City of Houston

Design Manual

Chapter 7

WATER LINE DESIGN REQUIREMENTS

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7.01 CHAPTER INCLUDES

A. Criteria for the design of water lines.

B. Criteria for 24-inch and larger water lines are in Appendix A of this Chapter.

7.02 REFERENCES

A. American Water Works Association (AWWA).

B. National Sanitation Foundation (NSF).

C. Uniform Plumbing Code

D. Refer to the list of references in Chapter 1, General Requirements.

7.03 DESIGN REQUIREMENTS

A. Obtain approval from the Office of the City Engineer (OCE) for exceptions or deviations from these requirements. Exceptions or deviations may be granted on a project-by-project basis.

B. Lines.

1. Locate water lines within street rights-of-way, permanent access easements with overlapping public utility easements, easements adjacent to street rights-of-way, or recorded water line easements:

   a. Pipe with 2-inch diameter is allowed only in rehabilitation projects where tie-ins to existing 2-inch lines are necessary.

   b. Pipe with 4-inch diameter may be used within cul-de-sacs (permanent dead end) less than or equal to 200 feet in length.

   c. Pipe with 6-inch diameter may be used if the line is less than 1000 feet in length and interconnected between 2 lines which are 8-inch diameter or larger, or if the 6-inch line terminates in a cul-de-sac or dead end street and meets the additional rule of this chapter. Only one fire hydrant or flushing valve is allowed on any length of 6-inch diameter line.

d. Use minimum 8-inch diameter pipe for lines over 1000 feet long or when 2 or more fire hydrants or flushing valves are required.

e. Pipe sizes are determined by the Professional Engineer and approved by the City. A minimum of 12-inch diameter pipe shall be used when parallel to a Railway Transit corridor for more than 300 feet.

f. Dead-end lines within public right-of-way:

(1) In temporary dead end situations the water line shall be 6-inch diameter or larger, shall not exceed more than 200 feet in length from the closest interconnection water line, and shall terminate with a fire hydrant or blowoff valve. The terminus of the line shall end with a plug and clamp. The fire hydrant or blowoff valve shall be located considering adequate drainage to avoid flooding during flushing.

(2) In permanent dead ends situations the water line shall be 6-inch diameter or larger, shall not exceed more than 500 feet in length from the closest interconnection water line and shall terminate with a fire hydrant or blowoff valve. The terminus of the line shall end with a plug and clamp. The fire hydrant or blowoff valve shall be located considering adequate drainage to avoid flooding during flushing.

(3) Water lines within cul-de-sac:

(a) Reduce pipe sizes successively. Carry 8-inch and/or 6-inch and/or 4-inch diameter pipe in accordance with requirements found in paragraph 7.03. The water line shall terminate with a fire hydrant and/or blowoff valve. Carry 6-inch diameter pipe to the last fire hydrant. If the water line continues beyond the last fire hydrant, use 4-inch diameter pipe to end the water line. The water line shall terminate with a standard 2-inch blowoff valve and box at the end of a 4-inch diameter water line. Place last service as near as possible to the end of water line. The fire hydrant and/or blowoff valve shall be located considering adequate drainage to avoid flooding during flushing. The terminus of the line shall end with a plug and clamp.

(b) Use following alternate if approved or requested by OCE.

1. Extend water line along both sides of the street and loop (connect both lines within the cul-de-sac turnaround).

2. The diameter of the looped water line shall be of the same size as the diameter of water line perpendicular to the cul-

de-sac. The diameter of the water line shall not exceed 8-inch within the cul-de-sac without approval from OCE.

3. Discontinue water line along perpendicular street between entry and exit locations of the looped water line so that water flow will occur down one side of cul-de-sac street and up the other side without disrupting the continuity of water flow.

