</td>
<td>0.010</td>
</tr>
<tr>
<td>Irregular section with pools, slight channel meander, increase above values by</td>
<td>0.010</td>
</tr>
<tr>
<td><strong>Floodplain – Pasture</strong></td>
<td></td>
</tr>
<tr>
<td>1. Short grass</td>
<td>0.030</td>
</tr>
<tr>
<td>2. Tall grass</td>
<td>0.035</td>
</tr>
<tr>
<td><strong>Floodplain – Cultivated Areas</strong></td>
<td></td>
</tr>
<tr>
<td>1. No crop</td>
<td>0.030</td>
</tr>
<tr>
<td>2. Mature row crops</td>
<td>0.035</td>
</tr>
<tr>
<td>3. Mature field crops</td>
<td>0.040</td>
</tr>
<tr>
<td><strong>Floodplain – Uncleared</strong></td>
<td></td>
</tr>
<tr>
<td>1. Heavy weeds scattered brush</td>
<td>0.050</td>
</tr>
<tr>
<td>2. Wooded</td>
<td>0.120</td>
</tr>
<tr>
<td><strong>MAJOR NATURAL STREAMS</strong></td>
<td></td>
</tr>
<tr>
<td>Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of “n” for larger streams of mostly regular sections, with no boulders or brush</td>
<td>Range from 0.028 to 0.060</td>
</tr>
<tr>
<td><strong>UNLINED VEGETATED CHANNELS</strong></td>
<td></td>
</tr>
<tr>
<td>Clays (Bermuda Grass)</td>
<td>0.035</td>
</tr>
<tr>
<td>Sandy and Silty Soils (Bermuda Grass)</td>
<td>0.035</td>
</tr>
</tbody>
</table>
Table 5-10: Manning’s Roughness Coefficients (n) for Artificial Channels

<table>
<thead>
<tr>
<th>Category</th>
<th>Lining Type</th>
<th>0-0.5 ft</th>
<th>0.5-2.0 ft</th>
<th>&gt;2.0 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid</td>
<td>Concrete</td>
<td>0.015</td>
<td>0.013</td>
<td>0.013</td>
</tr>
<tr>
<td></td>
<td>Grouted Riprap</td>
<td>0.040</td>
<td>0.030</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td>Stone Masonry</td>
<td>0.042</td>
<td>0.032</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>Soil Cement</td>
<td>0.025</td>
<td>0.022</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>Asphalt</td>
<td>0.018</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>Unlined</td>
<td>Bare Soil</td>
<td>0.023</td>
<td>0.020</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>Rock Cut</td>
<td>0.045</td>
<td>0.035</td>
<td>0.025</td>
</tr>
<tr>
<td>Temporary*</td>
<td>Woven Paper Net</td>
<td>0.016</td>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td></td>
<td>Jute Net</td>
<td>0.028</td>
<td>0.022</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>Fiberglass Roving</td>
<td>0.028</td>
<td>0.022</td>
<td>0.019</td>
</tr>
<tr>
<td></td>
<td>Straw with Net</td>
<td>0.065</td>
<td>0.033</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>Curled Wood Mat</td>
<td>0.066</td>
<td>0.035</td>
<td>0.028</td>
</tr>
<tr>
<td></td>
<td>Synthetic Mat</td>
<td>0.036</td>
<td>0.025</td>
<td>0.021</td>
</tr>
<tr>
<td>Vegetated Lining</td>
<td>Sod-lining, Grass</td>
<td>0.030</td>
<td>0.035</td>
<td>0.05</td>
</tr>
<tr>
<td>Gravel Riprap</td>
<td>1-inch D_{50}</td>
<td>0.044</td>
<td>0.033</td>
<td>0.030</td>
</tr>
<tr>
<td></td>
<td>2-inch D_{50}</td>
<td>0.066</td>
<td>0.041</td>
<td>0.034</td>
</tr>
<tr>
<td>Rock Riprap</td>
<td>6-inch D_{50}</td>
<td>0.104</td>
<td>0.069</td>
<td>0.035</td>
</tr>
<tr>
<td></td>
<td>12-inch D_{50}</td>
<td>–</td>
<td>0.078</td>
<td>0.040</td>
</tr>
</tbody>
</table>

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.
C. DETENTION PONDS:

Detention areas should have attractive natural-looking features, fit into the surrounding landscape, and add to the overall character of an area, as opposed to having boxy and geometric features. The shape of the detention basin should be as natural looking as practical, with terracing of the slopes and bottom.

Detention ponds shall be analyzed using the methods listed below. Inflow hydrographs developed in accordance with Computer Models, per Section 5.3.1(B) above, shall be used with the design depth-volume-discharge rating curve for the pond to determine the outflow hydrograph. An outflow hydrograph shall be plotted for the fifty, twenty, ten, four, two and one percent annual chance (2, 5, 10, 25, 50 and 100-year) storm events. If flow bypasses the detention basin, the allowable release must be adjusted accordingly. All detention structures shall be designed in accordance with the requirements herein and sealed by a Professional Engineer.

The following criteria shall serve as minimum requirements for detention pond design:

1. DETENTION POND VOLUME:

   a. Basins with drainage areas of 25 acres or less may be designed using the Modified Rational Method, or other method as approved by City Engineer. The detention volume for a given duration using the Modified Rational method is calculated as the difference between a trapezoidal inflow hydrograph and a triangular outflow hydrograph. Design must account for all onsite and offsite flows to the discharge point. A range of storm durations from 5 to 60 minutes, with 1-minute increment, is required to determine the critical duration for the detention basin.

   b. Basins with drainage areas greater than 25 acres, or when multiple detention ponds within a watershed are being modeled, or on-channel ponds are proposed, or where the Modified Rational Method is not appropriate or applicable, shall be designed using the Unit Hydrograph Method using HEC-HMS or software as approved by City Engineer. Design Engineer shall calculate the difference between the pre- and post-development (with no detention) runoff volumes from the one percent annual chance (100-year) storm event between the hours 11 to 18 of the unit hydrograph, with a minimum 15-minute increment.

   c. Calculations for the minimum storage volume required to mitigate the peak discharge shall be included within the drainage report. Sediment accumulation should be considered in all detention pond volume designs. All detention ponds shall have 20 percent more volume than the minimum calculated required volume for detention to account for sediment accumulations.

2. PERMANENT DETENTION POND STRUCTURES:

   a. Single-Stage - A single step discharge system would consist of a culvert system (single or multiple culverts). The inlet structure would be designed in such a way that the design discharges would pass through the system and a separate emergency spillway will be provided for the emergency flows.

   b. Multi-Stage - A multistage inlet would involve the placement of a control structure at the inlet end of the pipe. The inlet structure would be designed in such a way that the design discharges would pass through a weir or orifice in the lower levels of the structure. The pipe would need to be designed to carry the full range of flows from a drainage area.

d. Culverts used as outflow structures must be designed for inlet control.

e. Any outlet from the pond must be modeled as a culvert or series of culverts for a stepped outlet in both HEC-HMS and HEC-RAS

f. All detention outfall shall demonstrate and provide an adequate outfall in accordance with City Requirements.

g. For sites with watershed greater than or equal to 5 acres, the elevation of the top of the embankment shall be a minimum of 1 foot above the water surface elevation when the emergency spillway is conveying the maximum design or emergency flow. For sites with watersheds less than 5 acres, the minimum required freeboard is 1.0 foot above the computed 100-year water surface elevation in the detention facility. City Engineer may allow for reduction in freeboard requirements to 0.5 foot when the emergency spillway is designed for 0.2% (500 year) annual chance or greater storm event.

h. Earthen Embankments shall have a 4’ minimum top width for maintenance purposes.

i. A separate emergency spillway with the capacity to pass the 100-year design storm assuming the pond is full and the outfall structure is clogged, shall be provided to prevent breach of the pond embankment.

j. Detention basins shall provide positive drainage through the pond with a minimum slope of 1.0% for an earthen bottom. For slopes less than 1.0%, a concrete pilot channel with a minimum slope of 0.5% should be used with a minimum width of six (6) feet. The minimum earthen slope draining toward the pilot channel shall be one (1) percent.

k. Earthen detention basin shall have a side slope of 4:1 or flatter.

l. If other potential pollutants such as oils, grease, or fuel (gasoline and diesel) could be present in the site runoff, it may also be necessary to provide additional pre-treatment measures to remove these contaminants prior to the stormwater management facilities.

m. A maintenance ramp shall be provided for vehicular access in the detention basin for periodic desilting and debris removal. The slope of the ramp shall not exceed 6:1 and the minimum width shall be 12 feet.

n. Private Detention ponds in commercial sites can occur within parking lots with the following criteria:

   i. No fire lane may be located within a surface drainage pond and the maximum depth of 6” of ponded water is allowed in the parking lot.

   ii. Multiple signs shall be posted identifying the detention basin area. The signs shall have a minimum 1.5 square feet and contain the following Message: “WARNING this Area is a detention basin and is subject to periodic flooding to a depth of (provide design).”

o. Criteria established by the State of Texas for dam safety (TAC Title 30, Part 1, Chapter 299) and impoundment of state waters (Texas Water Code Chapter 11) shall apply where required by the state, and where, in the City Engineer’s judgment, the potential hazard requires these more stringent criteria. For embankment greater than 6’, design engineer must prove if a high hazard dam.
3. PUMPED DETENTION SYSTEMS

Pumped detention systems will not be acceptable methods of storm water mitigation. The City Manager may grant an exception for providing a pumped detention system, if all of the following exception requirements are met:

a. A gravity system is not feasible from an engineering and economic standpoint.
b. At least two (2) pumps are provided, each of which are sized to individually pump the design flow rate.
c. The selected design outflow rate must not aggravate downstream flooding.
d. A sump pump shall be provided to remove any water below the pump level.
e. The wet well shall be sized for the ultimate 1% annual chance (100-year) storm.
f. Emergency standby power shall be provided by either a diesel or natural gas generator set. The standby generator should be sized to power the pump station for at least twelve (12) hours.
g. Wet well shall be designed with trash collection rack and volume for sediment collection without diminishing the design capacity.
h. The pump station or pump wet well should be protected with fences, gates, and locks to prevent illegal entry.
i. Adequate access must be provided to the pump station or pump wet well. This access should be available for service and maintenance vehicles during a storm event.
j. Adequate verification is provided that the system will be operated and maintained on a continuous basis.
k. Pumps and controls shall be within a building that provides freeze protection and matches the general architecture of the development.

The Design Engineer shall provide a maintenance plan as part of the design. The maintenance plan shall indicate the ingress and egress locations to enter and maintain the pond, dewatering plan for basins with permanent storage, maintenance roles and responsibilities, contact information for the party responsible for the maintenance, and a maintenance schedule.

The Design Engineer shall provide a signed and sealed “Plan Conformance” letter after the completion of the detention pond (public and private) and provide the completed letter to the City. The letter shall verify that the detention system associated with the referenced project has been constructed in general conformance with the accepted Drainage Study and construction documents on file with the City.

The design of stormwater facilities shall not include any construction activities within areas defined as Drainageway Protection Zone 1, per UDC chapter 8.2.
D. RETENTION PONDS:

Retention facilities are used to fully retain the site runoff volume where no viable outfall exists, and native soil allows for adequate infiltration. Retained runoff is then evacuated through infiltration and evaporation. Retention facilities shall be designed, per the recommendations in the LID manual, to store the post-development site runoff from the one percent (1%) annual chance (100-year), 24-hour storm. The water surface in the retention facility shall return to the pre-storm level within 72-hours after cessation of the one percent (1%) annual chance (100-year) storm, 24-hour storm. A geotechnical report shall be provided to ensure adequate percolation can be achieved. The infiltration rate should be determined using one of the following: infiltrometer testing using a double ring infiltrometer (ASTM D 3385-94) or percolation test.

5.3.2 - CLOSED SYSTEMS

Closed systems include underground storm drain, culverts, and any drainage system with the potential for being surcharged. Refer to the Hydraulic Manual published by Texas Department of Transportation, Bridge Division for design procedures, equations, parameters, and other information for design of closed drainage systems except as modified herein. Software programs acceptable to the City Engineer that use procedures and equations derived from the Hydraulic Manual may be used. Spreadsheets and other non-commercial software calculations must show each step and be adequately documented for approval by the City Engineer.

A. STORM DRAIN

Storms Drain system should be design as follows:

1. Storm Drain systems shall be designed for gravity flow with no surcharge with flows from the twenty percent (20%) annual chance (5-year) storm. The Hydraulics shall then be checked for the 1 percent (1%) annual chance (100-year) storm by plotting the Hydraulic Grade Line (HGL) and Energy Grade Line (EGL) for the system. The final system design shall not allow the EGL to be higher than the ground and shall maintain the HGL below ground by at least one foot at all locations within the storm drain system. Refer to the TxDOT Hydraulic Manual for inlet capacities, entrance loss calculations and other factors required to calculate and plot the energy and hydraulic grade lines.

