

# **City of San Angelo**

## **Design Standards for Water and Sewer**



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**Engineering Services Division**

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# Section 1 Minimum Design Standards for Water Distribution

## 1.1 General

- A) All water distribution system design shall be in accordance with the requirements of TCEQ Chapter 290, AWWA Standards, current City of San Angelo ordinances and the City of San Angelo Minimum Design Standards for Water Distribution.

## 1.2 Design Flow

- A) Water mains shall be designed to provide for residential and commercial uses and fire protection.
- B) Design flow for residential use shall be based on the following:

Design Criteria	Design Value	Units
Peak Hourly Demand	900	gpcd
Maximum Daily Demand	450	gpcd
Average Daily Demand	200	gpcd
Capita per Household (Single Family)	3.2	persons
Capita per Household (Multi-family)	2.5	persons

- C) Design flow for fire protection shall be based on the following:

Proposed Use	Minimum Fire Flow (gpm)
1- and 2-Family Residential	1,000
Other Than 1- and 2-Family Residential	1,500-8,000

- 1. Fire protection must comply with the Fire Marshall's Office regulations and in no case be less than currently adopted International Fire Code (IFC) requirements.
- 2. Additional infrastructure may be required to provide fire protection service when existing water mains are inadequate.
- D) Design flow for development other than residential use shall be as directed by the Engineering Services Division.

## 1.3 Design Pressure

- A) Distribution systems shall have a maximum operating pressure of 150 pounds per square inch (psi) and a minimum operating pressure of 35 psi.
- B) Distribution systems shall maintain a 20 psi residual pressure during fire flow conditions and a 35 psi residual pressure during peak hourly demand.

## 1.4 Hydraulic Design

- A) Distribution mains shall be designed to have a maximum velocity of 10 feet per second (fps) during peak flow conditions.
- B) Distribution mains shall be designed using a Hazen-Williams friction coefficient, "C", equal to 140.

## 1.5 Typical Layout

- A) Water Mains:
  - 1. Water mains shall be located within an alley, street right of way or dedicated public utility easement.
  - 2. Unless approved otherwise by the Engineering Services Division, water mains shall be located behind the right-of-way line within a minimum 10-foot wide public utility easement.

3. Water mains shall typically be located on the uphill and opposite side of the street of sanitary sewer mains.
4. Water mains shall be designed as looped systems, except as specified herein.
5. Where a water main crosses a street or railroad right-of-way, the crossing shall be made perpendicular or as near to perpendicular as possible.
6. Minimum radius of curvature and maximum deflection angle of pipe joints shall be restricted to 75% of manufacturer’s recommendation, after which the use of horizontal or vertical bends will be required.
7. Water mains shall extend to the limits of the platted property or the subdivision served, and further when required to tie into existing mains beyond the limits of the development.

B) Valves:

1. Valves shall be installed at each junction such that no connecting leg is unvalved.
2. At street intersections, valves shall be located outside of pavement.
3. At alley intersections with thoroughfare streets, valves shall be located at the projected right-of-way line of the street.
4. Where possible, valves in streets should be designed to fall outside of wheel paths.

**1.6 Service Taps, Service Lines and Meters**

- A) Domestic water service shall be provided from an alley, street right of way or dedicated public utility easement adjacent to the property being served.
- B) Water meters shall be located within a right-of-way, alley or easement and shall typically be positioned one foot from the edge of the property line of the property to be served.
- C) The portion of service line within the right-of-way, alley or easement shall typically be located along the most direct route from the water main to the edge of the property to be served.
- D) No portion of a service line shall be allowed to cross property boundaries into adjacent private property without coverage by a dedicated public utility or private easement agreement.
- E) Water meters shall be located and maintained such that they are accessible to maintenance personnel.
- F) Standard water service connections are as follows:

Meter Size	Tapping Saddle and Valve Size	Approximate Maximum Flow (GPM)	Service Line Size (Main to Meter)	Standard Use
5/8"	1"	20	1"	Residential – Domestic Only
1"	1"	50	1"	Residential & Commercial – Domestic or Irrigation or Combination
1-1/2"	2"	120	2"	Commercial & Limited Residential – Irrigation Only
2"	2"	160	2"	Commercial & Limited Residential
4"	4"	500	4"	Commercial Only
6"	6"	1,000	6"	Commercial Only

- G) Meter sizes two inch and larger require approval by the Engineering Services Division.
- H) Meter sizes larger than two inch shall be installed within an approved concrete meter vault and include an appropriately sized meter bypass as to maintain service during periodic maintenance of the meter.

- I) Tall buildings or site configurations where the height from the meter to the highest outlet is 50 feet or greater shall require the installation of an approved backflow prevention device on the customer side of the meter.

### 1.7 Bedding and Cover

- A) Water distribution mains sized 8-inch diameter and smaller shall ordinarily have a minimum cover of 30 inches from top of pipe to finished ground surface.
- B) Water mains sized 12-inch diameter and larger shall ordinarily have a minimum cover of 36 inches from top of pipe to finished ground surface.
- C) All water mains shall be laid at uniform depth, avoiding excessive or dramatic high and low points.
- D) Pipe bedding and embedment shall be in accordance with the Standard Specifications for Water Main Construction but in all cases shall be not less than manufacturer recommendations.

### 1.8 Relation to Sanitary Sewer Mains and Appurtenances

- A) No physical connection shall be made between a drinking water supply and a sanitary sewer system.
- B) Appurtenances shall be designed and constructed so as to prevent any possibility of sewage entering the drinking water system.
- C) Water mains shall be located a minimum of nine feet horizontally outside to outside from existing or proposed sanitary sewer mains, manholes, cleanouts and appurtenances.
- D) Where the nine feet separation distance cannot be achieved, the following criteria shall apply:
  - 1. New water main installation – parallel lines:
    - i. Where a new water main parallels an existing, non-pressure or pressure rated sanitary sewer main and the design engineer is able to determine that the existing sanitary sewer main is not leaking:
      - a. The new water main shall be located a minimum of two feet above and a minimum of four feet horizontally between outside diameters from the existing sanitary sewer main.
      - b. Every effort shall be made not to disturb the bedding and backfill of the existing sanitary sewer main.
    - ii. Where a new water main parallels an existing pressure rated sanitary sewer main and it cannot be determined by the design engineer if the existing sanitary sewer main is leaking:
      - a. The existing sanitary sewer main shall be replaced with at least 150 psi pressure rated pipe.
      - b. The new water main shall be located a minimum of two feet above and a minimum of four feet horizontally between outside diameters from the replaced sanitary sewer main.
    - iii. Where a new water main parallels a new sanitary sewer main:
      - a. The sanitary sewer main shall be constructed of at least 150 psi pressure rated pipe.
      - b. The new water main shall be located a minimum of two feet above and a minimum of four feet horizontally between outside diameters from the existing sanitary sewer main.
  - 2. New water main installation – crossing lines:
    - i. Where a new water main crosses over an existing, non-pressure rated sanitary sewer main:
      - a. A minimum two foot separation distance between outside diameters shall be maintained.
      - b. One segment of the water main pipe shall be centered over the sanitary sewer main such that the joints of the water main pipe are equidistant and at least nine feet horizontally from the centerline of the sanitary sewer main.
      - c. Whenever possible, the crossing shall be centered between the joints of the sanitary sewer main pipe.
      - d. Every effort shall be made not to disturb the bedding and backfill of the existing sanitary