4. Fire hydrants to be spaced as if only a single line existed.

5. Alternatively, extend water line to an adjacent cul-de-sac under the following conditions:

   a. Obtain a separate 20-foot wide water line easement.

   b. Install water lines inside a continuous steel casing pipe. Extend the casing uninterrupted from R.O.W. to R.O.W. No horizontal or vertical deflections or connections are allowed. Construct encased water line of restrained joint bell and spigot pipe to prevent lateral movement. Provide casing spacers and end seals in accordance with Standard Specifications.

   c. Obtain approval from OCE.

g. Install water lines that are located in side lot easements inside a continuous steel casing pipe. Extend the casing uninterrupted from R.O.W. to R.O.W. Diameter of pipe shall not exceed 12 inches. Provide isolation valves within 100 feet of each end. No horizontal or vertical deflections or connections are allowed. Construct encased water line of restrained joint bell and spigot pipe to prevent lateral movement. Provide casing spacers and end seals in accordance with Standard Specifications.

h. Offsets through intersections shall span the width of the intersection whenever practical.

i. The water line alignment shall have the minimum number of bends and appurtenances as is reasonable for the project scope.

j. Restrained joint calculations shall be utilized at all such locations governed by Best Practices and shall be provided to the City upon request.

C. Location, Depth of Cover, and Separation Requirements

Table 7.1
WATER LINE LOCATION WITHIN A STREET RIGHT-OF-WAY

RIGHT-OF-WAY WIDTH & EXISTING OR ANTICIPATED CURB FACE TO FACE PAVING WIDTH		8" & SMALLER[1] [2] [4]	12"THRU 20"[1] [2] [4]
100-FOOT ROW (ALL STREETS):		8 feet	7 feet
80-FOOT ROW (ALL STREETS):		7 feet	6 feet
60-FOOT ROW:			
MAJOR THOROUGHFARE:	44 feet	5 feet	5 feet
COMMERCIAL, SCHOOL, PARK	40 feet	7 feet	6 feet
RESIDENTIAL:	27 feet	12 feet [3]	12 feet [3]
50-FOOT ROW:			
ALL STREETS:	35 feet	5 feet	5 feet
ALL STREETS:	27 feet	7 feet	7 feet

[1] The number listed below is the maximum allowable distance from the right-of-way to the nearest outside diameter of the proposed water line.
[2] The minimum distance from the right-of-way to the nearest outside diameter of the proposed water line shall be 5 feet without a water line easement adjacent to the rights-of-way (see easement requirements for less than 5 feet).
[3] Investigate the possibility of a future 35-foot face-to-face curb-and-gutter section to replace existing streets with roadside ditches.
[4] The maximum and minimum distance from the right-of-way shall be applied in such a way as to preserve room in the right-of-way for future expansions and relocations, to the extent possible.

1. Boulevard streets: When necessary, water lines may be located within the esplanade. The lines should be located as near the centerline of street right-of-way as possible to avoid conflict with future pavement widening.

2. Locations within an easement: Locate water lines 12-inch diameter and smaller in the center of a 10-foot minimum width dedicated water line easement and water lines 16-inch diameter and larger in the center of a 20-foot minimum width dedicated water line easement. Do not locate lines 16-inch diameter and larger in side lot easements. For location within side lot easements, see Chapter 5, Easement Requirements. Obtain approval from OCE for lines to be located in wider or multi-use easements.

3. When a water line and appurtenances is placed parallel or adjacent to another utility line, other than a sanitary sewer, and is located above the other utility, water lines and appurtenances shall have a minimum of 4 feet horizontal clearance from outside wall to outside wall of the other utility.

4. Water lines and their appurtenances shall have minimum horizontal clearance of 4

feet as measured from each outside wall, to adjacent utilities, other than sanitary sewer.

5. When a water line is to be placed parallel to a railway corridor, maintain minimum 30 feet horizontal clearance from centerline of nearest outside track rail.