2. Storm drains shall maintain a minimum cover per the manufactures design recommendations. Storm drains located under public roadways shall maintain sufficient depth of cover such that the crown of the pipe/box must remain below the pavement section’s treated subgrade.

3. The starting HGL at an outfall into a creek or channel shall be the 1 percent (1%) annual chance (100-year) storm, fully developed water surface unless an approved flood hydrograph is available to provide a coincident flow elevation for the system’s peak.

4. When a proposed storm sewer is to connect to an undersized existing storm sewer system, calculation of the HGL for the proposed storm sewer shall start at the outfall of the existing storm sewer system.

5. The maximum velocity for a storm drain line is 12.0 fps for the 20 percent (20%) annual chance (5-yr) event.

6. The minimum cleaning velocity for a storm drain line is 3.0 fps for a 20 percent (20%) annual chance (5-year) event and a minimum slope of 0.5% shall be maintained in the pipe, unless otherwise approved by the City Engineer.

7. No public storm drains lines shall be less than eighteen (18) inches in diameter. Laterals that convey drainage from an inlet to the main line may be 15 inches, if a manhole is located at both ends.
8. The maximum distance between manholes in storm drain line shall be five hundred (500) feet.
9. Inlets or junction boxes shall be constructed at locations of change in sizes, changes in grade or alignment, unless otherwise approved by City Engineer. At points of change in storm drain size, pipe crowns (soffits) shall be set at the same elevation.
10. Laterals shall be connected to trunk lines using manholes, junction boxes or manufactured wye connections. Special situations may require laterals to be connected to trunk lines by a cut-in. However, such cut-ins must be approved by the City Engineer and shown as a detail in the Engineering Plans.

B. CULVERTS

Culverts are structures that allows water to flow under a road, railroad, trail, or similar obstruction. Culverts shall be designed as follows:

2. The design and construction of bridge-class culverts shall be provided in accordance with the requirements of the AASHTO’s current edition of the Standard Specifications for Highway Bridges and supplemented using TxDOT standards and guidelines as applicable.
3. All culverts are to be designed with headwalls, wingwalls and aprons, or with flared end sections at the inlet and outlet. Headwalls, wingwalls, and flared-end sections should be designed and constructed to use the existing grades of the site.
4. In Design of culverts, both the minimum and maximum velocities must be considered. A minimum velocity of flow is required to assure self-cleansing condition, while maximum velocities are limited to prevent excessive erosion. The minimum cleaning velocity for a culvert is 3.0 fps for a 20 percent (20%) annual chance (5-year) event and a minimum slope of 0.5% shall be maintained in the culvert, unless otherwise approved by the City Engineer.
5. Culverts shall be designed for the 1 percent (1%) annual chance (100-year) storm with one-foot (1’) freeboard from the top of the curb. The hydraulic design of culverts shall be based upon design guidelines set forth by TxDOT, the U.S. Department of Transportation, or other suitable material as approved by the City Engineer.
6. Culvert calculations shall be provided to the City for review. Calculations shall include, but are not limited to, headwall, tailwater, and flowline elevations, lowest adjacent grade and structure elevations, inlet and outlet control calculations, and velocity calculations. Culverts, Wingwalls, Headwalls and necessary erosion protection shall be provided at all culverts and shall comply with the most current Texas Department of Transportation (TxDOT) standards.
7. Culvert railing, if required, shall be either TxDOT Combination Rail (Type C223) or Traffic Rail (Type T223), or City Engineer approved equivalent.

5.3.3 STORM DRAIN SYSTEMS

Where storm drains are provided, they shall be designed in accordance with the criteria of this manual and the structures provided shall be designed and constructed in accordance with design criteria and assumptions used in the design. A design report shall provide the calculations and show that the structures and facilities included in the construction plans will function as the calculations describe. Calculations of hydraulic grade shall be shown in the report and the line plotted on the profiles included in the construction plans.
A. STORM DRAIN INLETS

All storm drain inlets that accept storm water from streets shall be grate inlets, curb inlets or sidewalk underdrains using City of Boerne or TxDOT standard details. Alternate details may be submitted to City Engineer for consideration. The maximum approved vertical inlet opening is 6 inches. Openings larger than 6 inches require approval of the City Engineer and, if approved, must contain a bar or other form of restraint to prevent entry by a child and/or large debris.

The design and location of all inlets must take into consideration pedestrian and bicycle traffic. If grate inlets in roadways or other paved areas are used, they should be designed for safe passage of bicycles meeting TDLR accessibility standards.

Slot inlets. Although slotted drains can be used to intercept sheet flow, or flow in wide sections, they are not recommended for use in the City of Boerne since they are very susceptible to clogging from debris. Slot inlets may only be used with the permission of the City Engineer. If slot inlets are allowed, the inlet capacity shall be calculated by both equations for a curb inlet, Grate Inlets on Grade, and the manufacturer’s design guidelines, and the lesser inlet capacity, or more conservative method, shall be used for design.

Grate inlets shall not be used in City maintained streets or alleys unless approved by the City Engineer. Grate inlets in a sump are subject to clogging by debris during storm events and are not recommended for use in sumps or sags. A grate inlet in a sump or a sag operates under either weir or orifice flow. Capacity calculations for both conditions will be performed and the lesser of the two capacities will be the design capacity of the grate inlet. Since grate inlets in a sump are prone to clog, only 50% of the perimeter shall be used for the weir calculations and 50% of the surface area shall be used for the orifice calculations. An emergency overflow path shall be provided if the grate inlet becomes clogged or ceases to function as designed. The emergency overflow path must be located within public right-of-way, open space lot or within a drainage easement.

B. CURB INLET PLACEMENT

All curb inlets shall be designed according to the following standard and their design must be approved by the City Engineer:

1. Inlets must be located where the allowable street flow capacities are exceeded, at low points (sumps or sags) and upstream of transition between normal and super-elevated street sections. 
2. Curb Inlets should be provided on both sides of crowned streets to remove storm water. 
3. Inlets are required at the low point of superelevation to prevent flow across the roadway. 
4. Thoroughfares, arterials, and collectors (except for neighborhood collectors) shall not allow storm drainage to cross traffic lanes. 
5. The minimum length is 5’ and no more than 20’ of inlet shall be constructed at one location along one curb line without City Engineer approval. 
6. Inlets are required on both sides in a sag condition without an emergency overflow path. An emergency overflow path is the path the storm water will take if the drainage facility becomes clogged or ceases to function as designed. The emergency overflow path must be located within public right-of-way, open space lot or within a drainage easement. 
7. Multiple sag inlets shall be located no closer than 300’ on same section of roadway.
8. If curb inlet extensions are used with the curb inlet, they shall be place on the up-gradient end of the curb inlet. If more than one extension is proposed, then verification of the hydraulic capacity of the block out openings will be required to verify that the extensions have sufficient capacity to convey the required design storm to the primary curb inlet. Curb Inlet Extensions are not allowed in sump conditions.

9. Depressed gutters shall have a maximum allowable inlet depression of two and ½ (2.5) inches.

10. At bridges, gutter flow shall be intercepted prior to flowing onto the bridge to prevent ice from developing during cold weather.

C. STORM DRAIN OUTFALL

The Design Engineer shall demonstrate the drainage from the site is conveyed to an adequate outfall. The outfall for the storm drain system should discharge into a natural low, drainage easement, existing storm drainage system, or a channel. The outfall of the storm drain should be positioned in the existing low or proposed channel in the downstream direction to reduce the turbulence and erosion. The design engineer should meet with City Engineer to discuss project if a defined low does not exist for the discharge of the outfall.

For exit velocities more than five (5) feet-per-second, energy dissipation, in addition to erosion protection may be required to minimize erosion. Appropriate energy dissipating structures (baffle blocks, stilling basins, rip-rap aprons, etc.) may be used to control erosion and shall be designed in accordance with accepted practices such as outlined in FHWA Hydraulic Design of Energy Dissipators for Culverts and Channels (HEC-14).

Discharge pipes shall intersect creeks at an angle not to exceed 60 degrees where the channel bottom is 20 feet or less (measured from toe to toe). Discharge pipes may intersect creeks at a 90-degree angle where the channel bottom is greater than 20 feet (measured from toe to toe), with prior approval of the City Engineer. Discharge pipe shall point in the downstream direction.

When pipe, or channels, discharge into natural creek or channel, the erosion protection shall extend to the opposite bank of channel to a height equivalent to the discharge depth.

5.3.4 - BRIDGES

Bridges are a support structure that allows an object to travel from one point to another by crossing over a body of water, a valley or other obstacle. Bridges shall be designed as follows:

1. The design and construction of roadway bridges shall be provided in accordance with the requirements of the AASHTO’s current edition of the Standard Specifications for Highway Bridges and supplemented using TxDOT standards and guidelines as applicable.

2. Bridges shall be designed to conform to the drainage requirements of the TxDOT Hydraulic Design Manual.

3. The water surface elevation during the 100-year storm event shall be at least twenty-four (24) inches below the lowest bridge girder to allow for the passage of floating debris. The water surface elevation during the one percent (1%) annual storm event upstream of bridges shall not increase due to channel constrictions and hydraulic losses caused by the bridge.

4. Estimates of local and long-term scour shall be calculated according to methods detailed in the TxDOT Hydraulic Design Manual to determine the required abutment protection and establish the required depth of the bridge support structures.
5. Scour protection should extend upstream and downstream to a point where nonerosive channel velocities are established. The protection should be placed sufficiently high on the adjacent banks to provide protection from erosion under design flood conditions. The protection should be based on a scour analysis and consideration of the channel stability.

6. Roadway widths of bridges shall conform to the standards for streets, unless otherwise designated by the City Engineer. Curbs adjacent to sidewalks shall be a minimum of five (5') foot width on bridges and shall be constructed with the City standard parapet wall and railing on the outside of the bridge.

7. Consideration shall be given to reducing the environmental impacts of proposed bridge crossings. Impacts should be minimized by reducing the footprint of the proposed improvements within the jurisdictional waters of the U.S. and within the floodplain. Piers within the floodplain should be limited to the maximum extent possible.

8. Bridges shall be modeled with USACE’s backwater hydraulic modeling program HEC-RAS in accordance with Section 5.2 (Computer Models).

9. If TxDOT standard sheets pertaining to structures are utilized, the Engineer shall ensure the loading, geometry, and allowable soil pressures are applicable to the standard design selected. The Engineer shall ensure that interruptions to the structure (i.e., wall stem or footing reinforcement altered by openings, utilities, geometric changes, or curved sections of the wall) do not compromise the design and performance of the structure. Consideration shall be given to the site-specific geotechnical requirements and whether a TxDOT standard design is applicable. No TxDOT standard sheets shall be modified unless the Engineer designs, draws, signs, and seals the modified standard. If TxDOT standard sheets are not applicable, a custom structural design shall be provided. Engineer shall provide design calculations validating that TxDOT details used are applicable.

10. All bridge railing shall be either TxDOT Combination Rail (Type C223) or Traffic Rail (Type T223), or City Engineer approved equivalent.

5.4 - USE OF STREETS AS DRAINAGE FACILITIES

Streets may be used to carry storm water to dedicated drainage facilities. However, streets may not be used as a continuation of or discharge for other drainage facilities such as ponds, channels, or sub-surface facilities without approval of the City Engineer. For developments draining into an existing roadway, the outlet design shall provide for a change in the discharge pattern from concentrated flow back to sheet flow, following as near as possible in the direction of the gutter and the 100-year storm discharge depth shall be three (3) inches or less and velocity less than 5 feet per second. Drainage crossing sidewalks shall be covered or bridged to minimize danger to pedestrians.