- sewer main.
- e. If the existing sanitary sewer main is disturbed or shows signs of leaking it shall be replaced for at least nine feet in both directions (18 feet total) with at least 150 psi pressure rated pipe.
- ii. Where a new water main crosses over an existing, pressure rated sanitary sewer main:
    - a. An absolute minimum separation distance of six inches between outside diameters shall be maintained.
    - b. One segment of the water main pipe shall be centered over the sanitary sewer main such that the joints of the water main pipe are equidistant and at least nine feet horizontally from the centerline of the sanitary sewer main.
    - c. Whenever possible, the crossing shall be centered between the joints of the sanitary sewer main pipe.
    - d. Every effort shall be made not to disturb the bedding and backfill of the existing sanitary sewer main.
    - e. If the existing sanitary sewer main is disturbed or shows signs of leaking it shall be replaced for at least nine feet in both directions (18 feet total) with at least 150 psi pressure rated pipe.
  - iii. Where a new water main crosses over a new, non-pressure rated sanitary sewer main and the standard length of the sanitary sewer main pipe is at least 18 feet in length:
    - a. A minimum two foot separation distance between outside diameters shall be maintained.
    - b. The sanitary sewer main shall be constructed of pipe with a minimum pipe stiffness of 115 psi at 5.0% deflection (SDR 26) for at least nine feet in both directions (18 feet total) from the centerline of the water main.
    - c. One segment of the water main pipe shall be centered over the sanitary sewer main such that the joints of the water main pipe are equidistant and at least nine feet horizontally from the centerline of the sanitary sewer main.
    - d. Whenever possible, the crossing shall be centered between the joints of the sanitary sewer main pipe.
    - e. The sanitary sewer main shall be embedded in flowable fill from four inches below to six inches above the outside diameter of the pipe for the total length of one pipe segment, minimum nine feet in each direction from water main, plus 12 inches beyond the joint on each end.
  - iv. Where a new water main crosses over a new, non-pressure rated sanitary sewer main and the standard length of the sanitary sewer main pipe is less than 18 feet in length, one of the following two procedures must be followed:
    - 1)
      - a. A minimum two foot separation distance between outside diameters shall be maintained.
      - b. One segment of the water main pipe shall be centered over the sanitary sewer main such that the joints of the water main pipe are equidistant and at least nine feet horizontally from the centerline of the sanitary sewer main.
      - c. The sanitary sewer main within nine feet horizontally on either side of the water main shall be constructed of pipe having a minimum pressure rating of at least 150 psi.

or
    - 2)
      - a. The sanitary sewer main shall be encased in a section of pipe with a minimum pipe stiffness of 115 psi at 5.0% deflection (SDR 26) for at least nine feet in both directions (18 feet total) from the centerline of the water main.
      - b. An absolute minimum separation distance of six inches shall be maintained between outside diameters of the casing pipe and water main pipe.



- c. One segment of the water main pipe shall be centered over the sanitary sewer main such that the joints of the water main pipe are equidistant and at least nine feet horizontally from the centerline of the sanitary sewer main.
  - d. The casing pipe shall be at least two nominal pipe diameters larger than carrier pipe.
  - e. The carrier pipe shall be supported at five-foot or less intervals with casing spacers, with a spacer being located a maximum of two feet from each joint.
  - f. Each end of the casing pipe shall be sealed with at least two feet of watertight non-shrink cement grout or a manufactured watertight seal.
- v. Where a new water main crosses over a new, pressure rated sanitary sewer main:
- a. An absolute minimum separation distance of six inches between outside diameters shall be maintained.
  - b. The sanitary sewer main shall be constructed of at least 150 psi pressure rated pipe.
  - c. One segment of the water main pipe shall be centered over the sanitary sewer main such that the joints of the water main pipe are equidistant and at least nine feet horizontally from the center line of the sanitary sewer main.
  - d. Whenever possible, the crossing shall be centered between the joints of the sanitary sewer main pipe.
  - e. The sanitary sewer main shall be embedded in flowable fill from four inches below to six inches above the outside diameter of the pipe for the total length of one pipe segment, minimum nine feet in each direction from water main, plus 12 inches beyond the joint on each end.
- vi. Where a new water main crosses under a sanitary sewer main:
- a. An absolute minimum separation distance of one foot between outside diameters shall be maintained.
  - b. The water main shall be encased in a section of pipe with a minimum pipe stiffness of 115 psi at 5.0% deflection (SDR 26) for at least nine feet in both directions (18 feet total) from the centerline of the sanitary sewer main.
  - c. The casing pipe shall be at least two nominal pipe diameters larger than carrier pipe.
  - d. The carrier pipe shall be supported at five-foot or less intervals with casing spacers, with a spacer being located a maximum of two feet from each joint.
  - e. Each end of the casing pipe shall be sealed with at least two feet of watertight non-shrink cement grout or a manufactured watertight seal.
  - f. Both the water main and sanitary sewer main must pass a pressure and leakage test as specified in AWWA C600.
  - g. Alternatively to encasement pipe, the water main can be constructed of ductile iron or steel pipe with mechanical or welded joints as appropriate.
3. Manholes, cleanouts and appurtenances:
- i. Where a new water main crossing within nine feet of a new or existing sanitary sewer manhole, cleanout or other appurtenance:
    - a. The water main shall be encased in an 18-foot or longer section of pipe with a minimum pipe stiffness of 115 psi at 5.0% deflection (SDR 26).
    - b. The casing pipe shall be centered on the sanitary sewer manhole, cleanout or appurtenance and shall be at least two nominal pipe diameters larger than the carrier pipe.
    - c. The carrier pipe shall be supported at five-foot or less intervals with casing spacers, with a spacer being located a maximum of two feet from each joint.
    - d. Each end of the casing pipe shall be sealed with at least two feet of watertight non-shrink cement grout or a manufactured watertight seal.