6. Do not place water line appurtenances in flow lines of the roadside ditches. The nearest outside diameter of any water line shall be no closer to a building line, building foundation or building slab than 10 feet for water lines 12 inches in diameter and smaller and no closer than 15 feet for water lines 16 inches in diameter and larger.

7. Depth of cover

   a. Provide the following minimum depths of cover from the top of curb for curb-and-gutter streets or from mean elevation of the nearby ditch bottom and the nearby right-of-way for open-ditch section:

Table 7.2
DEPTH OF COVER FOR WATER LINES

SIZE OF LINE	DEPTH OF COVER		ABSOLUTE MINIMUM
	TOP-OF-CURB	OPEN-DITCH SECTION	
12-INCH & SMALLER	4 feet [2]	5 feet	3 feet[2]
16-INCH	5 feet[2]	6 feet	3 feet[2]
20-INCH	6 feet	8 feet	4 feet[1,2]

[1] Cement stabilized embedment required.
[2] Minimum 6 feet of cover where crossing railway

   b. Whenever possible, changes in grade or alignment to clear utilities or underground features should be accomplished by deflecting the pipe joints. The use of regular bends for any change in grade will not be allowed without prior approval from OCE for variance.

   c. No vertical or horizontal offsets or bends allowed for water lines in casings.

   d. Use restrained joint pipe for lines 20-inch diameter and smaller with less than 4 feet or more than 8 feet of cover. The following direct bury alternates may be used:
      (1) Ductile iron pipe pressure 250 psi with approved restrained joints.

(2) PVC pipe with integral restrained joint system, or ductile iron restrained joints fittings, epoxy lined and coated. Use AWWA C900 DR 18 for PVC restrained joints. Use 250 psi AWWA C900 DR 14 for vertical offsets.
(3) Use only ductile iron and PVC products listed on OCE approved products list and/or in accordance with City Standard Specifications.

D. Appurtenances

1. Do not place appurtenances under pavement.

2. Valves

a. Spacing - set at maximum distances along the line as follows:
(1) 4-inch through 12-inch diameter - 1000 feet.
(2) 16-inch and 20-inch diameter - 2000 feet.

b. Location:
(1) Normally, locate valves at street intersections along the street right-of-way lines projected across the water line. Tapping sleeves and valves are excluded from this requirement. Maintain a minimum of 30 feet from the centerline of the outside rail. Do not propose valves inside ramps or at curb.
(2) Isolate fire hydrants and flushing valves from the water line with a valve located in the fire hydrant or flushing valve branch. This valve shall not be located in the slope or flow line of roadside ditches.
(3) Intermediate valves, not located on the projection of the right-of-way line, shall be located on lot lines or 5 feet from fire hydrants but not set in driveways.
(4) Locate valves a minimum of 9 feet horizontally from sanitary sewer crossings and 4 feet horizontally from other utilities crossings.
(5) Valves located near reducers shall be located on the smaller diameter pipe.
(6) Provide flanged outlet and mount isolation valve directly on the flange on any branches to larger diameter water line.

c. Valve Type (Unless otherwise specified):
(1) 20-inch and smaller - Gate valves.
(2) Gate valves should be used for all meter installation.

d. Number of Valves:
(1) Total number of valves at any water line intersection shall equal total number of lines leading out from the intersection point minus one, three valves for a cross, and two valves for a tee for 20-inch diameter lines and smaller.

3. Fire Hydrants and Flushing Valves
Fire hydrants should be designed to maintain sufficient water pressure for service to adequately protect public safety in residential area. The system must also be designed to provide fire fighting capability to maintain a minimum pressure of 20 psi under combined fire and drinking water flow conditions. The minimum fire flow for the residential area should be 1,500 gpm.

a. Spacing:
(1) Single-family residential development - 500-foot maximum spacing.
(2) All other developments - 350-foot maximum spacing.