The maximum spread of storm water in street gutters must provide for the requirements of below. The depth of flow in streets shall be measured at its deepest point, at the curb in the gutter. At no time shall the calculated storm water flow exceed ten (10) feet per second in a 1% annual chance (100-year) storm event. Inlets shall be provided to minimize the flow of storm water in streets and alleys. Streets carrying storm water shall always have a minimum cross slope of 2% except at transitions from crowned sections to superelevated sections. In transition, the longitudinal slope shall be a minimum of 0.70% whenever the cross slope is less than 2% and the requirements of Table 5-11 below must be met:
### Table 5-11: Storm Water Carrying Capacity of Streets by Functional Classification

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>5-Year Criteria</th>
<th>100-Year Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Thoroughfare</td>
<td>Two 12’ lanes dry</td>
<td>Maximum 6 IN depth</td>
</tr>
<tr>
<td>Arterial</td>
<td>Two 11’ lanes dry</td>
<td>Maximum 6 IN depth</td>
</tr>
<tr>
<td>Arterial (Divided)</td>
<td>One 11’ lane dry each direction</td>
<td>Maximum 6 IN depth</td>
</tr>
<tr>
<td>Collector (Curbed Street)</td>
<td>One 12’ lane dry</td>
<td>Curb Full</td>
</tr>
<tr>
<td>Collector (Bar Ditch)</td>
<td>One 12’ lane dry</td>
<td>Contained within ROW</td>
</tr>
<tr>
<td>Neighborhood Collector</td>
<td>One 10’ lane dry</td>
<td>Curb Full</td>
</tr>
<tr>
<td>Local (Non-residential, Curbed Street)</td>
<td>One 10’ lane dry</td>
<td>Curb Full</td>
</tr>
<tr>
<td>Local (Non-residential, Bar Ditch)</td>
<td>One 10’ lane dry</td>
<td>Contained within ROW</td>
</tr>
<tr>
<td>Local (Residential, Curbed Street)</td>
<td>Max 4 IN depth</td>
<td>Curb Full</td>
</tr>
<tr>
<td>Local (Residential, Bar Ditch)</td>
<td>Max 4 IN depth</td>
<td>Contained within ROW</td>
</tr>
<tr>
<td>Access</td>
<td>Curb full</td>
<td>Contained within ROW</td>
</tr>
</tbody>
</table>

Note: Bar ditches are considered channels that convey stormwater for street capacity purposes only. Channels carrying stormwater runoff for the site that are adjacent to the street must meet all capacity and all other requirements for channels and defined in this code.

### 5.5 - OPEN DRAINAGE CHANNELS

The design of all open drainage channels, including roadside bar ditches, shall be based on a one percent (1%) annual chance (100-year) storm frequency and must be approved by the City Engineer.

#### 5.5.1 - CAPACITY OF OPEN DRAINAGE CHANNELS

All open drainage channels shall be designed with at least the minimum freeboard specified in the Minimum Drainage Channel Freeboard Table:

<table>
<thead>
<tr>
<th>Design Depth of Flow</th>
<th>Required Freeboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5 feet</td>
<td>0.5 foot</td>
</tr>
<tr>
<td>5 – 10 feet</td>
<td>10% of design depth</td>
</tr>
<tr>
<td>More than 10 feet</td>
<td>1.0 foot</td>
</tr>
</tbody>
</table>

Note: Allowance for extra freeboard shall be made when the centerline radius of the channel is less than three (3) times the bottom width or for supercritical flow regime.

#### 5.5.2 - MAINTENANCE ACCESS OF CHANNELS

Access shall be provided for all channels to allow equipment access for maintenance. Access shall have a width of at least 15 feet and a cross slope no greater than two percent. Maintenance ramps used for access shall have a maximum 6:1 running slope and a maximum 5% cross slope. An unobstructed access easement connecting the channel drainage easement with a roadway parallel to or near the easement shall be provided at a minimum spacing of one access easement at a minimum of 1,000 feet intervals. This may be adjusted by no more than 100 feet to lessen impacts to quality trees or to avoid restrictive slopes. Access routes shall also be provided to all energy dissipators. Additional access routes may be required as directed by the City Engineer.
Access shall be provided within dedicated right-of-way or within the drainage easement dedicated for the channel. The bottom of the channel cannot be considered as maintenance access.

5.5.3 - LINING OF OPEN DRAINAGE CHANNELS

Use Velocity Control Requirements in Table 5-13 below to determine the channel lining used for scour protection and erosion control. The maximum calculated velocity for 100-year storm shall be used for design. The only approved linings are shown in Table 5-13. Flow conditions are recommended for all channel designs, as super critical flow tends to have high velocities and high potential for channel erosion. Supercritical flow conditions will not be allowed in channel unless concrete lined.

Table 5-13: Velocity Control Requirements

<table>
<thead>
<tr>
<th>Type of Channel Lining Required</th>
<th>Maximum Velocity (feet/sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetated earth</td>
<td>3.0</td>
</tr>
<tr>
<td>Sod lined</td>
<td>5.0</td>
</tr>
<tr>
<td>Gabion basket/mattress lined *</td>
<td>12.0</td>
</tr>
<tr>
<td>Concrete lined</td>
<td>20.0</td>
</tr>
</tbody>
</table>

* All Gabion basket/mattress lined channels require design Engineer to compute the Shear stress in accordance with Chapter 7, Design of Roadway Channels with Flexible Linings, *Hydraulic Engineering Circular 15 (HEC 15)*. Channels shall be designed to be stable and to not create safety hazards. When gabion basket/mattress are used, the need for an underlying filter material must be evaluated. The filter material may be either a granular filter blanket or geotextile fabric.

Additionally, a variety of commercially available permanent synthetic fabrics and channel lining products intended to reduce erosion are available. The use of permanent synthetic fabrics or channel linings for within Boerne is restricted to areas maintained by private HOA/POA or areas of existing development where the ROW constraints prohibit the use of a grass-lined section and for the lining of emergency spillways and dam embankments. The linings shall be restricted to channels with a Froude number of 0.8 or less and shall be designed with velocity limit of 80% of manufactures recommendation. Such use shall be allowed only upon written approval for an exception from the City Engineer.

5.5.4 - DESIGN OF CONCRETE LINED CHANNELS

The City of Boerne encourages the preservation of natural channels and drainage patterns. Concrete lined channel shall only be permitted in areas of existing development where constraints prohibit the use of a grass lined section. All concrete lined channels shall be designed according to the following standards, and their design must be approved by the City Engineer:

1. From the top of the concrete lining to the top of the ditch, the side slope shall be three horizontal to one vertical (3:1) or flatter, nor shall the slope be less than 12 horizontal to one vertical. (4:1 or flatter when within roadway clear zones).
2. For normal conditions, the concrete lining shall be a minimum of four inches thick and reinforced with No. 3 round bars placed not more than 18 inches on centers in both directions. Where the surface, the nature of the ground, height and steepness of slope, or other factors become critical, the design shall be in accordance with the latest structural standards and codes.
3. Maximum side slopes of concrete riprap shall be one to one, unless actual soils test data submitted by a soils engineer shows that a steeper special design is allowable. A minimum of 200 pounds per square foot surcharge shall be used.

4. Vertical walls shall not exceed a depth of two feet unless the channel is properly fenced or enclosed.

5. Any vertical walls greater than 12 inches shall be a minimum of 5’ from sidewalks unless pedestrian rail is provided.

6. The minimum longitudinal slope shall be 0.5 percent, or 0.1 percent with a minimum “cleaning” velocity of three (3) feet per second (3 fps) during an existing conditions five (5) year storm event.

5.5.5 - DESIGN OF SOD-LINED AND EARTH CHANNELS

The City of Boerne encourages the preservation of natural channels and drainage patterns. All sod-lined and earth channels shall be designed according to the following standards, and their design must be approved by the City Engineer:

1. Supercritical flow shall not be allowed in channels except at drop structures and other energy dissipators where the channel is concrete lined.

2. The side slope shall be 3:1 or flatter (4:1 or flatter when within roadway clear zones).

3. Channels with longitudinal slope less than 1 (one) percent or bottom widths greater than twenty (20) feet, a concrete pilot channel shall be provided. The minimum bottom width of the pilot channel shall be six (6) feet. The minimum [earthen] slope draining toward the pilot channel shall be one (1) percent.

5.5.6 - INTERCEPTOR CHANNELS

Interceptor channels for proper conveyance of upstream storm water sheet flow shall be required on all subdivision plats where upstream contributing area exceeds the criteria indicated below. Interceptor channels shall be constructed with the subdivision improvements for any lot that would intercept natural drainage.

- **Residential Subdivisions:** Interceptor channels shall be provided for where the drainage area to platted lots exceeds the depth of two (2) average residential lots with equivalent zoning.

- **Non-residential Subdivisions:** Interceptor channels shall be required where the off-site drainage area contributing to the proposed development exceeds two (2) acres.

5.5.7 - BAR DITCHES

Bar ditches constructed within the ROW shall be designed in accordance with requirements for open drainage channels.

5.6 - FLOOD HAZARDS

All subdivisions shall conform to the *Flood Disaster Protection Act of 1973*, Public Law 93-234, and the latest revisions thereof and the City of Boerne *Flood Damage Prevention Ordinance*, as amended, and policies as dictated by the Federal Emergency Management Agency (FEMA) shall be adhered to.

Additional floodplain requirements are provided in UDC Section 8.1.
5.6.1 - FLOODPLAN DESIGNATIONS AND GENERAL RESTRICTIONS

Local Flood Plains shall be designated as the area inundated by the one percent (1%) annual chance (100-year) flood for all watersheds draining 25 acres or more that do not have a regulatory floodplain and are defined as a drainageway per UDC Appendix A. Local floodplains are further defined by a minimum 1-foot flow depth to exclude shallow concentrated or sheet flows from being identified as elevated risk zones per FEMA guidelines. Base flood elevation data shall be generated for all local floodplains and submitted to the City of Boerne for review with any proposed development. Development is prohibited within the local floodplain, except where allowed by in the UDC, Section 8.1. Redevelopment within the local floodplain may be allowed according to the provisions in the UDC, Section 8.1.

5.6.2 - GENERAL REQUIREMENTS IN FLOODPLAINS

The limits of the 100-year FEMA or 100-year local floodplain and the limits of the floodway shall be shown on the preliminary and final plats as applicable. The minimum building slab elevation for lots in or within 100 feet of the 100-year floodplain shall be based on the following table:

<table>
<thead>
<tr>
<th>Basis of Study</th>
<th>Minimum building slab elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlas 14 Rainfall</td>
<td>1.0 foot above 100-year floodplain Base Flood Elevation</td>
</tr>
<tr>
<td>Rainfall other than Atlas 14</td>
<td>2.0 feet above the 100-year floodplain Base Flood Elevation</td>
</tr>
</tbody>
</table>

5.6.3 - FLOOD HAZARDS TO WATER AND WASTEWATER SYSTEMS

1. New or replacement water supply systems and/or wastewater systems shall be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from the systems into flood waters.
2. On-site waste disposal systems shall be located to avoid impairment of them or contamination from them during flooding.

5.6.4 - REVIEW OF PROPOSED SUBDIVISION FLOOD HAZARDS

Proposed subdivisions shall be reviewed to assure that:

1. All such proposals are consistent with the need to minimize flood damage;
2. All public utilities and facilities, such as sewer, gas, electrical, and water systems are located, elevated, and constructed to minimize or eliminate flood damage; and
3. Adequate drainage is provided to reduce exposure to flood hazards.

5.6.5 - ACCESS TO SUBDIVISIONS

No new “island” subdivisions, lots or streets that would be surrounded by the flood waters of the 100-year flood, shall be permitted unless:

1. The area is accessible to high ground by a street elevated above the 100-year flood level; or
2. Additionally, unflooded access shall be accessible to a collector or arterial street that is not adjacent to the development or to a distance of one-quarter (1/4) mile, whichever is less, during a four percent (4%) annual chance (twenty-five year) flood event. Director of Engineering & Mobility may waive the design criteria above for developments under five (5) acres in size.
5.7 - PROTECTION OF SURFACE WATER SUPPLIES

Water Supply Protection Zones within the area draining into a lake which is used or intended to be used by the City as a surface reservoir for drinking water shall be defined as the Water Supply Protection Zones established under the UDC, Section 8.2. On all sides around the shores at normal pool of any lake which is used or intended to be used by the City as a surface water reservoir, the buffer zone shall be the distance defined in UDC, Section 8.2.

5.8 - DRAINAGE EASEMENTS

5.8.1 - GENERAL REQUIREMENTS

Natural waterways and channels should be used wherever practical to carry runoff. Any modifications to existing waterways and channels must be approved by the City Manager. Where a subdivision is traversed by a watercourse, drainageway, natural channel or stream, an easement or right-of-way shall be provided conforming substantially to the local or FEMA one percent annual chance (100-year) floodplain, plus additional width to accommodate future needs. Final determination on public or private designation of easements is to be made by the City Engineer.

5.8.2 - ENCLOSED SYSTEMS

Storm drainage easements shall be provided for existing and proposed enclosed drainage systems. Easements shall be centered on the systems. The minimum easement width shall be based on the following formula:

\[ W = 5' + 2H + D \]

Where:
- \( W \) is the width of the easement
- \( H \) is the depth of soil cover over the pipe or box structure
- \( D \) is the diameter or width of pipe or box structure

5.8.3 - OPEN CHANNELS

Storm drainage easements along proposed or existing open channels shall provide sufficient width for the required channel and such additional width as may be required to provide ingress and egress of maintenance equipment; to provide clearance from fences and space for utility poles; to allow maintenance of the channel bank; and to provide adequate slopes necessary along the bank.