- E) For the instances described above, the following conditions shall apply:
  1. Acceptable materials for new pressure rated pipe for non-potable use shall include PVC C-900 and C-905 pipe, minimum DR 25.
  2. Where an option is given to encase the carrier pipe or use pressure rated pipe, the encasement option shall be used.
  3. No change in the inside diameter of a sanitary sewer main shall be allowed such that would interrupt smooth flow within the pipe.
  4. Flowable fill, also called cement stabilized sand or lean grout, shall consist of at least 2.5 bags of cement per cubic yard of mixture. The use of brown coloring in flowable fill for pressure rated sanitary sewer main embedment is recommended for identification during future construction.
  5. In all cases suitable backfill or other structural protection shall be provided to prevent settling and/or failure of the higher pipe.
- F) Location of fire hydrants
  1. Fire hydrants shall not be installed within nine feet vertically or horizontally of any sanitary sewer main, manhole, appurtenance or service line regardless of the type of construction.
- G) Location of potable or raw water supply or suction lines
  1. Suction mains to pumping equipment shall not cross sanitary sewer mains or service lines.
  2. Raw water supply lines shall not be installed within five feet of any tile or concrete sanitary sewer main or service line.
- H) Proximity of septic systems
  1. Water mains shall not be installed closer than 10 feet to septic system drain fields or tanks.
- I) Water and sewer lines shall be installed in separate trenches.
- J) For other instances not covered in these design standards, consult current TCEQ regulations.

**1.9 Pipe Size and Spacing**

- A) Distribution mains shall be located and sized in accordance with the current City of San Angelo Water System Master Plan and current TCEQ rules:

Water Line Size	Typical Spacing
16-inch or larger	Section Line (mile)
12-inch	Half-Section Line (1/2 mile)
6- or 8-inch	Eighth-Section Line (660 feet)

- B) Standard pipe sizes that shall be used are 1-, 2-, 4-, 6-, 8-, 12-, 16-, 20-, 24-, 30- and 36-inch. Pipe sizes not listed here are considered non-standard and shall not be used in the City of San Angelo water distribution system unless approved by the Engineering Services Division.
- C) The standard minimum pipe size for distribution mains shall be 8-inch.
- D) On dead-end lines where fire protection is not required, where there is no potential for future extension, and where the design engineer can certify that a smaller pipe size will meet peak hourly demand, the Engineering Services Division will consider 4- and 6-inch main sizes.

**1.10 Pipe Materials**

- A) Water main pipe used in the City of San Angelo water distribution system shall be Cement-lined Ductile Iron, C900 PVC, C905 PVC, C301 Prestressed-Concrete Steel Cylinder Pressure or C303 Concrete Bar-wrapped Steel Cylinder Pressure pipe.

**1.11 Methods of Connection**

- A) Tapping Sleeves

1. Tapping sleeves with tapping valves shall be used whenever possible for connections to existing mains in order to avoid interruption of water service.
2. Size-on-size taps shall only be allowed with prior approval by the Engineering Services Division.
3. Using a tapping sleeve of equal or smaller size than the main to be tapped and immediately increasing the pipe to a larger size shall only be allowed with prior approval by the Engineering Services Division.

B) Cut-in Tees

1. When it is necessary for a size-on-size connection and interruption of water service is not an issue a cut-in tee with valve can be used.
2. Cut-in tees shall not be used without prior approval by the Engineering Services Division.

C) Flanged Outlets

1. All fitting-to-fitting or fitting-to-valve connections shall be flanged.

### 1.12 Valve Spacing / Placement

A) For distribution mains 12-inch diameter or smaller, valves shall be placed as specified below unless otherwise specified by the Engineering Services Division.

1. Valves shall be located between each tee, cross or other junction such that each leg can be isolated independently.
2. In-line valves shall be located such that no more than two fire hydrants are out of service when a single leg of main is isolated or at a maximum spacing of 1,000 feet between valves, whichever is less.

B) Transmission mains 16-inch diameter and larger shall be equipped with valves at ½-mile intervals unless intersected by mains or it is determined by the Engineering Services Division that more valves are required.

### 1.13 Fire Protection Requirements

A) Fire protection must comply with the City of San Angelo Fire Marshall's Office regulations, and in no case be less than the currently adopted International Fire Code requirements.

B) Fire Service Lines:

1. Fire protection personnel completing any work on a fire protection sprinkler system, with the exception of the connection to the existing main, must be licensed with the Texas Department of Insurance State Fire Marshal's Office as a Fire Sprinkler Contractor and must be in compliance with the Texas Insurance Code, Chapter 6003, Fire Protection Sprinkler System Service and Installation and 28 TAC 34.700, Fire Sprinkler Rules.

C) Fire hydrants:

1. The Fire Marshal's Office and Engineering Services Division shall approve of the location of all new fire hydrants.
2. Fire hydrant leads shall be minimum six-inch diameter and shall be mechanically restrained at the tap/tee and the hydrant.
3. Fire hydrant leads shall not exceed 300 feet in length when immediately supplied by a looped main and 150 feet when connected to a dead-end main. The length of a dead-end fire hydrant lead shall be included in the overall length calculation of the main if supplied by a dead-end main.
4. Fire hydrants shall be located at intersections wherever possible.
5. Consult Section C-104 of the International Fire Code for requirements on hydrants that may obstruct access during firefighting operations.
6. A hydrant shall be placed at the throat or beginning of each cul-de-sac at the intersecting street.
7. Additional fire hydrants may be required based on length of cul-de-sac.
8. Fire hydrants placed at the bulb end of cul-de-sacs should be avoided.

9. On divided highways hydrants shall be placed on each side of the highway wherever possible.
10. Fire hydrants shall be installed with the four inch nozzle facing the required access way or street.
11. Fire hydrants shall be installed and maintained so that the center of the lowest water outlet is 18 inches above the ground.
12. Fire hydrants shall be placed so that they are readily visible from the street and be between 18 inches and three feet from the back of curb.
13. No bushes, ground cover over six inches in height, or other obstructions shall be placed within a five foot radius in all directions of a hydrant or fire department connection.
14. Where fire hydrants are vulnerable to vehicular damage appropriate crash posts shall be provided.
15. Crash posts shall be four inch, cement-filled pipe with a minimum of three feet above finished grade and two feet of pipe anchored in concrete below grade.
16. No obstructions shall exist within a three foot working area of each fire hydrant.