b. Location in or along street right-of-way:
(1) Locate fire hydrants primarily at street intersections.
(2) Locate fire hydrants at PCS of the intersection curb radius, 3 feet behind curb or projected future curb.
(3) On streets with roadside ditches, set the fire hydrants within 5 feet of rights-of-way lines.
(4) Set intermediate fire hydrants on lot lines, as extended to pavement, when located between right-of-way intersections. These locations may be adjusted 5 feet either way to avoid driveways or obstructions. In either case, do not locate fire hydrants closer than 3 feet from curbed driveways or 5 feet from non-curbed driveways.
(5) a. Fire hydrants may be set in the esplanade section of City streets when locations at back of curbs are not feasible. In such cases, the preferred location is 7 feet behind back of curb to provide access for parkway mower. In no instance shall the fire hydrant be closer than 3 feet from back of esplanade curb or closer than 10 feet from esplanade nose.
b. Fire hydrants shall not be located between parallel adjacent Rail Tracts in Railway Transit Corridor.
(6) For commercial building with fire service connections, place additional fire hydrant on the same side of the street as wet and dry connections. This hydrant is not counted in fire hydrant spacing.

c. Location of fire hydrants or flushing valves outside and adjacent to street rights-of-way:
   (1) The City Fire Marshall will establish and approve the location of fire hydrants and flushing valves in apartment complexes, platted private street developments, and other multi-family developments within the City.
   (2) Locate fire hydrants and flushing valves in protected, easily-accessible areas behind curb lines.
   (3) For fire hydrants or flushing valves which are located adjacent to water lines for fire protection constructed in 10-foot wide water line easements, the fire hydrant or flushing valve shall be centered in a minimum 10-foot by 10-foot separate easement.

d. For commercial developments inside the City and ETJ, provide isolation valves at each end of fire loops requiring on-site fire hydrants.

e. Fire hydrants shall be designed to have a 4-foot bury where possible. As a normal policy bends or offsets in fire hydrant branch will not be allowed. Bends may be used to maintain a 4-foot bury or to maintain 3-foot back of curb with prior approval from OCE. In case of conflict DIP fire hydrant leads may be used for a minimum of 3-foot of bury.

4. Fittings

a. Normally use "all bell" (designated AB) for fittings. Properly designed thrust blocks shall be provided for each AB fitting for diameters 12-inch and smaller.

b. Provide fittings with approved restraint joints for diameters 16-inch and larger. Provide fittings with approved restraint joints for all diameters when crossing a railway. Provide calculations to determine limits of restrained joints for diameters 16-inch and larger. Show length of restrained joints on drawings in the profile view.

c. At dead end, use plugs with retention clamps and carrying the designation "plug and clamp" For 12-inch and smaller lines. Provide thrust blocks at end of plug, with polyethylene encasement as a bond-breaker between concrete blocking and pipe. For 16-inch and larger lines, use blind flanges or approved dished head plugs, and use restrained joint lengths in lieu of thrust blocking. When stubs are provided for future extensions, isolate the stub with a valve, and do not allow service connections to stub until extended.

E. Water Meter Service

1. Water meter service for lines in or along street rights-of-way. Locate in areas with easy access and with protection from traffic and adjacent to rights-of-way whenever possible. Do not locate meters in areas enclosed by fences. Obtain approval from OCE to locate meters within 30 feet from the center line of outside rail.

   a. Meters 2 inches and smaller and Shut-off valves (stop boxes): Locate in rights-of-way, water line easements, or in a minimum 5-foot by 5-foot separate water meter easement contiguous with public right-of-way. Provide concrete meter boxes for meters located under sidewalks.

   b. Meters 3 inches to 6 inches: Locate in minimum 10-foot by 20-foot separate water meter easement contiguous with public right-of-way. Provide Plan and Profile for OCE approval.

   c. Meters 8 inches and larger: Locate in minimum 15-foot by 25-foot separate water meter easement contiguous with public right-of-way. Provide Plan and Profile for OCE approval.