The minimum unobstructed easement width shall be the width of the channel plus 15 feet on one side (20 feet with utilities) and 2 feet on the opposite side unless approved by the City Manager. The channel top width is determined by the locations where the channel side slopes intersect with adjacent grade with cross slopes less than 10 percent.

In areas where a channel is directly adjacent and parallel to a street right-of-way, 5 feet may be deducted from the total width of the easement so that the easement width on one side of the channel is 10 feet (15 feet with utilities).
5.8.4 - OVERFLOW DRAINAGE

Storm drainage easements shall be provided for emergency overflow drainage ways of sufficient width to contain within the easement storm water resulting from a one percent (1%) annual chance (100-year) frequency storm. An emergency overflow drainage way is the path the storm water will take if the drainage facility becomes clogged or ceases to function as designed. The emergency overflow path must be located within public right-of-way or within a drainage easement or common area lot.

5.8.5 - RESIDENTIAL COMMON AREA LOTS

For Residential subdivisions with lots smaller than three (3.0) acres, public drainage easements crossing lots and property lines are prohibited. Public drainage easements shall be placed in separate common area lots.

5.8.6 - DETENTION & WATER QUALITY DESIGN FEATURES

Storm drainage easements around proposed detention structures and basins (private and public) shall provide sufficient width for the required basin and all required structural elements (embankment, outfall structure, inlets, etc.) and such additional width as may be required to provide ingress and egress of maintenance equipment; to provide clearance from fences and space for utility poles; to allow maintenance of the basin berm and outlet works; and to provide adequate slopes necessary along the perimeter. The perimeter easement shall be a minimum of 15 feet from the top of slope of any excavated or built-up embankment that has a slope greater than 4:1. The easement shall contain the 1% Annual Chance (100-yr) floodplain at the designed pool elevation.

5.9 - STORMWATER TREATMENT IN WATER SUPPLY ZONE DRAINAGE AREAS

All stormwater management facilities in drainage basins upstream of a City water supply reservoir shall be designed as Low Impact Development Facilities to treat 95 percent of the annual stormwater runoff volume as defined in UDC, Section 8.2(A). The water quality volume in Water Supply Zone Drainage Areas is defined as the runoff resulting from the first 2.35" of rainfall. Any subsequent runoff more than the design capacity of the basins shall bypass the basins and remain segregated from the contained runoff waters including those waters in a detention basin if required. Input to and release from the drainage facilities required by this subsection for water quality protection, shall be designed according to the requirements in UDC, Section 8.2(B), and utilize vegetated swales and/or overland flow dispersion measures where possible before release into the reservoir or a contributing stream.

5.10 - RESIDENTIAL LOT DRAINAGE REQUIREMENTS

No more than two (2) average residential lots, with equivalent zoning, may drain onto another lot.

The City of Boerne encourages the preservation of natural soils and vegetation. If a mass grading plan is proposed to modify grades of residential lots, the plan shall be prepared and submitted to the City with the infrastructure documents.
Lots that drain entirely to the rear (FHA “C” lots) are discouraged and may only be used when adjacent to platted open spaces or parks. The City Manager may grant an exception for “C” lots provided that the developer designs and installs a private drainage system that is located within a private drainage easement dedicated to an HOA or POA and that the system meets the minimum public storm water system standard contained in this Manual.

The following items shall be included on residential grading plan:

1. Indicate typical lot grading for lots in the subdivision using typical FHA lot grading types (A, B, and C)
2. Proposed finished floor of all building pads
3. Proposed ground elevations at all major corners of all proposed building pad locations.
4. Proposed ground elevations at all lot corners.
5. Phases of clearing and mass grading including sequencing timing and appropriate Best Management Practices (BMP’s).
6. The minimum earthen proposed slope across any portion of a residential building pad, in the same direction of storm water runoff, shall be 2.0%
7. The grade shall fall a minimum of 6 inches within the first 10 feet from the building pad.
8. Slopes across any portion of a residential building lot may not be steeper than 4:1, unless it’s being kept in an existing and natural state.
9. If the elevation difference of adjacent building pads is in excess of two (2) feet, then a retaining wall shall be provided along the adjacent property lines. These walls, including structural design, shall be clearly identified in the construction plans and shall be installed prior to the acceptance of the public improvements.
10. No slopes steeper than 4:1 shall be located within five (5) feet of a park, open space lot or pedestrian trail/sidewalk.
11. The maximum allowed cut or fill shall be five (5) feet, or as approved by City Engineer for site specific issues.

Lots where mass grading has occurred shall be verified by a survey prior to commencement of stabilization for paving. Prior to final acceptance of improvements, a lot grading certification letter, signed by professional engineer, shall accompany the required as-built plans. All final grades shall be within +/- 0.3 feet of those shown on the approved construction plans.
5.11 - MAINTENANCE OF DRAINAGE FACILITIES

The property owner or designee will maintain the hydraulic integrity of drainage systems not dedicated to the City. The City will maintain the hydraulic integrity of drainage systems dedicated to and accepted by the City. Maintenance of the floodplain, drainage easements, and water quality features shall be explicitly stated in a recorded instrument that includes the following:

1. Maintenance Schedule - A maintenance schedule supported by engineering or scientific published documents shall be submitted to the Engineering & Mobility Department prior to approval of construction plans for public and private facilities. The City has the right to conduct periodic inspections of privately owned and maintained drainage and water quality improvements to ensure that the maintenance schedule is being implemented.

2. Maintenance Inspection Report - The person responsible for maintenance of any structural stormwater management practice installed pursuant to this section shall submit to the Engineering & Mobility Department an inspection report annually for the first two years following construction and then every other year in perpetuity. The inspection report shall be prepared by a registered design professional licensed by the State of Texas or a certified inspector who has completed an approved inspection course. A stormwater management facility for an individual single-family residential lot is not required to submit inspection reports.

5.12 - INTERBASIN DIVERSION

1. Development may not divert stormwater from one watershed to another, except as authorized by this section.

2. A proposed diversion of less than 20% of the site based on gross site area or less than 1.0 acre, whichever is smaller, may be allowed if the applicant demonstrates that:
   a. Existing drainage patterns are maintained to the extent feasible; and
   b. There are no adverse environmental or drainage impacts.

5.13 - FLOOD STUDY REQUIREMENTS

Any Engineering Plans for floodplain alterations shall be based on engineering hydrologic and hydraulic analyses presented in a Flood Study.
5.13.1 - PROCESS

The review process and timeline vary for each project. All initial Conditional Letter of Map Revision (CLOMR) submittals shall go through the City before submitting to FEMA.

1. If a Flood Study is required, a preliminary Flood Study shall be submitted to the City to be reviewed by City staff or an engineering consultant. Review comments will be returned to the Engineer. Once comments have been addressed, a final Flood Study shall be submitted to the City for acceptance prior to receipt of a Grading and Floodplain Development Permit.

2. If a Flood Study and CLOMR are required, a preliminary CLOMR application and Flood Study shall be submitted to the City to be reviewed by City staff or an engineering consultant. Review comments will be returned to the Engineer. Once the comments have been addressed, a revised CLOMR application and Flood Study shall be submitted to the City for acceptance. The City’s Floodplain Administrator must sign the MT-2 Form 1 prior to submitting to FEMA. Once the CLOMR application is submitted to FEMA, review comments will be returned to the Design Engineer. Comments should be addressed and returned to FEMA and the City. All projects within the FEMA floodplain shall receive acceptance from FEMA prior to issuance of a Grading or Floodplain Development Permit.

5.13.2 - REPORT

The Flood Study shall be prepared, signed, and sealed by a Professional Engineer in the State of Texas trained and qualified to provide similar analyses. At a minimum, the Flood Study shall include the following:

1. Project Description;
2. Vicinity Map;
3. Data Collection – Describe type of data collected (previous studies, record drawings, topographic data, survey, field observations, etc.);
4. Methodology – Description of the hydrologic and/or hydraulic analyses used, including method used to determine historic rainfall and stream data, soils reports, selection of variables (such as Manning’s roughness coefficients), base models, and discharges and water surface elevations for the ultimate design floods and FEMA base floods;
5. Scour Analysis - Results of a scour analysis in accordance with USACE’s current edition HEC-RAS (River Analysis System) User’s Manual for structures within the floodplain, including bridges, culverts, aerial crossings, drop structures, and retaining walls;
6. Comparison tables – Comparison tables between existing and proposed conditions for water surface elevations, freeboard, discharge, valley storage, average velocities, and maximum subsection velocities in accordance with this section;
7. Results – Documentation that the principles of equal conveyance and channel stability have been achieved;
8. Hydrologic Exhibits - Drainage area maps, land use and soil data exhibits, and time of concentration calculations, if applicable;
9. Hydraulic Workmaps - Exhibits showing the ultimate floodplain limits for the design flood for existing and proposed conditions. If applicable, FEMA floodplain and FEMA floodway limits shall also be shown;
10. Appendix - Additional tables or figures not included in the report;
11. Printouts- Printouts from HEC-RAS and HEC-HMS, as applicable. At a minimum, HEC-RAS printouts should include: summary results table for existing and proposed conditions; stream profile for existing and proposed conditions; and, cross section plots for existing and proposed conditions. Cross section plots shall at a minimum include the following variables: 100-year water surface elevation, subsection velocity distribution, Manning’s roughness coefficients, and legend. Cross section plots shall at a minimum include the following labels: project title, plan title, run date, x and y axis titles, and cross section description;

12. Input and Output data - Copies of hydrologic and hydraulic modeling program input and output data for existing and proposed conditions for the design floods and FEMA base floods; and,

13. Digital Files - Digital files of all hydrologic and hydraulic models as described in Section 5.14.4.

5.13.3 - BASE MODELS

The Engineer shall use the City’s current effective base models for development along floodplain areas. If a model is not available, the Engineer shall be required to develop floodplain hydrologic and hydraulic models in accordance with these standards. Modeling must be performed for the design floods. If a CLOMR or LOMR is required, FEMA flows shall also be used. For projects requiring both a Flood Study and CLOMR, seek guidance from the Floodplain Administrator regarding base models.

5.13.4 - MODELING PROGRAMS

In general, the information needed for the Flood Study shall be obtained by running a flood routing model, such as USACE’s HEC-HMS or HEC-1, or NRCS’s WinTR-20, and a backwater model, such as USACE’s HEC-RAS or HEC-2. Unless an existing base model is in place, HEC-HMS and HEC-RAS shall be used.

Hydraulic models shall be prepared and labeled as following:

1. Effective Model
2. Duplicate Effective Model
3. Corrected Effective Model
4. Existing Conditions Model
5. Proposed Conditions Model

The EFFECTIVE model is simply the model used to develop the Flood insurance Study. Recent studies, and some older studies, are available from the city. If city does not have the study on file, the requestor should contact the FEMA Engineering Library. If the model is not available, the requestor will need to create an effective model that duplicates the results in the Flood Insurance Study.

The DUPLICATE EFFECTIVE model is the Effective model run using the modeler’s hardware and software. For HEC-RAS models, the software is preferably the current version of HEC-RAS. The Duplicate version should not be an earlier version than the Effective version. Occasionally floodway widths are set using user specified water surface increase (Method 4) in the Effective model. The Duplicate Effective floodway limits should always be set using right and left encroachment station (Method 1) to match the Effective model widths. Also, starting water surface elevations should always be set using a fixed water surface elevation to match the Effective model.
The CORRECTED EFFECTIVE model may or may not be required, depending on whether or not there are errors in the Effective model. These errors should be fixed in Corrected Effective model. Some of the errors may include (supporting documentation is required):

1. Inappropriate expansion and contraction coefficients;
2. Datum adjustments;
3. Bridge modeling errors (appropriate loss calculations, weir coefficients, pier coefficients, bridge rails);
4. Culvert modeling errors (size, materials, entrance and exit losses);
5. Incorrect ineffective flow locations and elevations;
6. Incorrect or unreasonable Manning’s roughness coefficients (supporting documentation is required);
7. Gross errors in topography at existing sections;
8. Negative surcharges and surcharges over 1.00’;
9. Man-made changes prior to the Effective Model that are not captured in the model.

The EXISTING CONDITIONS model inserts cross-sections and/or modifies effective cross-sections to accurately portray the existing conditions at the project site. These cross-sections should not be duplicated or interpolated, but should be based on field surveys at the project site and field surveys and/or other available topographic data away from the project site. Enough sections should be added in order to accurately model the proposed changes. Encroachment stations shall be added to new cross-sections, based on the FIRM, or interpolated from the Non-Encroachment Area (NEA) tables. The encroachment stations should then be adjusted so that the floodway water surface elevations match the Corrected Effective (or Duplicate Effective, if the Corrected Effective is not required). The Existing Conditions model should also incorporate any man-made changes since the Effective Model. Non-permitted floodway encroachments associated with the project (current violations) should not be included in the Existing Conditions model. The non-permitted encroachments should be included in the Proposed Conditions model or removed prior to permitting.