**1.14 Easements**

- A) Public water mains shall typically be located within a minimum 10-foot wide public utility easement on private property immediately adjacent and parallel to the right-of-way line.
- B) The minimum width of an easement for a public water main not immediately adjacent and parallel to a right-of-way is 20 feet exclusive or wider if shared with a public sanitary sewer main or other utilities or if depth of water main is greater than 10 feet.
- C) When a fire hydrant is to be installed on private property, an easement shall be dedicated which provides a minimum of 10 feet clearance in all directions from the center of the fire hydrant.
- D) When a large, commercial water meter and vault are to be installed on private property, an easement shall be dedicated which provides a minimum of 10 feet clearance in all directions from the center of the vault.

**1.15 Pipe Restraints and Reaction Blocking**

- A) Pipe restraints and reaction blocking shall typically be performed per the City’s standard details.
- B) If unusual or non-typical soil conditions are encountered or reasonably expected to be encountered during pipe installation, the design engineer shall provide calculations and sizing for restraints and blocking at the request of the Engineering Services Division.

**1.16 Tunneling, Jacking and Boring**

- A) Tunneling, jacking and boring are approved methods for water main placement under restrictive conditions when open cut construction is not permitted.
- B) Only straight pipe alignments for both horizontal and vertical alignment are allowed.
- C) Casing shall extend full width of right-of-way or as directed by the Engineering Services Division.
- D) Casing pipe shall be a minimum of two nominal pipe sizes larger than encased pipe.
- E) Casing pipe thickness shall be:

Casing Diameter	Minimum Casing Thickness
<16 inches	3/8 inch
≥16 inches	1/2 inch

- F) Manufactured centralizers or spacers shall be required at minimum five foot intervals, with a spacer being located a maximum of two feet from each joint, or as recommended by the manufacturer. Only approved centralizers may be used.
- G) For bores in excess of 100 feet, approved fused- or restrained-joint pipe shall be used.

- H) Slick boring or directional drilling without encasement shall be considered on a case-by-case basis by the Engineering Services Division.
- I) Care shall be taken to minimize the annular space between the cased or uncased pipe and the earthen walls of the bored hole. Annular space that consistently exceeds 1-inch and/or reasonably poses a hazard to the integrity of structures above shall be injection grouted, as determined by the Engineering Services Division.

**1.17 Dead-end Mains**

- A) Dead-end water mains shall not be allowed unless approved by the Engineering Services Division as a necessary stage in the growth of the system.
- B) The entire length of a dead-end main shall not exceed 750 feet in length.
- C) Where dead-end mains are permitted they shall be designed such that:
  - 1. The system may be periodically flushed by use of a blow-off valve or fire hydrant  
or
  - 2. A temporary looped connection is installed.

**1.18 Abandonment of Water Mains**

- A) When a water line is to be abandoned, allowances shall be made so that existing and new water mains may be in service simultaneously, thereby providing a means for transferring customer's service from the old main to the new main with minimal interruption.
- B) If the construction of a proposed main necessitates the abandoning of the existing main prior to the new main's placement into service, provisions for providing temporary services must be addressed.
- C) On mains to be abandoned, the design engineer shall note locations of "cut and plug" as close as possible to the main that remains in service.
- D) Unless approved otherwise by the Engineering Services Division, all abandoned water mains under pavement and structures shall be fully filled with grout.
- E) Fire hydrants, valves and other fittings located on mains to be abandoned shall be removed and delivered to the City of San Angelo Water Utilities Department.

## Section 2 Minimum Design Standards for Sanitary Sewer

### 2.1 General

- A) All sanitary sewer system design shall be in accordance with the requirements of TCEQ Chapter 217, AWWA Standards, City of San Angelo Sewer System Master Plan, current City ordinances and the City of San Angelo Minimum Design Standards for Sanitary Sewers.

### 2.2 Design Flow

- A) The design of the sanitary sewer system shall be based on the following:
1. For sewers in new developments the mains and lift stations shall be designed for the estimated future population to be served plus adequate allowance for future institutional and commercial flows.
  2. Minimum flow capacity for sizing of sewer mains for peak flow conditions shall not be less than the following:

Design Criteria	Design Value	Units
Average Daily Flow	100	gpcd
Peak Factor, 2-hour flow <0.5 MGD	4	-
Peak Factor, 2-hour flow >0.5 MGD	3	-
Capita per Household (Single Family)	3.2	persons
Capita per Household (Multi-family)	2.5	persons

3. Minimum residential population density shall be figured on a basis of 6 houses per acre, and 70 percent of total land area developed as residential, unless detailed analysis of the area to be served indicates differently.
4. Design flow for development other than residential use shall be based on TCEQ requirements or as directed by the Engineering Services Division:

### 2.3 Hydraulic Design

- A) The minimum velocity at the design flow rate shall be two feet per second (fps).
- B) Maximum allowable velocity shall be 10 fps.
- C) Manning's coefficient for design purposes shall be  $n=0.013$  for PVC pipe.
- D) Manhole inverts shall be designed in such a manner that the energy gradient is consistently falling in the direction of flow.

### 2.4 Design Details

- A) Sewer Pipe
1. The standard pipe sizes that shall be used are 4-, 6-, 8-, 10-, 12-, 15-, 18-, 21-, 24-, 27-, and 30-inch. Pipe sizes not listed here are considered non-standard and shall not be used in the City of San Angelo sanitary sewer system, unless approved by the Engineering Services Division.

2. The following slopes shall apply to sanitary sewer mains:

Pipe Diameter	Minimum Slope (%)	Maximum Slope (%)
6 inch	0.50	12.35
8 inch	0.33	8.40
10 inch	0.25	6.23
12 inch	0.20	4.88
15 inch	0.15	3.62
18 inch	0.11	2.83
21 inch	0.09	2.30
24 inch	0.08	1.93
27 inch	0.06	1.65
30 inch	0.055	1.43

3. Gravity sewer mains shall have uniform grade between manholes.
4. Minimum radius of curvature and maximum deflection angle of pipe joints shall be restricted to 75% of manufacturer's recommendation.
5. A manhole must be at the point of curvature and the point of termination of a curve.
6. The maximum allowable manhole spacing for a gravity sewer main with horizontal curvature is 300 feet.
7. All sewer mains shall terminate in a cleanout or manhole.
8. The standard minimum pipe size for gravity sewer mains shall be 8-inch diameter.