   d. Separate tap and service lead shall be designed for each domestic meter. Meter, line size, and appurtenances shall conform to the latest edition of the Uniform Plumbing Code.

   e. All water meters must have the same size as of the service lines except 4-inch and 12-inch diameter service lines shall be installed for 3-inch and 10-inch water meters.

   f. Irrigation meters are to be branched off the domestic service.

   g. Double detector check valves allowed for use on un-metered fire lines for closed type systems in accordance to the City of Houston Ordinance Chapter 47.

   h. 3 inches and larger meters set in right-of-way or any placement other than the dedicated easement will require approval from the OCE.

   i. Meters larger than 10 inches, or applications in potential hazardous chemical environs must be installed in an above ground meter installation assembly.

2. Refer to Submittals Paragraph 7.04, and Drawings Paragraph 7.07 of this Chapter, for approval and drawing requirements for meter service leads 4-inch diameter and larger, and metered sprinkler connections.

3. For proposed apartments or townhomes in private street developments, provide one master meter sized for the entire development. Exceptions may be granted by OCE. If an exception is approved, do not interconnect multiple meters.

4. Provide a dedicated water main easement for commercial developments with on-site water mains (for fire protection) or, provide fire service meters adjacent to the public right-of-way. If a dual feed is desired, both feeds shall be metered. An above-ground, reduced pressure, zone-type backflow preventer shall be installed on the water line downstream from the meters.

5. Do not install stub outs for future water services.

6. The water meter report and survey shall be reconciled to verify that all meters are shown on the Drawings. Meters larger than 2-inch shall be called out and require connections to be designed.

F. Water Line Crossings

1. Public and private utility crossings other than sanitary sewer: Where a water line crosses another utility other than a sanitary sewer, a minimum of 6 inches of vertical clearance must be maintained between the outside wall of the water line and the outside wall of the utility.

2. Stream or ditch crossings

a. Elevated crossings, general:
   (1) Elevated crossings are preferred to underground crossings.
   (2) Design elevated crossings with the elevation of the bottom of the water line above the low chord of the nearest adjacent bridge or a minimum 1-1/2 feet above the 100-Year Floodplain Elevation, whichever is greater.
   (3) Water lines shall be steel pipe and shall extend a minimum of 15 feet beyond the last bend or to the right-of-way line of the crossing, whichever is greater.

b. Elevated crossings on existing structures:
   (1) 12-inch diameter and smaller water lines supported on existing or proposed bridges, must meet the following criteria. Coordinate location of lines, in advance, with OCE.
      (a) Have adequate structural capacity.
      (b) Have sufficient clearance above bent cap elevation for installation under the bridge.

c. Elevated crossings on separate structures:
   (1) Use a separate elevated supporting structure for 16-inch diameter and larger water lines unless otherwise approved by OCE. Locate separate structures a minimum of 10 feet clear from other existing or proposed structures.
   (2) Support the line on columns spaced to accommodate structural capacity of the pipeline considering deflection and loading.
   (3) Base column support design on soil capacity, spacing, loading, and structural requirements.
   (4) Provide sufficient span length to accommodate the cross section of future widening of the stream or ditch, if available.
   (5) Provide appropriately sized air release valves at the highest point of the water line.
   (6) Provide pedestrian pipe guards on elevated crossings.

d. Underground Crossings:
   (1) Provide a minimum 5-foot clearance above top of pipe to the ultimate flow line of the ditch.
   (2) Provide sufficient length to exceed the ultimate future development of the stream or ditch.
   (3) Water lines shall be restrained joint pipe in casing and shall extend a minimum of 15 feet beyond the last bend or to the right-of-way line of the crossing, whichever is greater.
   (4) No water line underneath detention pond or amenity lake is allowed.
   (5) Water line shall be installed with an isolation valve on both sides with a 40 foot minimum clearance from the end of casing on at least one side.