The Existing Conditions model may also need to include additional cross-sections upstream or downstream of the existing model. This will be necessary if the boundary water surface elevations do not match between the Existing Conditions model and the Proposed Conditions model. Sometimes, this may not be possible, or the effect is so large that the models simply will not match at the upstream limit. In these cases, run the model a minimum of one mile past the project limits. When the effect of a project extends upstream through a different model, either that model or the information contained in the model should be used to analyze the hydraulics upstream.

The PROPOSED CONDITIONS model is a modification of the Existing Conditions model. FEMA has provided City guidance that all elements of a proposed project must be modeled, so all revisions associated with the project should be included, even if those revisions are not within the floodway itself. For example, changes outside of the floodway that are integral to the project should be included, such as approach fill for bridges or “drainage easements.” There should be no increase in the water surface elevations for both the base flood and the floodway /NEA runs. There should be no change in the floodway widths on either side of the stream compared to the Existing Conditions model.

5.13.5 - CLOMR AND LOMR REQUIREMENTS

CLOMR and LOMR applications shall meet current City and FEMA requirements. For any FEMA floodplain alterations, a CLOMR must be approved before a Grading or Floodplain Development Permit will be granted. A LOMR shall be submitted within 6 months after the completion of any FEMA floodplain alterations.
5.13.6 - NO-RISE/NO-IMPACT CERTIFICATIONS

The engineering “no-rise / no-impact” certification and supporting technical data must stipulate NO impact or NO changes to regulatory or local 100-year base flood elevations, floodway elevations, or floodways widths at the new cross-sections and at all existing cross sections anywhere in the model. Therefore, the revised computer model should be run for significant distances upstream and downstream of the development site or at the discretion of the Floodplain Administrator to insure proper “No-Rise / No-Impact” certification.

Certification for proposed developments encroaching into the local or FEMA floodway or floodplain, the following supporting data must be submitted to floodplain administrator for review and should include, but may not be limited to:

1. No-Rise Letter on City standard form
2. Copy of the Duplicate Effective model
3. Copy of the Corrected Effective model
4. Existing conditions, or Pre-project model
5. Proposed conditions, or post-project model
6. FIRM and certified topographic workmap, showing floodplain and floodway, the additional cross-sections, the site location with the proposed topographic modification superimposed onto the maps, and a copy of the effective FIRM showing the current floodway or floodplain.
7. Documentation clearly stating analysis procedures. All modifications made to the original FIS model to represent revised existing conditions, as well as those made to the revised existing conditions model to represent proposed conditions, should be documented and submitted with all supporting data including which modeling version.
8. Effective Floodway Data Table copied from the FIS report
9. Statement defining source of additional cross-section topographic data and supporting information.
10. Cross-section plots of all cross sections within analysis limits for the pre-and post-project models
11. Design and Construction Plans, per City requirements
12. Copy of the source from which input for original FIS model was taken
13. Digital Copy of all input and output files
14. Printout of output files from runs for all models.

Note:

a. Floodway widths at new cross-sections are set by measuring from the effective FIRM.
b. No change on floodway widths at effective cross-sections unless there is an error.
c. No-rise analysis should not optimize floodway and non-encroachment width. The purpose of the no-rise is to determine the impact on the flood levels, the parameters (including encroachment stations) should remain as unchanged as possible from the effective model. Changes in encroachment stations require an approved Conditional Letter of Map Revision from FEMA.
d. No changes in hydrology unless there is an obvious error
e. Interpolated cross-sections may be allowed outside of the project area where increased precision is needed. Interpolated cross-sections shall be identical in the Existing Conditions and Proposed Conditions models.
f. Hydraulic models should not be truncated if the water surface elevations and velocities do not match between the Existing and Proposed models at the upstream cross-section to the nearest 0.01’.
5.13.7 - VERIFICATION OF FLOODPLAIN ALTERATIONS

1. Prior to final acceptance by the City of public or private infrastructure for projects involving floodplain alterations or adjacent to defined floodplains, creeks, channels and drainageways, a certified statement shall be prepared by a registered public surveyor showing that all lot elevations, as developed within the subject project, meet or exceed the required minimum finished floor elevations shown on the final plat of the subdivision. This certification shall be filed with the City Engineer.

2. In addition, at any time in the future when a building permit is desired for existing platted property which is subject to flooding or carries a specified or recorded minimum finished floor elevation, a registered public surveyor shall survey the property prior to obtaining a building permit. The certified survey data showing the property to be at or above the specified elevation shall be furnished to the City Engineer for approval. Certificate of compliance with the provisions of this article pertaining to specified finished floor elevations shall be required.

3. The Owner /Developer shall furnish, at their expense, to the City Engineer sufficient engineering information to confirm that the minimum floor elevations proposed are as required by this section. Construction permits will not be issued until:
   a. A CLOMR or amendment has been issued by FEMA; and,
   b. Lots and and/or sites are certified by a registered public surveyor and are elevated from the floodplain according to the FEMA-approved revisions to the floodplain and the requirements of this article.
CHAPTER 6 - EROSION CONTROL REQUIREMENTS

The final infrastructure documents as listed in Chapter 1 shall be accompanied by an Erosion Control Plan (ECP) for the control of erosion and sedimentation. The ECP shall include a construction sequencing plan which details the proposed placement, maintenance and removal of temporary erosion controls, the slope stabilization techniques which are to be employed and the restoration measures, including vegetative types, which are to be employed as part of the process of subdivision development. The plan shall list and show the location of temporary erosion controls, show the physical details of the controls, and include a construction sequencing list which will govern the timing of the use of various controls in relation to distinct steps in subdivision construction.

Erosion control design elements not specifically addressed in this Engineering Design Manual should be designed in accordance with the latest addition of:


6.1.1 - CONSTRUCTION SITES AND DISTURBED AREAS

Private property owners, developers or builders shall be accountable for any erosion of their property or construction site which results in measurable accumulation of sedimentation in dedicated streets, alleys, any drainageway or other private properties. Any accumulation or deposit of soil material beyond the limits of the property or in City streets, alleys, or drainage facilities in an amount sufficient to constitute a threat to public safety and comfort as determined by the City Engineer shall constitute a violation. Sediment carried by stormwater runoff through these areas shall be prevented from entering storm drain systems and natural watercourses.
6.1.2 - CONSTRUCTION CONTROLS

Structural and non-structural controls may be used for controlling pollutants for storm water discharges from small and large sites. Structural controls shall comply with details and specifications in the latest edition of the TCEQ, LCRA and these standards. When the TCEQ Manual and these standards are in conflict, these standards shall govern.

The following are acceptable temporary controls for use during construction:

Non-Structural
1. Minimizing the area of disturbance
2. Preserving existing vegetation

Structural
1. Silt fence, with minimum spacing per Table 3-18, LCRA Highland Lakes, Water Quality Management Technical Manual
2. Inlet protection
3. Rock check dams, with spacing per Table 3-19, LCRA Highland Lakes, Water Quality Management Technical Manual
4. Stabilized construction entrances
5. Sediment traps
6. Vegetated buffer strips
7. Temporary sedimentation basin
8. Hydro mulch

It is the responsibility of the design engineer to select and design appropriate construction controls for each site. If the most appropriate control is not shown in the TCEQ or LCRA Manual, the design engineer shall submit calculations and references for design of the control to the City Engineer for review and approval.

During construction, there will be on-going inspections by City inspectors throughout the construction phase. Corrective actions to address erosion controls effectiveness, including the installation of additional controls, may be required by the inspector. Deviations from approved plans may require a plan revision. Minor adjustments to erosion control locations will not require a plan revision but must be documented by the responsible party.

6.1.3 - TEMPORARY SEDIMENTATION BASINS

Temporary Sedimentation Basins shall be constructed before any watershed with land disturbing activities greater than one (1) acre occur.

If the development has a permanent detention pond proposed, the permanent basin shall be constructed to act as the required temporary sedimentation basin. Guidelines for construction of the permanent basin should be followed, but placement of permanent outfall piping should not be carried out until the site construction phase is complete.
If no permanent detention pond is proposed, a temporary sedimentation basin must provide sufficient storage to contain a calculated volume of runoff from a 2-year, 24-hour storm from each disturbed acre drained. When calculating the volume of runoff from a 2-year, 24-hour storm event, it is not required to include the flows from offsite areas and flow from onsite areas that are either undisturbed or have already undergone permanent stabilization if these flows are diverted around both the disturbed areas of the site and the sediment basin. Capacity calculations shall be included in the erosion control plan (ECP).

All sedimentation basins shall include a temporary dewatering outlet with a vertical perforated riser, or alternate design as approved by City Engineer, to provide a drawdown time of between twenty-four (24) and forty-eight (48) hours.

6.1.4 - TEMPORARY STABILIZATION

Portions of a site that have been disturbed, but where no work will occur for more than 21 days shall be temporarily stabilized as soon as practicable, and no later than 14 days, except when precluded prolonged drought.

Temporary stabilization shall consist of providing a protective cover, designed to reduce erosion on disturbed areas. Temporary stabilization may be achieved using temporary seeding, soil retention blankets, hydro-mulches and other techniques that cover 100 percent of the disturbed areas until either final stabilization can be achieved or until further construction activities take place. Seeding must be used in conjunction with any covers or soil retention blankets.

Perimeter controls such as silt fence, vegetated buffer strips or other similar perimeter controls are intended to act as controls when stabilization has not occurred. Perimeter controls may remain in place during temporary stabilization.

6.1.5 - FINAL STABILIZATION

Final stabilization consists of soil cover such as vegetation, geo-textiles, mulch, rock, or placement of pavement. For stabilizing vegetated drainage ways and stormwater facilities, sod or seeded soil retention blankets shall be used. Hydro mulch will not be allowed in vegetated swales, channels or other drainage ways.

The plan for final stabilization shall be coordinated with permanent controls in the drainage plan and with the landscaping plan, if applicable.

Topsoil is typically removed when a site is cleared. Since topsoil is essential to establish new vegetation, it should be stockpiled and then reapplied to the site for revegetation, if appropriate. Although topsoil salvaged from the existing site can often be used, it must meet certain standards and topsoil may need to be imported onto the site if the existing topsoil is not adequate for establishing new vegetation.
6.1.6 - INSPECTION AND MAINTENANCE DURING CONSTRUCTION

The owner/developer shall construct all controls required by the Erosion Control Plan (ECP). All temporary erosion controls shall be inspected weekly and after every rainfall event greater than 0.5 inches; however, daily inspections may be warranted when environmentally sensitive features are located on or immediately adjacent to the site.

Certified inspection reports shall be retained as part of the ECP and shall be available to the City upon request. Within forty-eight (48) hours of the inspection, controls identified as damaged or deteriorated shall be repaired or replaced, as appropriate. Controls shall also be routinely cleaned to maintain adequate capacity.

The owner/developer shall implement procedures to remove discharged soil from all portions of the storm drainage system including streets, gutters, inlets, storm drain, channels, creeks, ponds, etc.

Notes requiring the inspection and maintenance shall be placed on ECP drawings. The ECP shall identify the responsible party for inspecting and maintaining each control.

6.1.7 - EROSION CONTROL PLAN

Erosion and Control Plan (ECP) shall include the following design concepts:

1. Maximum use shall be made of vegetation to minimize soil loss. Vegetation measures should begin as soon as possible during construction to allow for establishment at construction termination.
2. Natural vegetation should be retained wherever possible.
3. Erosion controls should be phased as necessary to reflect changes in drainage patterns to remain effective during the construction period.
4. Where inadequate natural vegetation exists or where it becomes necessary to remove existing natural vegetation, temporary controls should be installed promptly to minimize soil loss and ensure that erosion and sedimentation does not occur. The developer is responsible for maintenance of site erosion control devices until 85% vegetation cover has been provided or replaced as determined by the City Engineer. Periodic maintenance shall be performed by the developer to remove accumulated sediment that would otherwise inhibit the proper functioning of the erosion control devices. Temporary controls are required to maintained on all permitted construction sites.
5. During construction, erosion controls shall be used to slow drainage flow rate and prevent downstream sedimentation.
6. Erosion control elements should be implemented as soon as practical in the development process.
7. Waste or disposal areas and construction roads should be located and constructed in a manner that will minimize the amount of sediment entering streams.
8. Frequent fording of live streams will not be permitted; therefore, temporary bridges or other structures shall be used wherever an appreciable number of crossings of a stream are necessary.
9. When work areas or material sources are in or adjacent to live streams, such areas shall be separated from the stream by a dike or other barrier to keep sediment from entering a flowing stream. Care shall be taken during the construction and removal of such barriers to minimize the sediment transport into a stream.
10. Should preventative measures fail to function effectively, the applicant shall act immediately to bring the erosion and/or siltation under control by whatever additional means are necessary.
11. Erosion control devices shall be placed to trap any losses from stockpiled topsoil. Some acceptable forms of site erosion control devices include, but are not limited to, silt fences, silt traps, geonetting and geotextiles. Hay bales are not permitted.
12. The selection and timing of the installation of erosion controls shall be based upon weather and seasonal conditions that could make certain controls not practicable.
13. Vegetation used for vegetative cover shall be suitable for local soil and weather conditions. Ground cover plants shall comply with listings from the Texas Agricultural Extension Service for native plants.
14. Runoff shall be diverted away from construction areas as much as possible.
15. Stripping of vegetation from project sites shall be phased so as to expose the minimum amount of area to soil erosion for the shortest possible period of time. Phasing shall also consider the varying requirements of an erosion control plan at different stages of construction and shall include the establishment of new vegetation or permanent erosion control measures.
16. Developers, builders, or owners of property shall install all utilities, including communications (telephone, cable, etc.) utilities, before final acceptance of a subdivision, property and/or structure. Final acceptance will also be contingent upon having all necessary erosion control measures installed to minimize off-site sediment.
17. Erosion Control Plan (ECP) shall follow TCEQ rules for Construction Activities.
CHAPTER 7 - DOMESTIC WATER DESIGN REQUIREMENTS

7.1 - WATER SYSTEM DESIGN STANDARDS

All water production, trunk main, and distribution facilities shall be designed and sized to meet the minimum design standards in the Table 7-1.