B) Manholes

1. A manhole shall be provided at every change in direction, grade, or connection with other sewer main lines or service laterals 6-inch diameter and larger.
2. Manholes shall be a minimum of 48-inch barrel diameter and 30-inch diameter ring and cover.
3. Manhole spacing and depth shall be as follows:

Pipe Diameter	Manhole Depth	Manhole Diameter	Max. Spacing Between Manholes
15 inches or smaller	0-16 Ft.	48 in.	500 Ft.
15 inches or smaller	Over 16 Ft.	60 in.	500 Ft.
Over 15 inches	All depths	60 in.	800 Ft.

4. Manholes greater than 16 feet deep or serving pipes larger than 15 inches shall be 60-inch diameter and be constructed of fiberglass or concrete with an approved protective coating system.
5. Gravity service connections 6-inch diameter and larger shall discharge into a new or existing manhole, as approved by the Engineering Services Division.
6. Force mains shall discharge directly into a manhole or wet-well with consideration for minimizing splashing and the generation of damaging and malodorous gasses.
7. Manholes and wet-wells receiving force main discharge shall be constructed of fiberglass or concrete with an approved protective coating system.

8. Minimum elevation difference across manhole inverts shall be as follows:

Deflection Angle Between Inlet/Outlet	Min. Elevation Difference
Less than 30°	0.10 Ft.
Greater than 30°	0.20 Ft.

9. Connections at manholes shall be designed such that the flowline of lateral mains and service lines enter the manhole at or above the 3/4 diameter point of the outflow pipe above the manhole invert.
10. Connections to existing manholes shall be made such that the existing manhole floor is not disturbed. Causing damage to or jeopardizing the watertight integrity of an existing concrete manhole floor during construction activities shall warrant replacement of the entire manhole.
11. Drop manholes shall be provided for lateral mains and service lines entering a manhole at an elevation 24 inches or more above the manhole invert.
12. Drop manholes shall be made using an exterior or “outside” drop system.
13. Where the difference in elevation is less than 24 inches, the invert shall be filleted to prevent solids deposition.
14. Manholes shall be stubbed out with suitable size pipe wherever future extension of the sewer is anticipated.
15. Stub-outs shall extend beyond the edge of existing or proposed paving.
16. Manholes located within a 100-year flood plain or any area subject to stormwater infiltration shall incorporate a watertight, bolt-down ring and lid and an Inflow Prevention Devices (IPDs).

C) Service Connections

1. Minimum size gravity service connection shall be four-inch diameter.
2. Standard four-inch services shall connect to the sewer main, at or above the spring line, by use of a tapping saddle or service fitting.
3. Wye service fittings shall be provided, aligned with the direction of flow, on new sewer mains for service connections at each lot or building site.
4. Sanitary sewer services six-inch and larger shall connect to the sewer main at a new or existing manhole.
5. Manhole connections shall be made at or above the 3/4 diameter point of the outflow pipe above the manhole invert.
6. Maximum size service connection shall be equal in size to the sewer main unless otherwise specified by the Engineering Services Division.
7. No portion of a service line shall be allowed to cross property boundaries into adjacent private property without coverage by a dedicated public utility or private easement agreement.
8. Service connection to a sewer main shall not be installed within five feet of the outside wall of a manhole.
9. The portion of service line within the right-of-way, alley or easement shall typically be located along the most direct route from the sewer main to the edge of the property to be served.

**2.5 Typical Layout**

- A) Sanitary sewer mains shall be located within an alley, street right of way or dedicated public utility easement.

B) Mains

1. Unless approved otherwise by the Engineering Services Division, sanitary sewer mains shall be located behind the right-of-way line within a minimum 10-foot wide public utility easement.
2. Sewer mains shall be typically located on the downhill and opposite side of street of water mains.



3. Where a sanitary sewer main crosses a street or railroad right-of-way, the crossing shall be made perpendicular or as near to perpendicular as possible.

C) Manholes

1. Manholes shall be located as to provide access for maintenance equipment and operations.
2. Where possible, manholes in streets should be designed to fall outside of traveled wheel paths.
3. Where possible, in-line manholes in alleys should be designed to fall at the projected intersection of perpendicular lot lines.

- D) Sanitary sewer mains shall extend to the limits of the platted property or the subdivision served.

## 2.6 Bedding and Cover

- A) Sewer mains shall ordinarily have a minimum of 30 inches of cover from top of pipe to finished ground surface.
- B) Where a sewer main has less than 30 inches of cover, provisions shall be made to protect the pipe from impact loading.
- C) Maximum sanitary sewer depth in alleys shall be 10 feet unless approved by the Engineering Services Division.
- D) Where less than 36 inches of elevation difference between the finished lot grade at building line and the top of the sewer main is provided, the plans shall indicate that the lot is served by a "shallow sewer" and appropriate elevation information shall be given.
- E) Pipe bedding and embedment shall be in accordance with the Standard Specifications for Sanitary Sewer Main Construction but in all cases shall be not less than manufacturer recommendations.

## 2.7 Relation to Water Mains

- A) No physical connection shall be made between a drinking water supply and a sewer system.
- B) Appurtenances shall be designed and constructed so as to prevent any possibility of sewage entering the drinking water system.
- C) Sanitary sewer mains and appurtenances shall be located a minimum of nine feet horizontally outside to outside from existing or proposed potable water mains.
- D) Where the nine feet separation distance cannot be achieved, the following guidelines shall apply:
1. New sanitary sewer main installation – parallel lines:
    - i. Where a new sanitary sewer main parallels a water main:
      - a. The sewer main shall be constructed of pipe with a pressure rating for both the pipe and joints of at least 150 psi.
      - b. The sewer main shall be located a minimum of two feet below and a minimum of four feet horizontally between outside diameters from the water main.
  2. New sanitary sewer main installation – crossing lines:
    - i. Where a new sanitary sewer main crosses under a water main and the sewer main is constructed of pipe with a minimum pressure rating of 150 psi:
      - a. An absolute minimum separation distance of six inches between outside diameters shall be maintained.
      - b. One segment of the sewer main pipe shall be centered under the water main such that the joints of the sewer main pipe are equidistant and at least nine feet horizontally from the centerline of the water main.
      - c. Whenever possible the crossing shall be centered between the joints of the water main pipe.
      - d. The sanitary sewer main shall be embedded in flowable fill from one quarter of the diameter of the sanitary sewer main below the centerline of the pipe up to 12 inches above top of pipe