3. TxDOT and County Road Crossings

a. Extend carrier pipe from right-of-way to right-of-way.

b. Use restrained joint pipe in steel casing under existing and future roadway from a point 5 feet outside of the service road or outside of pavement toward the right-of-way, to a similar point on the other side of the highway across the right-of-way. For highway or roadway crossings with open-ditch sections, extend restrained joint pipe in steel casing from right-of-way to right-of-way.

c. Where additional right-of-way has been acquired, or is being acquired, for future widening, the restrained joint pipe in steel casing shall extend to within 10 feet of each right-of-way line.

4. Railroad Crossings

   a. For mainline and spurline railroad crossings, the water line material shall conform to Railroad requirements and have restrained joint pipe within a steel casing which extends no less than 30 feet from the center line of the outside rails within City of Houston right-of-way, and from right-of-way to right-of-way, on railroad owned property.

   b. Install isolation valves on each side of rail crossings.

   c. Crossings are to be made perpendicular to rail.

   d. Design Engineer to use a Corrosion Consultant to evaluate pipe and casing materials and the effect to and from rail systems.

5. Additional Requirements

   a. Use electrically isolated flange joints for transitions between two dissimilar metallic pipes. Electrically isolate water lines from casing pipe and supports.

   b. The carrier pipeline shall extend a minimum of 1 foot beyond the end of the casing to allow flanged joints to be constructed.

6. Oil or Gas Pipeline Crossings: Do not use metallic pipe when crossing oil or gas lines unless a properly designed cathodic system is implemented or casing installed with OCE approval. Other pipe may be used, regardless of depth, subject to approval by OCE. Maintain a minimum 2-foot vertical separation between the pipeline and water line.

7. On-site Fire Loops within Commercial Developments

   a. For commercial developments inside the City and in the ETJ requesting on-site water mains, comply with the following requirements to allow maintenance and future repair operations:
      (1) Do not allow placement of structures, paved parking or equipment pads over the easement.
      (2) Provide 20-foot-wide longitudinal pavement joints along easement lines where the water line is located under driveway.
      (3) Fire loops should be placed under the unpaved and porous area except crossing driveways.
      (4) Fire loops maybe placed in the Type 2 permanent access easement meeting all others requirements.

G. Trenchless Construction: Use trenchless construction method by following the general criteria:

1. Improved streets - Use trenchless construction to cross a street regardless of surface. Trenchless length shall be computed as roadway width at proposed crossing location plus 5 feet to either side of roadway.

2. Driveways - Use trenchless construction to cross active driveways. Compute crossing length as driveways width plus 1 foot to either side. Where proposed lines are in close vicinity and parallel to culvert pipes along roadside ditch streets, the length of crossing shall be the same as the length of existing culvert plus 1 foot either end.

3. Trees - Use trenchless construction to cross within 10 feet of trees 6 inches and larger in diameter. Use an appropriate trenchless length to clear the tree canopy.

4. Transit Railways - Use trenchless construction to cross within 30 feet of center line of outside rails.

H. Circulation and Flushing for Water Quality:

1. The layout of the water distribution system shall provide maximum circulation of water to prevent future problems of odor, taste, or color due to stagnant water.

2. Provide a source of fresh water at each end or at multiple points of a subdivision. Provide ways to create circulation and place valves and fire hydrants to allow simple flushing of lines.

I. Interconnections

1. For interconnections between utility districts outside the City, written approval must be given by the TCEQ.

2. A written agreement between the districts must be approved by the City and recorded in the county records and furnished to the City.

3. Set meter at the point of connection in a separate easement sized to conform to requirements of Chapter 5. Meter to conform to requirements given in the City of Houston Standard Specifications and Standard Details.

4. Requirements for installation of a meter may be waived by the City, if provisions are made in the agreement between the districts. In this event, a separate easement, sized to conform to requirements of Chapter 5, and valves shall be provided for future meter installation.

5. Agreement between districts shall provide for annexation of the meter site by one

district and shall require the installation of a meter. The installation and full cost shall be provided by the district not annexing the meter site.