Table 7-1: Water System Minimum Design Standards

<table>
<thead>
<tr>
<th>Demand Assumptions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Equivalent</td>
<td>2.7 persons per residential unit</td>
</tr>
<tr>
<td>Average Daily Demand</td>
<td>160 gallons per capita per day</td>
</tr>
<tr>
<td>Peak Daily Demand</td>
<td>2 times average daily demand</td>
</tr>
<tr>
<td></td>
<td>(= 320 gallons per capita per day)</td>
</tr>
<tr>
<td>Peak Hour Flow Rate</td>
<td>3.5 x average hourly rate</td>
</tr>
<tr>
<td></td>
<td>(= 560 gallons per capita per day)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply Requirements</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Capacity</td>
<td>Peak Daily Demand</td>
</tr>
<tr>
<td>High Service Pumps</td>
<td>Peak Hour Demand plus fire flow</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Storage Requirements</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Storage</td>
<td>One day of storage (160 gallons per capita)</td>
</tr>
<tr>
<td>Elevated Storage</td>
<td>Top 20’ = 40 gallons per capita</td>
</tr>
<tr>
<td></td>
<td>Top 40’ = 4 hours of maximum fire flow + average demand</td>
</tr>
</tbody>
</table>

7.2 - WATER MAINS

7.2.1 - GENERAL SPECIFICATIONS

Domestic water mains shall be sized and extended through the limits of a development to serve adjacent properties to point(s) as determined by the Utilities Director to ensure orderly development. Piping for water mains and connections shall be in accordance with the current edition of the following:

3. American Water Works Association (AWWA) Standards.
7.2.2 - SIZING OF WATER MAINS

Computer modeling, as prepared by the design engineer, is the preferred method for sizing water mains. For phased development, the model must show that each individual phase meets the peak flow requirements of this design manual. The following criteria shall be used for the minimum requirements to size public water mains:

1. Single-Family Residential
   a. Water mains smaller than eight inches shall not be permitted, except for permanent Cul-de-Sacs less than 600 feet long may be six inches in diameter.

2. Multi-family Residential
   a. Water mains smaller than eight inches shall not be permitted.
   b. Water mains greater than 600’ in length between intersecting mains or supplying more than two fire hydrants/fire service lines, shall be a minimum of 12”, unless water model verifies 8” diameter is adequate.

3. Commercial, Schools & Industrial
   a. Looped 8” water mains shall be used for fire hydrants located in parking lots and not adjacent to buildings.
   b. Water mains greater than 1,000’ in length or supplying more than two fire hydrants/fire service lines shall be a minimum of 12”.

4. All water mains shall be sized to have maximum velocities of 8 feet per second for Maximum Daily Demands and maximum velocities of 10 feet per second for Combined Maximum Daily Demand and Fire Flow Demands.

5. The City may require oversizing of certain mains in accordance with Chapter 7 of the UDC.

6. A minimum of 12-inch main is required within, or adjacent to the frontage of, collector or higher roadway classifications. A neighborhood collector may provide an 8-inch main only if a water model is provided determining an 8-inch main is adequate.

7. New connections to existing mains that are substandard size shall not be allowed. Substandard mains shall be determined by the Utilities Director based on criteria including, but not limited to: size, material, condition, pressure, flow rate, etc.

8. Offsite improvements may be necessary to provide adequate water service to the site.

7.2.3 - LOOPING REQUIREMENTS

In all areas, all lots shall be provided service connections from looped water mains, whose inside diameter is eight inches or larger, providing water flow from two directions or sources, except as noted in this section. Exceptions to looping requirements may be approved by the Utilities Director, and a water model may be required to determine peak flow requirements of this manual and the fire code are met.

Utility providers other than the City of Boerne may or may not require looping. If looping is not required, a letter must be provided from the utility provider noting that all minimum requirements of this ordinance and the fire code are met.

For projects located within an approved Master Development Plan (MDP), each individual subdivision phase shall have two points of connection, one connection to a minimum 8” main and the second connection may be a stub to a future subdivision within the MDP. At no time shall there be a portion of an individual subdivision phase with a demand greater than 75 LUE’s without looping being constructed. Stubs to neighboring undeveloped properties and the edge of the development are additional to these requirements.
Water mains serving more than two fire hydrants must be a looped system connected to two different existing water mains, unless a water model can be provided to show proposed fire hydrants meet minimum flow requirements.

7.2.4 - DEVELOPMENT EXTERNAL CONNECTION REQUIREMENTS

For multi-phase developments with an approved Master Development Plan (MDP), the minimum number of external connections to an existing water system shall be as follows:

<table>
<thead>
<tr>
<th>Development LUE Count</th>
<th>Development Supply/Looping requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25</td>
<td>Two connections. One connection to minimum 8” main and other connection may be a stub to neighboring property.</td>
</tr>
<tr>
<td>25 thru 200</td>
<td>Two connections. One connection to a minimum 12” Trunk Main and other connection may be a stub to neighboring property.</td>
</tr>
<tr>
<td>200 thru 400</td>
<td>Two connections. One of which is to a minimum 12” Trunk Main and other to minimum 8” main.</td>
</tr>
<tr>
<td>400 and greater</td>
<td>Two connections providing dual source of water production. Both connections to separate 12” Trunk Mains, or larger.</td>
</tr>
</tbody>
</table>

When two connections are required, the second required development connection may be phased if the demand for the initial connection does not exceed 200 LUE’s. Required stubs to neighboring undeveloped properties and the edge of the development are additional to these requirements.

7.2.5 - DEAD END MAINS

1. Dead-end mains shall be avoided and may only be considered when a looped or interconnected water main system is not available. All dead-end lines shall only be installed upon approval from the City Engineer and at a maximum length of 150 feet.
2. Dead end mains with a permanent cul-de-sac up to 600 ft. shall be allowed.
3. Dead end water mains, where future extension will occur, shall extend a minimum of 5’ beyond the edge of the pavement. If adjacent to a fitting, extend a minimum of 20’ or one pipe joint beyond fitting.
4. At dead ends, gate valves shall be located within 150 feet pipe length from the end points of the main.

7.2.6 - LOCATION

1. All water mains shall be in dedicated streets or fire lanes, or in the community open space in a planned unit development or cottage development.
2. On streets with curbs and sidewalks, all water mains shall be in the public right-of-way at uniform distance between the curb and the sidewalk.

7.2.7 - SLOPE

All water mains shall be designed to have minimum 0.1% slope to allow for draining and flushing, if necessary.
7.2.8 - HORIZONTAL AND VERTICAL ALIGNMENT

1. No water line shall be deflected either vertically or horizontally, in excess of 75% of the recommendations by the manufacturer of the pipe, without the appropriate use of bends or offsets.
2. Unless authorized by City Engineer, all bends shall be 45 degrees or less where practical. Two 45-degree bends in a series shall be separated by a distance of five pipe diameters instead of a 90-degree bend.

7.2.9 - GAS TRANSMISSION PIPELINE CROSSINGS

Water mains proposed to parallel or cross existing gas pipelines shall adhere to the owner of the gas pipeline’s clearance and other requirements. When feasible, water and wastewater mains shall maintain a minimum horizontal clearance of 5 feet and vertical clearance of 3 feet, as measured from the outside diameters of each main. Coordination with the pipeline owner is required to confirm clearance requirements. The more stringent clearance requirements will be enforced.

7.2.10 - MINIMUM FLOW REQUIREMENTS

1. Water mains in principle mercantile and industrial areas shall be sized so that the minimum fire flow from any single fire hydrant shall be not less than 3,000 gallons per minute with 20 psig residual pressure.
2. Water mains in light mercantile areas shall be sized so that the minimum fire flows from any single fire hydrant shall be not less than 2,500 gallons per minute with 20 psig residual pressure.
3. Water mains in one- and two-family residential areas shall be designed as follows:
   a. If any house within the development having a fire-flow calculation area equal or greater than 3,600 square feet (SF), the water mains shall be sized so that the minimum fire flow at any single fire hydrant shall not be less than 1,750 gallons per minute with 20 psig residual pressure and a domestic use of 2 gpm for every lot in the subdivision.
   b. If developer/subdivider provides a signed letter stating that all homes within the development will be less than 3,600 SF and that City will not be obligated to issue a building permit within the development for any proposed home equal or greater than 3,600 SF, a reduction to the fire flow will be approved such that the minimum fire flow at any single fire hydrant shall not be less than 1,000 gallons per minute with 20 psig residual pressure.
4. On-site water mains and hydrants shall be installed capable of supplying fire flow required by the current adopted edition of the Fire Code, Appendix B: Fire-flow Requirements for Buildings, as interpreted by the City’s Fire Marshal.

7.2.11 - VALVE LOCATIONS

1. The distribution system shall be equipped with a sufficient number of valves and the valves shall be so located that no case of accident, breakage or repair to the water distribution system mains will necessitate shutting from service a length of water main greater than either one side of a single block or a maximum of 500 feet.
2. Valves on main lines shall be located adjacent to fire hydrant tees.
3. On distribution mains, a minimum of 2 valves are required at all tees and 3 valves at all crosses.
4. When water mains cross creeks, a valve shall be located 15’ beyond the top of creek bank on each side of the creek crossing.
5. Valves shall not be in parking spaces of parking lots or within barrier free ramps.
7.2.12 - SERVICE LINES

All water service lines and fittings shall be in accordance with the Standard Specification for Public Works Construction, latest edition. Any change of use or proposed development that increases the demand on the system shall be required to replace any existing substandard water services. Substandard services shall be determined by the Utilities Director based on criteria including, but not limited to: size, material, condition, pressure, flow rate, etc.

The minimum sizes of service lines that shall be used are as required in the following table:

Table 7-3: Minimum Water Service Line Sizes

<table>
<thead>
<tr>
<th>Number of Dwelling Units</th>
<th>Service Line Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3/4</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3 - 4</td>
<td>1 1/2</td>
</tr>
<tr>
<td>5 - 10</td>
<td>2</td>
</tr>
<tr>
<td>11 - 50</td>
<td>4</td>
</tr>
<tr>
<td>51 - 80</td>
<td>6</td>
</tr>
<tr>
<td>More than 80</td>
<td>8</td>
</tr>
</tbody>
</table>

7.2.13 - CREEK CROSSINGS

Where water mains are laid under any flowing stream or semi-permanent body of water, such as a marsh or pond, the water main shall be installed with valves on each side of the crossing to allow the isolation and testing of that portion of the water main to determine if there are any leaks.

A primary consideration in the design of creek crossings is the prevention of soil erosion at the areas of trench backfill. At a minimum, cement stabilized backfill shall be used from bank to bank. The cement stabilized backfill shall be covered with channel lining as required in Chapter 5, Drainage Design Requirements.
7.3 - FIRE HYDRANTS

7.3.1 - GENERAL REQUIREMENTS

1. All fire hydrants shall have a six-foot clear horizontal radius of 360 degrees around the fire hydrant free from obstructions.
2. All fire hydrants shall always be located on street corners or side property lines to be readily accessible.
3. All fire hydrants shall be equipped with at least a 6-inch valve located on the hydrant lead and the valve and hydrant shall be mechanically anchored to the main. The center of a hose outlet shall be not less than 18” above final grade. The center of a hose outlet shall not be greater than 36” above final grade.
4. Fire hydrants shall be located no greater than 8’ from a fire apparatus road.
5. No more than one fire hydrant shall be installed on any 6-inch water main.