- for the total length of one pipe segment, minimum nine feet in each direction from water line, plus 12 inches beyond the joint on each end.
- ii. Where a new sanitary sewer main crosses under a water main and the sewer main is not constructed of pipe with a pressure rating of at least 150 psi:
    - a. A minimum two foot separation distance between outside diameters shall be maintained.
    - b. One segment of the sewer main pipe shall be centered under the water main such that the joints of the sewer main pipe are equidistant and at least nine feet horizontally from the centerline of the water main.
    - c. Whenever possible, the crossing shall be centered between the joints of the water main pipe.
    - d. The sanitary sewer main shall be embedded in flowable fill from one quarter of the diameter of the sanitary sewer main below the centerline of the pipe up to 12 inches above top of pipe for the total length of one pipe segment, minimum nine feet in each direction from water line, plus 12 inches beyond the joint on each end.
  - iii. Where a new sanitary sewer main crosses over a water main, one of the following two procedures must be followed:
    - 1)
      - a. The sanitary sewer main within nine feet horizontally on either side of the water main shall be constructed of pipe having a minimum pressure rating of at least 150 psi.
      - b. An absolute minimum separation distance of one foot between outside diameters shall be maintained.
    - or
    - 2)
      - a. The sanitary sewer main shall be encased in a section of pipe with a minimum pressure rating of at least 150 psi (C-900) for at least nine feet in both directions (18 feet total) from the centerline of the water main.
      - b. The casing pipe shall be at least two nominal pipe diameters larger than the carrier pipe.
      - c. The carrier pipe shall be supported at five-foot or less intervals with casing spacers, with a spacer being located a maximum of two feet from each joint.
      - d. Each end of the casing pipe shall be sealed with at least two feet of watertight non-shrink cement grout or a manufactured watertight seal.
      - e. Both the water main and sanitary sewer main must pass a pressure and leakage test as specified in AWWA C600.
  3. The use of brown coloring in flowable fill for pressure rated sanitary sewer main embedment is recommended for identification during future construction.
  4. In all cases suitable backfill or other structural protection shall be provided to prevent settling and/or failure of the higher pipe.
- E) Sanitary sewer manhole and clean out separation from water
1. Sanitary sewer manholes and clean outs must be installed so as to provide a minimum of nine feet of outside to outside clearance from an existing or proposed water main.
  2. Where the nine foot separation distance cannot be achieved, an encasement pipe as described above may be used for the water main.
- F) For the instances described above, the following conditions shall apply:
1. Acceptable materials for new pressure rated pipe for non-water main use shall include PVC C-900 and C-905 pipe, minimum DR 25.
  2. Where an option is given to encase the carrier pipe or use pressure rated pipe, the encasement option shall be used.

3. No change in the inside diameter of a sanitary sewer main shall be allowed such that would interrupt smooth flow within the pipe.
  4. Flowable fill, also called cement stabilized sand or lean grout, shall consist of at least 2.5 bags of cement per cubic yard of mixture. The use of brown coloring in flowable fill for pressure rated sanitary sewer main embedment is recommended for identification during future construction.
  5. In all cases suitable backfill or other structural protection shall be provided to prevent settling and/or failure of the higher pipe.
- G) Water and sewer lines shall be installed in separate trenches.
- H) For other instances not covered in these design standards consult current TCEQ regulations.

## **2.8 Abandonment of Sewer Mains and Manholes**

- A) When a sewer system is to be abandoned the design engineer shall ensure that all existing mains and service connections are properly plugged or transferred to the new system prior to decommissioning of the existing system.
- B) Sewer Mains
1. If a line to be abandoned terminates in a manhole that will remain in service, the existing main to be decommissioned shall be plugged from within the manhole and clearly marked on the plans.
  2. Cutting and plugging of existing lines directly outside of manholes should be avoided.
  3. If a portion of a line is to be abandoned, a manhole or cleanout shall be installed on the new terminus of the portion of line to remain in service.
  4. Unless approved by the Engineering Services Division, all abandoned sewer mains shall be fully filled with grout.
- C) Sewer Manholes
1. Manholes may be decommissioned by either of the following methods or as approved by the Engineering Services Division:
    - i. Complete removal of the manhole structure including ring, lid, cone, riser sections, base and all appurtenances. The excavation shall be backfilled with compacted native material or flowable fill.
    - ii. Remove cone, ring and lid sections and backfill to top of remaining structure with flowable fill. Remaining excavation shall be backfilled with compacted native material or flowable fill.

## **2.9 Easements**

- A) Public sanitary sewer mains shall typically be located within a minimum 10-foot wide public utility easement on private property immediately adjacent to the right-of-way line.
- B) The minimum width of easement for a public sanitary sewer main not immediately adjacent and parallel to a right-of way is 20 feet exclusive or wider if shared with a public water main or other utilities or if depth of sewer main is greater than 10 feet.

## **2.10 Soil Analysis**

- A) If unusual or non-typical environmental conditions are encountered or reasonably expected to be encountered during pipe installation, the design engineer shall submit a report showing the types and characteristics of the soils to be encountered, water table elevations along the proposed sewer main route, recommended methods of dewatering for sewer main construction, and the recommended methods of backfilling and compacting to be used.

## **2.11 Tunneling, Jacking and Boring**

- A) Tunneling, jacking and boring are methods used for sanitary sewer main placement under restrictive conditions when open cut construction is not allowed.
- B) Only straight pipe alignments for both horizontal and vertical alignment are allowed.

- C) Casing shall extend full width of right-of-way or as directed by the Engineering Services Division.
- D) Casing pipe shall be a minimum of two nominal sizes larger than encased pipe.
- E) Casing pipe thickness shall be:

Casing Diameter	Minimum Casing Thickness
<16 inches	3/8 inch
≥16 inches	1/2 inch

- F) Manufactured centralizers or spacers shall be required at minimum five foot intervals, with a spacer being located a maximum of two feet from each joint, or as recommended by the manufacturer. Only approved centralizers may be used.
- G) For bores in excess of 100 feet, approved fused or restrained joint pipe shall be used.
- H) Slick boring or directional drilling without encasement shall be considered on a case-by- case basis by the Engineering Services Division.
- I) Care shall be taken to minimize the annular space between the cased or uncased pipe and the earthen walls of the bored hole. Annular space that consistently exceeds 1-inch and/or reasonably poses a hazard to the integrity of structures above shall be injection grouted, as determined by the Engineering Services Division.