6. For connection to City water lines serving districts or areas outside the City, written approval must be obtained from the TCEQ. No customer may take pump suction directly from City water lines. If a customer has his own well or other supply, an appropriate backflow preventer must be installed to prevent water from flowing into City water lines. Conform to the procedures for connection to City water lines in effect at the time of connection. Consult with the Public Utilities Division for current requirements.

J. Water Lines Separation from Sanitary Sewers

1. Water Lines Parallel to Gravity Sanitary Sewers and Force Mains:
Locate water lines a minimum of 9 feet horizontally apart, measured from outside wall to outside wall, when parallel to gravity sanitary sewers and force mains. Use the following procedure when stated separation cannot be achieved:

a. The existing sanitary sewer shall be replaced with lined ductile iron pipe or PVC pipe meeting ASTM specifications, having a minimum working pressure rating of 150 psi or greater and equipped with pressure-type joints.

b. The water lines, gravity sanitary sewers, or force mains, shall be separated by a minimum vertical distance of 2 feet, and a minimum horizontal distance of 4 feet, measured between the nearest outside walls of the pipes.

Following alternate shall be used only, if the above can not be achieved

c. Water line or sanitary sewer shall be constructed with approved restrained joints in an approved casing with at least two nominal sizes larger than the carrier pipe. The carrier pipe shall be supported at five-foot intervals with spacers or be filled to the springline with washed sand.

2. Water Lines Crossing gravity Sanitary Sewers and Force Mains. Conform to requirements of TAC § 290.44 Paragraph (e).

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a. No protection is required if the sanitary sewer is 9 feet below the water line.

b. For all other cases, use Table 7.3 on the next page.

Table 7.3
PROTECTION REQUIREMENTS AT WATER LINE (WL) - SANITARY SEWER (SS) CROSSINGS

	PROPOSED WATER LINE				PROPOSED SANITARY SEWER			
	OVER		UNDER		OVER		UNDER	
	EXISTING SS	PROP SS	EXISTING SS	PROP SS	EXISTING WL	PROP WL	EXISTING WL	PROP WL
Minimum 2 feet vertical clearance	√ [1]	√ [1]	√	√	√[6]	√	√ [1]	√ [1]
Place 1 full section (min 18 ft) of WL centered at SS Crossing. Provide restrained joints on WL, spaced at least 9 ft horizontally from centerline of SS	√	√	√	√	√[6]	√		√
Place 1 full section (min 18 ft) of SS centered at WL Crossing. Provide restrained joints on SS, spaced at least 9 ft horizontally from centerline of WL		√			√[6]		√	√
Replace 1 full section of existing SS with pressure-rated DIP or pressure-rated PVC pipe with adapters and restrained joints centered at WL crossing	√ [2, 3]		√ [3]		√[6]			
Provide DIP for small diameter WL (less than 24 inches), PVC pipe is only allowed if encased as per TAC § 290.44, and use restrained joints for both DIP and PVC pipe			√	√	√[6]	√		
Embed SS with CSS for the total length of 1 pipe segment plus 1 foot beyond the joints on each end	√ [2, 3]	√ [4]	√ [3]	√ [4]	√ [5,6]	√ [4]	√ [4]	√ [4]
Place 1 full section (min 18 ft) of min 150 psi SS centered at WL crossing. Provide restrained joints on SS, spaced at least 9 ft horizontally from centerline of WL or encase in a joint of 150 psi pressure pipe (min 18 ft) two nominal sizes larger with spacers at 5 ft interval.				√	√	√		