7.3.2 - MAXIMUM SPACING

1. Every building in the City limits shall be within 500 feet of a standard City fire hydrant.
2. In commercial and industrial areas, hydrants shall be located so that there will be at least one hydrant every 300 feet average as measured along dedicated streets.
3. In light mercantile areas containing multi-family apartment houses, hydrants shall be located in dedicated streets or fire lanes behind curbs and be spaced not more than 300 feet hose lay from any building within the district, each distance to be measured down any standard fire hose laid from the fire hydrant to the building.
4. In residential areas, hydrants shall be located so that there will be a fire hydrant every 500 feet average distance as measured along dedicated streets, including dedicated easements and fire lanes in mobile home parks and travel trailer parks.

7.4 - STORAGE TANKS

All ground level and elevated storage tanks shall be designed, installed, and constructed in accordance with current American Water Works Association (AWWA) standards with reference to materials to be used and construction practices to be followed.

7.5 - PRESSURE PLANES

7.5.1 - GENERAL REQUIREMENTS

1. The City currently operates multiple water pressure planes. The locations of the existing and proposed pressure planes are shown in the City’s Water Master Plan.
2. Prior to the design of a water system, the Design Engineer shall investigate and determine if the proposed water main crosses the boundary between pressure planes. The Design Engineer shall coordinate with the City prior to the design of a water main that crosses a pressure plane boundary. For those pressure planes separated by a street, a main shall be provided for each pressure plane on their respective side of the street. Proposed mains that approach pressure zone boundaries shall be designed to loop within their designated pressure planes as shown in the City’s Water Master Plan.
CHAPTER 8 - SANITARY SEWER DESIGN REQUIREMENTS

8.1 - SANITARY SEWER DESIGN STANDARDS

1. Sanitary sewer mains shall be sized and extended through the limits of a development to serve adjacent properties to point(s) as determined by the Utilities Director to ensure orderly development.

2. All wastewater collection system improvements shall be designed and sized to meet the minimum design standards in the following table:

   Table 8-1: Wastewater System Minimum Design Standards

<table>
<thead>
<tr>
<th>Demand Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Equivalent</td>
</tr>
<tr>
<td>Average Daily Flow</td>
</tr>
<tr>
<td>Peak Daily Flow</td>
</tr>
<tr>
<td>Infiltration Factor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average Capacity Requirements</th>
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</thead>
<tbody>
<tr>
<td>Single Family Residential</td>
</tr>
<tr>
<td>Multi-Family Residential</td>
</tr>
<tr>
<td>Commercial</td>
</tr>
</tbody>
</table>

3. All sewers shall be sized to accommodate the maximum peak flow plus infiltration flows which will render the pipe flowing no greater than three-fourths full.

4. Minimum slope shall be according to current Texas Commission on Environmental Quality rules and regulations and sewerage design standards.

8.2 - SEWER LOCATION

1. All sewer mains are to be in the street right-of-way or dedicated utility easement.

2. All sewer services shall be located on the front lot lines. In commercial areas, the Utility Director may approve alternate service location.

3. Separation distances between sewer mains or laterals and potable waterlines shall be in accordance with regulations of the Texas Commission on Environmental Quality (TCEQ).

8.3 - MATERIALS

Materials shall be in accordance with the City of Boerne, *Standard Specifications for Public Works Construction*, current version.

8.4 - TRENCHING

Sewers shall be constructed according to City standard specifications as to trenching, bedding, backfill and compaction.
8.5 - MINIMUM DIAMETER OF MAINS

Eight-inch diameter pipe shall be the minimum acceptable for sewer mains and lines, except that a sewer main less than 600 feet long may be six inches in diameter if located on a cul-de-sac or an existing dead-end street within a residential subdivision.

8.6 - MANHOLES

1. Manholes shall be located to facilitate inspection and maintenance of the wastewater main and spaced not more than 400 feet apart. Manholes shall be installed at the following locations:
   a. Intersections of mains
   b. Horizontal alignment changes
   c. Vertical Grade Changes
   d. Change in pipe size
   e. Change of pipe material
   f. The point of discharge of a force main into a gravity wastewater main
   g. Intersection of service lines to main lines 24” or larger
   h. A manhole is required at the point of connection of a building service line to the public wastewater service stub for multi-family projects exceeding fifteen (15) dwelling units and for commercial developments with use of a 2” domestic meter or larger.
2. Manholes shall not be in parking spaces of parking lots.
3. All gravity lines into manholes, including drop connections, shall match crown-to-crown.
4. Interior flowline angle between incoming and outgoing mains shall not be less than ninety degrees unless approval of deviation granted by the Utility Director.
5. Where new construction ties into an existing manhole, the interior of the existing manhole shall be coated per the requirements of the Standard Specifications for Public Works Construction, latest edition.
6. Manhole ventilation shall be provided as required by TCEQ Rules and Regulations.

8.7 - LIFT STATIONS AND FORCE MAINS

It is the intent of the City to provide wastewater service by main extensions. In the rare occasion that a wastewater main extension is not a feasible service alternative, the City may require design and construction of a lift station and force main to serve a development. Lift stations and force mains are discouraged due to their higher risk of causing a wastewater overflow and increased maintenance costs. If service by a gravity wastewater main and all other design alternatives have been evaluated and determined to be unfeasible by the City Engineer, lift stations and force mains shall be designed with the criteria described as follows:

1. Prior to design of Lift Station, the Design Engineer shall submit two (2) copies of engineering design report for the lift station.
2. The report must clearly show that gravity lines are not available and are not economically feasible and that the number of lift stations has been minimized. The justification must include a cost benefit analysis of gravity versus lift station project including 30 years of operation and maintenance of the proposed system.
3. A plan for the service area of the proposed lift station shall be prepared. This plan shall include a map showing the location of the lift station, the service area, the boundaries of the sewer basin it is in and the location of the nearest existing wastewater interceptor within or outside of that basin.
4. The Engineering Report shall be approved by a City Engineer prior to beginning preparation of the plans and specifications.
5. Lift stations shall be designed in accordance with TCEQ Chapter 217, Subchapter C.
6. Lift station capacity shall be no less than 100 gallons per minute per pump.
7. Lift station force mains shall be designed and sized to produce a complete exchange of wastewater every other cycle of the pumps.

9. The minimum force main size shall be four inches.

10. Lift stations shall be a minimum of 150’ from residential structures and enclosed, for noise and odor control, in a building that matches the general architecture of the subdivision.

11. The lift station shall be connected to the City monitoring system via auto-dialer.

12. Force mains shall be sized so that the flow velocity is between three (3.0) and six (6.0) feet per second at ultimate development. During initial development phases, flow velocities may be as low as two and one-half (2.5) feet per second.

13. The maximum diameter of a force main shall be eight (8) inches. Force mains requiring a greater capacity can install parallel mains.

### 8.8 - MINIMUM DIAMETER OF SERVICE LINES

Service lines serving individual lots shall be no smaller than 6 inches in diameter.

### 8.9 - GAS TRANSMISSION PIPELINE CROSSINGS

Sewer mains proposed to parallel or cross existing gas pipelines shall adhere to the owner of the gas pipeline’s clearance and other requirements. When feasible, water and wastewater mains shall maintain a minimum horizontal clearance of 5 feet and vertical clearance of 3 feet, as measured from the outside diameters of each main. Coordination with the pipeline owner is required to confirm clearance requirements. The more stringent clearance requirements will be enforced.

### 8.10 - INVERTED SIPHON

An inverted siphon can be designed to a portion of a wastewater main which dips below the hydraulic grade line to avoid any obstructions including, but not limited to a drainage structure, utility, tunnel, or stream. Inverted siphons should be avoided and shall only be considered where all other design alternatives have been evaluated and avoidance or adjustment of the obstructing utility or structure is not feasible, as determined by the Utility Director and City Engineer.

When allowed, a siphon must be designed in accordance with TCEQ requirements, and include the following:

1. Two or more barrels;
2. Minimum 8-inch diameter main;
3. Two manholes with adequate clearance for cleaning with a flushing truck;
4. Sufficient head to achieve a velocity of at least 3 feet per second at initial and design flows. The arrangement of inlet and outlet works must divert the normal flow to one barrel and designed such that any barrel can be taken out of service for cleaning;
5. Provisions to allow cleaning across each bend with equipment available to the entity in charge of operation and maintenance of the facility; and,
6. A design that minimizes nuisance odors.
CHAPTER 9 - RECLAIMED WATER DESIGN REQUIREMENTS

9.1 - RECLAIMED WATER DESIGN STANDARDS

Piping and appurtenances for reclaimed water mains and connections shall meet the minimum criteria as required by the City of Boerne, *Standard Specifications for Public Works Construction*, as currently amended.

Reclaimed water mains shall be sized and extended through the limits of a development to serve adjacent properties to point(s) as determined by the Utilities Director to ensure orderly development.

9.2 - SIZING OF RECLAIMED WATER MAINS

All reclaimed water production and distribution facilities shall be designed and sized to meet the minimum design standards and be based on the Developer/Subdivider’s expected average and peak reclaimed water consumption as identified in the design report. All reclaimed water mains shall be installed at locations designated by the City. Computer modeling is preferred for sizing reclaimed water mains based on Developer/Subdivider’s expected reclaimed water consumption; however, for reclaimed water mains less than sixteen (16) inches in diameter other engineering calculation methods may be accepted. All reclaimed water mains shall be sized to provide necessary service to the subdivision being developed and per the minimum standards indicated in the Table 9-1.

Table 9-1: Reclaimed Water System Minimum Design Standards

<table>
<thead>
<tr>
<th>Demand Assumptions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Average Irrigation Application Rate</td>
<td>1,987 GPD / Irrigated Acres</td>
</tr>
<tr>
<td>Peaking Factors</td>
<td></td>
</tr>
<tr>
<td>Summer – 1.37</td>
<td></td>
</tr>
<tr>
<td>Winter – 0.66</td>
<td></td>
</tr>
<tr>
<td>Peak Flow Rate</td>
<td>Maximum Summer Irrigation Volume over 14-Hour Period</td>
</tr>
</tbody>
</table>

Subdivider shall specify the total irrigated areas and percent impervious cover in accordance with the land use category. Additional demands for reclaimed water shall be clearly defined in the report. The City may require oversizing of certain mains in accordance with UDC, Article 7.9.
9.3 - LOOPING REQUIREMENTS

1. In all areas, all lots being provided service connections from looped reclaimed water mains, whose inside diameter is four inches or larger, providing water flow from two direction or sources, except dead end mains in cul-de-sacs up to 600 ft shall be allowed. Exceptions to looping requirements may be approved by the Utilities Director, and a reclaimed water model may be required to determine peak flow requirements of this manual are met.

2. For projects located within an approved Master Development Plan (MDP), each individual subdivision shall have two points of connection, one connection to a minimum 4” main and the second connection may be a stub to a future subdivision within the MDP. Stubs to neighboring undeveloped properties and the edge of the development are additional to these requirements. Utility providers other than the City of Boerne may or may not require looping. If looping is not required, a letter must be provided from the utility provider noting that all minimum requirements of this ordinance are met.

9.4 - LOCATION

All reclaimed water mains are to be in the right-of-way, as designated by the Utility Director.

9.5 - VALVE LOCATIONS

1. The distribution system shall be equipped with a sufficient number of valves and the valves shall be so located that no case of accident, breakage or repair to the reclaimed water distribution system mains will necessitate shutting from service a length of reclaimed water main greater than either one side of a single block or a maximum of 500 feet.

2. A minimum of 2 valves are required at all tees and 3 valves at all crosses.

3. When water mains cross creeks, a valve shall be located 15’ beyond the top of creek bank on each side of the creek crossing.

4. Valves shall not be in parking spaces of parking lots.
CHAPTER 10 - GAS MAIN DESIGN REQUIREMENTS

10.1 - GENERAL SPECIFICATIONS

Piping and appurtenances for gas systems and services shall meet the minimum criteria as required by the City of Boerne, *Standard Specifications for Public Works Construction*, as currently amended. All materials that will become a permanent part of the gas distribution system must be approved by the City with written assurance that minimum requirements are being satisfied for the selection and qualification as established by Federal and State Regulations. All components used in the construction of a gas pipeline and related facilities must be to withstand operating pressures and temperatures without impairment.

Gas mains shall be sized and extended through the limits of a development to serve adjacent properties to point(s) as determined by the Utilities Director to ensure orderly development. The developer/subdivider shall pay all costs associated with the design and construction of the City of Boerne gas distribution system.