**2.12 Lift Station**

- A) Lift station design must conform to the most recent TCEQ design criteria.
- B) General
  - 1. A thorough engineering analysis must be performed on physical and economic factors to determine if a lift station is required.
  - 2. A preliminary engineering report must be submitted to the Engineering Services Division outlining all factors, including TCEQ regulations, involved in the engineering design of the proposed lift station.
  - 3. The Engineering Services Division will review the preliminary report and reserves the right to determine if there is merit to require a lift station.
  - 4. Design of a lift station facility, including pumps and force main, shall take into consideration the entire drainage basin to be served and include provisions for future expansion.
  - 5. The review and approval process for lift station design could be subject to additional rules and requirements more comprehensive than those listed in these specifications.
- C) Site Layout
  - 1. The lift station site location shall be approved by the Engineering Services Division.
  - 2. Lift station site shall be chosen to provide the least negative impact to surrounding existing and future development.
  - 3. Lift station site shall be located so it may serve as much of the entire sewer drainage basin as possible.
  - 4. If required the station may need to be located off-site of the development in order to best serve the drainage basin.
  - 5. Lift station site shall be protected from the 100-year flood plain and shall be accessible during the 25-year storm event.
  - 6. Lift station site and associated access road shall be located within a dedicated right-of-way or permanent easement.

- i. Access road shall be a minimum 12-foot wide, 6-inch thick compacted TxDOT Grade 2 base.
  - ii. Additional staging and parking areas shall be provided of equivalent material as the access road.
  - iii. The entire lift station grounds shall be minimum 6-inch thick compacted TxDOT Grade 2 base.
7. Lift station site shall be fully enclosed by a minimum 6-foot tall chain link fence with three-strands of barbed wire on 45-degree arms angled outward.
  8. Fences shall include a 14-foot vehicle gate and 3-foot man gate. Vehicle gate shall be situated such that pumps and equipment are accessible by service vehicles.
  9. Lift station shall have bypass capability.
  10. Lift station shall have lightning protection for all electronic components.
  11. Lift station site shall be illuminated by a security light system.
  12. Lift station shall be fitted with SCADA antennae.
  13. All piping associated with lift stations shall be approved gravity or pressure rated sewer pipe.

D) Valve Vault

1. Valve vault shall have separate, dedicated entrance with a ladder and an approved, lockable, 26-inch x 36-inch pedestrian-rated aluminum hatch.
2. Dry well shall be adequately vented with a minimum of two 4-inch vent pipes with one having an active ventilation blower.
3. Valve vault shall include independent pump discharge piping and check and isolation valves.
4. Provisions shall be made for water removal from the dry well valve vault.

E) Wet Well

1. Wet wells shall be constructed of water-tight and gas-tight fiberglass or concrete with an approved protective coating system.
2. Wet well shall have a pump maintenance hatch with an approved, double-door, lockable, 48-inch x 72-inch pedestrian-rated aluminum hatch and a separate, dedicated entrance hatch with an approved, lockable, 26-inch x 36-inch pedestrian-rated aluminum safety hatch.
3. A gravity sewer pipe discharging to a wet well must be located so that the invert elevation is above the level of the system's "on" setting.
4. No electrical junction boxes shall be located within the wet well.
5. All piping within wet well shall be PVC.
6. All interior components shall be stainless steel including nuts, bolts, other fasteners and all base plates.
7. Each pump shall be fitted with minimum 25 feet of stainless steel lifting chain.
8. Each pump shall be fitted with dual-rail stainless steel guide bar and upper guide bar brackets.
9. Wet well shall have a sloped bottom toward the pump intake to avoid solids deposition.
10. Wet well shall be adequately vented with a minimum of two 4-inch vent pipes with one having an active ventilation blower.

F) Control Panel

1. Lift station controls shall be housed within a NEMA 4X type 304 stainless steel control panel enclosure located adjacent to the lift station within the fenced site.
2. Control panel shall include all necessary components for power distribution and pump operations.
3. Control panel shall include alarm system with float controlled visual and audible alarm devices.
4. Control panel shall include provision for emergency generator connection.

## **Section 3 Checklist for Design Plans**

### **3.1 Plan Submittal Requirements**

- A) All water main construction plans shall be checked for conformance with the City of San Angelo Minimum Design Standards for Water Distribution prior to submittal to the Engineering Services Division.
- B) All sanitary sewer main construction plans shall be checked for conformance with the City of San Angelo Minimum Design Standards for Sanitary Sewer prior to submittal to the Engineering Services Division.

### **3.2 Plan Review**

- A) The design engineer may submit one print set or electronic set of construction plans to the Engineering Services Division for preliminary review and comment.
- B) Official review plans shall be submitted to the Planning and Development Services Department and in accordance with the requirements of that office.
- C) The Engineering Services Division shall have not less than three weeks from the date of receipt of plans to approve or provide comments to the design engineer.
- D) Upon completion of review, one set shall be returned to the design engineer with comments or an electronic red-lined set will be provided via email.
- E) If revised plans are required, the Engineering Services Division shall have not less than one week from the date of receipt of revised plans to approve or provide comments to the design engineer.
- F) After comments have been addressed and changes have been made, one set of mylar/film plans shall be provided to the Engineering Services Division for final approval for construction.
- G) If additional approved plan sets are required by the Planning and Development Services Department for associated Building Permits, the appropriate amount of additional plans shall be provided at that time.
- H) If additional approved plan sets are required by the design engineer, the appropriate amount of additional plans shall be provided at that time.
- I) If comments have not been addressed on plans submitted for final approval, the plans will be rejected and returned to the design engineer.
- J) If construction has not begun within three years from the date of approval by the Engineering Services Division, the plans may require resubmittal for review under updated standards.
- K) Utility plans submitted in conjunction with subdivision plats and approved by the Engineering Services Division that have not begun construction at the time that the plat expires shall become void and require resubmission.

### **3.3 Construction Plans**

- A) All plans to be used or kept on the job site shall be original or reproduced plan sets clearly marked "ACCEPTED" or "ACCEPTED AS NOTED" with the signature of reviewer and date approved by the Engineering Services Division and the Fire Marshal's Office (water plans with fire protection infrastructure only).
- B) Should circumstances during construction warrant changes from the accepted plans or specifications, a written request must be submitted and an approval obtained from the Engineering Services Division.
- C) Copies of the written approval shall be attached to the construction plans and maintained on the job site.

### **3.4 Inspection**

- A) The installation of water and sewer utilities shall be subject to inspection by the Engineering Services Division on a regular basis so as to provide complete inspection of underground or otherwise concealed

installations prior to covering or concealment.

- B) Upon completion of construction and satisfactory system tests the Engineering Services Division shall prepare and issue to the contractor, engineer and/or developer a punch list of outstanding items to be completed prior to acceptance.
- C) Water distribution and sanitary sewer system improvements shall not be put online or brought into service without written approval by the Engineering Services Division.

### 3.5 As-Built Drawings

- A) The contractor shall be responsible for recording constructed dimensions and information on a set of field drawings during the progress of construction and providing that information to the design engineer.
- B) The design engineer shall then be responsible for preparing a set of as-built drawings and ensuring that all changes made during construction have been documented on the as-built drawings.
- C) The Engineering Services Division shall review as-built drawings to ensure that changes in construction are accurately recorded.
- D) In the event that discrepancies exist between as-built drawings and as-constructed conditions, it shall be the responsibility of the design engineer to verify the as-built information and provide accurate as-built drawings.
- E) Reproducible mylar/film as-built drawings, certified by the design engineer, shall be presented to the Engineering Services Division within 30 days of completion of the construction.
- F) As-Built drawings shall include locations of all:
  - 1. Valves, valve vaults, fire hydrants, bends and tees or other changes in main pipe direction, material or size.
  - 2. Lift stations, manholes, cleanouts, bends and tees or other changes in main pipe direction, slope, material or size.

### 3.6 Acceptance

- A) Upon completion of punch list items the design engineer or contractor shall submit a request to the Engineering Services Division for a Final Inspection Report.
- B) A Final Inspection Report shall not be issued until the supplying-adjacent or receiving-downstream system has been accepted.
- C) A Final Inspection Report shall not be issued until as-built drawings are provided and accepted by the Engineering Services Division.
- D) Final plats shall not be approved and Building Permits and/or Certificates of Occupancy for facilities to be serviced by a newly constructed system will not be released by the Engineering Services Division until said system has been approved or appropriate performance guarantees have been established.

### 3.7 Plan Details

- A) Plan Format
  - 1. Standard drawing size shall be 24" x 36".
  - 2. Minimum drawing size for additional approved plans to be returned to the design engineer and for interim review with approval of the reviewing engineer shall be 11" x 17".
- B) The following information shall be shown on all construction plans:
  - 1. Title Block (lower right hand corner preferred)
  - 2. Scale
  - 3. Original Date and Revision Dates
  - 4. Name of Professional Engineer

5. Professional Engineer's Seal (For final approval only, preliminary plans shall be indicated as such)
  6. Firm Name, Firm Number and Contact Information
  7. City of San Angelo Water Utilities standard signature block (every sheet)
  8. City of San Angelo Water Utilities Department Contact Information:
    - i. Engineering Services Division:  
(325) 657-4201
  9. Drawing Number(s) Insertion Block
    - a. "W - \_\_\_\_\_" for water main plans
    - b. "S - \_\_\_\_\_" for sanitary sewer main plans
  10. Legal Description of Property Being Improved
  11. Statements:
    - i. "All work shall be performed in accordance with the City of San Angelo Design Standards and Specifications."
    - ii. Municipal water lines are to be constructed in accordance with the TCEQ Chapter 290, 'Rules and Regulations for Public water Systems'.
    - iii. Municipal sanitary sewer lines are to be constructed in accordance with the TCEQ Chapter 217, 'Design Criteria for Domestic Wastewater Systems'.
  12. City Bench Marks (as available)
  13. North Arrow
  14. Property Lines
  15. Street Names and Easements with Width Dimensions
  16. Other Pertinent Details (Buildings, Curbs, Water Courses, Etc.)
  17. Existing Utility Lines (Thin – Dashed).
- C) Water Plans
1. Proposed Water Mains (Bold – Solid)
  2. Stationing
  3. Size
  4. Length
  5. Material and Types of Joints
  6. Location Dimensions
  7. Meters
  8. Fittings
  9. Tees
  10. Crosses
  11. Reducers
  12. Bends
  13. Plugs
  14. Blow-offs
  15. Thrust Blocks
  16. Valves
  17. Fire Hydrants
  18. Plan, Profile (Required for water mains 16 inch and larger) and Complete Details for Off-Site



## Transmission Mains, Pump Stations, Special Valves and Vaults, Tanks, Etc.

- D) Sanitary Sewer Plans
  - 1. Proposed Sanitary Sewer Mains (Bold – Solid)
  - 2. Stationing
  - 3. Size
  - 4. Materials
  - 5. Gradients
  - 6. Location Dimensions
  - 7. Location and elevation of vertical control
  - 8. Proposed Manholes
  - 9. Stationing at Manholes
  - 10. Elevation of Inverts In and Out of Manholes
  - 11. Elevation of Manhole Rim
  - 12. Manhole Stub-Outs
  - 13. Proposed Future Extensions
  - 14. Proposed Service Connections or Stub-Ins
  - 15. Proposed Concrete Encasement
- E) Profile (required for all sanitary sewer lines and water lines 16-inch diameter and larger)
  - 1. Ground Surface - Existing (Dotted) and Proposed (Solid)
  - 2. Station Numbers
  - 3. Existing and Proposed Utilities Where Crossed
  - 4. Proposed Control Elevations and Grades
- F) Detail Sheet - As Required
  - 1. Standard Bedding, Backfill and Surface Repair Details
  - 2. Thrust Block and Joint Restraint Tables
  - 3. Fire Hydrant Detail
  - 4. Tapping Details
  - 5. Air Valve Detail
  - 6. Blow-off Detail
  - 7. Manhole Detail
  - 8. Drop Manhole Detail
  - 9. Cleanout Detail
  - 10. Crossing Detail
  - 11. Service Line Detail
  - 12. Bore Detail
- G) Master Plan - If Required
  - 1. Scale 1" = 50'
  - 2. Lot Lines
  - 3. Streets and Street Names
  - 4. Main Line Sizes and Material
  - 5. Valves/Fire Hydrants

6. Manholes/Cleanouts
7. Connections to Existing System