10.2 - SIZING OF NATURAL GAS MAINS

Computer modeling is preferred method for sizing gas mains. For phased development, the model must show that each individual phase meets the peak flow requirements of this design manual. The following criteria shall be used for the minimum requirements to size and loop gas mains:

1. All natural gas mains shall be installed in accordance with this article or as required by the City. All natural gas mains shall be sized to provide necessary service to the subdivision being developed with the minimum diameter being 1 inch.
2. The City’s standard pipe diameters for providing gas services are 1 and 2 inches. The City shall determine the appropriate service size after consideration of service requirement information provided by the Applicant or Customer.
3. The maximum gas pressure provided to a Customer shall be 2 psi, unless authorized by the City.
4. The City may require oversizing of certain mains in accordance with Article 7.9 of the UDC.

10.3 - LOOPING REQUIREMENTS

In all areas, all lots shall be provided service connections from looped gas mains, whose inside diameter is four inches or larger, providing gas flow from two directions or sources, to provide system redundancy except as noted in this section. Exceptions to looping requirements may be approved by the Utilities Director, and a gas model may be required to determine peak flow requirements of this manual are met.

10.4 - LOCATION

All natural gas mains are to be located in the street right-of-way or dedicated utility easement as designated by the City Manager.

10.5 - VALVE LOCATIONS

1. The distribution system shall be equipped with a sufficient number of valves and the valves shall be so located that no case of accident, breakage or repair to the reclaimed water distribution system mains will necessitate shutting from service a length of reclaimed water main greater than either one side of a single block or a maximum of 500 feet.
2. The distribution system shall be equipped with a sufficient number of valves and the valves shall be so located that no case of accident, breakage or repair to the gas distribution system mains will necessitate shutting from service a length of gas main greater than either one side of a single block or a maximum of 500 feet.

3. A minimum of 2 valves are required at all tees and 3 valves at all crosses.

4. When gas mains cross creeks, a valve shall be located 15’ beyond the top of creek bank on each side of the creek crossing.

5. Valves shall not be in parking spaces of parking lots.

6. The City reserves the right to specify additional valves or less spacing between valves as necessary to reduce the time to shut down a section of pipeline in an emergency. Spacing determined by size of pipe, operating pressures, and local conditions.

10.6 - GAS SERVICE STUBS

Stubs for future Customers may be installed when installing gas main. Stubs will be sized for anticipated usage and should terminate at location shown on City Standard Details, unless approved by the City Engineer. Service stubs may cross beneath streets and sidewalks and can be installed to serve residential lots on either side of a street. Each service shall be provided its own tap from the distribution main.
CHAPTER 11 – ELECTRIC DISTRIBUTION DESIGN REQUIREMENTS

11.1.1 - GENERAL SPECIFICATIONS

Electric lines and appurtenances for electrical distribution systems and services shall meet the minimum criteria as required by the City of Boerne, Utilities Rules and Regulations and the City of Boerne, Standard Specifications for Public Works Construction, as currently amended. All materials that will become a permanent part of the electric distribution system must be approved by the City with written assurance that minimum requirements are being satisfied for the selection and qualification as established by Federal and State Regulations.

Easements shall be kept clear of structures, signage, lighting, and large plantings. All electric primary facilities, including conductors, poles, transformers, junction boxes, etc. must be located within utility easements provided on the standard City of Boerne easement form, available from the city on request.

Electric lines shall be extended through the limits of a development to serve adjacent properties to point(s) as determined by the Utilities Director to ensure orderly development.

11.1.2 - ELECTRIC DESIGN REQUIREMENTS

The developer/subdivider shall pay all costs associated with the design and construction of the City of Boerne electric distribution system. The City of Boerne Utilities does not perform design of primary or secondary electric associated with site development or platting activities. The site developer or service applicate is responsible for design.

Design shall include the following design requirements:

1. Subdivisions or developments with 25 LUEs or greater shall provide a three phase electric system that is looped to a different three phases electric system.
2. City of Boerne Utilities primary conductor voltage is 7,200 Volt, phase to ground (12.5 KV phase-to-phase).
3. All metering equipment must be located within fifty (50) feet of a transformer providing service voltage.
4. Services that originate overhead and are routed underground at a riser pole must include a disconnect on the riser pole. Service risers are not allowed on City Owned primary electric distribution poles.
5. Transformers providing secondary voltages may be sized for 60 percent of the total connected load for a single service or 50 percent of the total connected load for multiple services. Total connected load is for multiple services is determined by aggregating all services to be attached or according to a main disconnect upstream of those services, whichever is smaller.
6. Service conductor (wire) must be sized for 100 percent of the total connected load, not to the service transformer capacity.
7. The developments proposed electric distribution system shall be designed in a manner that the electrical load is reasonably balanced.
11.1.3 - ELECTRIC SERVICE VOLTAGES

1. Single phase:
   a. 120/240 Volt
   b. 240/480 Volt

2. Three phase:
   a. 120/208 Volt
   b. 277/480 Volt
   c. 120/240/208 Volt (Delta)

11.1.4 - ELECTRIC POINTS OF SERVICE

Standard points of electric service are as follows:

1. Single phase:
   a. Overhead, 320 Amp maximum – top of weatherhead
   b. Underground, 320 Amp maximum – bottom of meter socket
   c. Overhead, greater than 320 Amp (CT metering) – Top of weatherhead
   d. Underground (Pedestal), greater than 320 Amp, inside pedestal
   e. Underground (non-pedestal), greater than 320 Amp, transformer for single service or end of common service wire (at owners gutter or main disconnect)

2. Three phase:
   a. Overhead – Top of weatherhead
   b. Underground - transformer
CHAPTER 12 - LID FACILITIES REQUIREMENTS

12.1 - GENERAL SPECIFICATIONS

All appurtenances for Low Impact Development (LID) systems shall meet the minimum criteria as required by the San Antonio River Basin Low Impact Development Technical Design Guidance Manual, current edition, and the City of Boerne, Standard Specifications for Public Works Construction, as currently amended.

City of Boerne requires the following local requirements for LID facilities:

1. The rainfall depths, as listed in UDC section 8.2(B), shall be used for calculating the minimum treatment volume.
2. The LID Systems shall be designed for bacteria and TSS reduction requirements as listed in UDC section 8.2(B).
3. Design for all basins (extended detention, bioretention, sand filter, etc.) shall have the following design features:
   a. Basins shall be designed as offline facilities, with a splitter structure used to isolate the water quality volume. The splitter box, or other City Engineer approved flow diverting approach, should be designed to convey the 100-year storm event.
   b. Online facilities may be approved only with an exception from the City Engineer. Exception may only be considered if the design engineer provides justifiable reason why the facility must be online and the facility is designed to contain the 100-year storm and meet all other requirements of a detention pond as outlined in Section 5.3 of this manual for capacity, freeboard, emergency overflow, access, etc.
   c. Basins shall include freeboard meeting same requirements of detention basins, see EDM section 5.3(C)(2).
   d. Basins shall include a maintenance access ramp meeting the same requirements of detention basins, see EDM section 5.3(C)(2).
   e. In areas where it may be difficult to treat every drainage area leaving the site, an exception may be granted by the City Engineer to provide overtreatment of drainage areas. Exception will only be considered if design engineer has made every reasonable effort to treat as much of the site as possible, detailed calculations are provided showing the amount of overtreatment being provided to cover untreated portion of the site, and a maximum of 10% of the site is left untreated and accounted for in overtreatment of other drainage areas.
## CHAPTER 13 – SURVEY REQUIREMENTS

### 13.1 - PLACEMENT OF LOT MARKERS AND STREET MONUMENTS

1. Monuments consisting of at least one-half inch iron pipe or at least one-half inch reinforced steel, 24 inches in length, shall be placed at all corners of the block lines, and at the point of intersection of curves and tangents of the subdivision. Other types of monuments may be used based upon site conditions with approval by the City Engineer.

2. Lot markers shall be metal, at least 24 inches in length, placed at each corner of each lot, flush with the average ground elevation, or they may be countersunk, if necessary, to avoid being disturbed.

### 13.2 - BENCHMARKS

1. At least two (2) benchmarks for every subdivision shall be permanently installed at opposing ends of the property, in an approved manner, at the location and coordinates as shown on the plat and construction plans.

2. Permanent benchmarks shall be made of an iron stake one-half (½”) in diameter and twenty-four inches (24”) long centered in concrete a minimum of six inches (6”) in diameter and twelve inches (12”) long. The iron stake should be left one-half inch above the concrete with a surveyors’ aluminum or plastic cap, stamped with the surveyors’ registered number or firm. The elevation shall be stamped on top of the benchmark.

### 13.3 - FINAL ACCEPTANCE

1. If construction damages, destroys, or alters existing survey markers, monuments, or property corners, they must be reset by a licensed surveyor prior to final acceptance. Full list of requirements for final acceptance is included in Chapter 2 of the UDC.
DISCLAIMER: This map and information contained herein were developed exclusively for use by the City of Boerne. Any use or reliance on this map by anyone other than the City of Boerne is at that party's risk and without liability to the City of Boerne, its officers, or employees for any discrepancies, errors, or variances which may exist.

Legend
- Drainageway Protection Zone 1
- Drainageway Protection Zone 2
- ETJ Boundary
- KCAD Parcels 2022
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Updated 4/14/2022
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<tr>
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</table>
Complete this worksheet as requirements for Zoning, Master Plan, Infrastructure Documents LOC, and Building Permit submittals. If trips exceed the thresholds provided in the Engineering Design Manual, a Traffic Impact Analysis (TIA) or other traffic documents must be prepared. Prior to preparing a TIA, contact Engineering and Mobility to schedule a TIA Scoping Meeting.

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Total 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

Peak Period
Peak Hour Trips
TIA Required
Turn Lane Evaluation Required

Reviewed/Approved by (City of Boerne): ________________________________

Worksheet Last Updated: March 2023
Complete this worksheet as requirements for Zoning, Master Plan, Infrastructure Documents LOC, and Building Permit submittals. If trips exceed the thresholds provided in the Engineering Design Manual, a Traffic Impact Analysis (TIA) must be prepared. Contact Engineering and Mobility to schedule a TIA Scoping Meeting.

| Type of Application: |
|____________________|

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**TRIPS ON CITY APPROVED TIA:**

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**EXISTING TRIPS IN DEVELOPMENT:**

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**TOTAL EXISTING TRIPS:**

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**PROPOSED TRIPS IN DEVELOPMENT:**

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**TOTAL PROPOSED TRIPS:**

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**TOTAL ALLOWED TRIPS:**

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**TRIPS REMAINING:**

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Does the existing + proposed trips exceed the allowed trips by 10%?

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Reviewed/Approved by (City of Boerne): _________________________________

Worksheet Last Updated: March 2023
TIA Scoping Meeting Worksheet

This worksheet was developed to facilitate the TIA scoping process. The developer’s representative shall complete the background information section and developer proposed portion of the TIA parameter section and submit this worksheet to the City with requested supplemental information two weeks prior to the scoping meeting.

### Background Information

| Project Name: | [ ] |
| Developer Representative: | [ ] |
| Representative’s Contact Information: | Phone: [ ] Email: [ ] |

Include with worksheet:
- [ ] Trip generation worksheet
- [ ] Preliminary Trip Distribution and Assignment Diagrams
- [ ] Site plan with driveway locations
- [ ] Basis for background traffic growth rate

### TIA Parameters

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<thead>
<tr>
<th>Parameter</th>
<th>Developer Proposed</th>
<th>City Concurrence</th>
<th>If no, identify modifications required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Build Out Year (indicate any phasing)</td>
<td></td>
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<td></td>
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<tr>
<td>Background Traffic Growth Rate</td>
<td></td>
<td></td>
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<tr>
<td>Proposed Peak Periods</td>
<td>AM: [ ] PM: [ ] Other: [ ]</td>
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<tr>
<td>Scenarios for Evaluation (e.g. Existing, No Build, Build, or Phased Build Conditions)</td>
<td>1)</td>
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<td></td>
<td>2)</td>
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<td>3)</td>
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<tr>
<td>Intersections for Analysis (in addition to all site driveways; if more than 6 intersections please attach list)</td>
<td>1)</td>
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<td></td>
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<tr>
<td></td>
<td>2)</td>
<td></td>
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<td>5)</td>
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<td>6)</td>
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</tbody>
</table>

### Additional Comments/Concerns to be Addressed in the TIA

________________________________________________________________________

________________________________________________________________________

__________________________  ____________________________
City of Boerne            Developer’s Representative

__________________________  ____________________________
Printed Name of Representative      Printed Name of Representative

Note: TIA Levels 1-3 are differentiated for fee purposes only

Date: [ ]/ [ ]/ [ ]

TIA Type: [ ] Master Plan Level   [ ] Level 1 (100-299 PHT)   [ ] Level 2 (300-1,000 PHT)   [ ] Level 3 (1,001 or more)

Rev 3/20/2023