1. Minimum clearance is 2 feet for non-pressure rated SS and 6 inches for pressure rated SS(with at least 150 psi pressure rating)
2. Minimum clearance is 2 feet for non-pressure rated SS and 1 foot for pressure rated SS
3. Required if existing SS is disturted and/or there is evidence of leakage
4. Not required for augered WL unless there is evidence of leakage, completely fill augered hole with bentonite/clay mixture
5. Not required for augered SS, completely fill augered hole with bentonite/clay mixture
6. Not allowed requires approval of City Engineer
7. Both Waterline and Wastewater main or lateral must pass a pressure and leakage test as specified in AWWA C600 standards

3. Sanitary Sewer Manholes: Provide a minimum 9-foot clearance from outside wall of existing or proposed manholes unless manholes and connecting sewers can be made watertight and tested for no leakage. If a 9-foot clearance cannot be obtained, the water line may be located closer to the manhole when prior approval has been obtained from OCE by using one of the procedures below; however, in no case shall the clearance be less than 4 feet.

    a. Water line shall be constructed with approved restrained joints in an approved casing with at least two nominal sizes larger than the carrier pipe. The carrier pipe shall be supported at five-foot intervals with spacers or be filled to the springline with washed sand.

4. Fire Hydrants: Do not install fire hydrants within 9 feet of sanitary sewers and force mains regardless of construction.

5. TCEQ Rules and Regulations for Public Water Systems, including any approved City variances shall apply if they are more strict than these guidelines or if they are not covered by these guidelines.

7.04 SUBMITTALS

A. Conform to the following submittal requirements in addition to those of Chapter 1 - General Requirements.

B. Water Line Sizes: Submit justification, calculations, and locations for proposed water lines, for approval by OCE.

C. Water Meter Service

1. For construction inside city limits, submit an application for meter services and metered sprinkler connections, to the Taps and Meters Section, prior to construction.

2. Submit requests for more than one service meter for townhomes in proposed private street developments to OCE.

D. Master Development Plan: For multiple phase developments, submit a master development plan. If within the ETJ, submit an overall district plan prior to the drawings being submitted for first phase construction.

E. Interconnections

1. Submit to the TCEQ requests for written approval of:

    a. Connection of City water lines to serve districts or areas outside city limits.
    b. Interconnections of districts.

2. Submit copies of approvals received from TCEQ to OCE.

7.05 QUALITY ASSURANCE

A. Prepare calculations and construction drawings under the supervision of a Professional Engineer trained and licensed under the disciplines required by the drawings. The final design drawings must be sealed, signed, and dated by the Professional Engineer responsible for development of the drawings.

7.06 DESIGN ANALYSIS

A. Water Line Sizes: Analyze system requirements to determine line sizes and obtain concurrence from the City.

B. Water Distribution System: The system must be designed to maintain a minimum pressure of 35 psi at all points within the distribution network at flow rates of at least 1.5 gpm per connection. The system must also be designed to provide fire fighting capability to maintain a minimum pressure of 20 psi under combined fire and drinking water flow conditions.

C. Elevated Stream, Ditch, or Aerial Crossings: Prepare appropriate design calculations for the supporting structure.

7.07 DRAWINGS

A. Conform to the following drawing requirements in addition to those of Chapter 3, Graphic Requirements and the City's standard water line details and Standard Specifications.

B. Provide a cross section drawing (plan and profile showing other utilities and pavement) of branch water lines that extend perpendicularly from main water lines when:

1. Branch line extends 20 feet or more, and/or

2. Branch lines have vertical bends.

3. When proposed lines, including services larger than 2-inches, cross Railway Transit facilities.

4. Any water taps size 4" or larger.

C. Appurtenances: Identify, describe, and enclose proposed water line and appurtenances in rectangular box on drawings.

1. Valves
   a. Designate 2-inch through 16-inch gate valves with box as GV&B.

b. Provide complete description and size for other valves.

2. Water meters, service leads, and un-metered sprinkler connections

a. Show the location of service line tees, tapping sleeve and valves, valve boxes, and temporary plugs to be installed to serve future 3-inch diameter or larger meters.

b. Develop plan and profile sheets for 4-inch diameter and larger leads and connections.

D. Construction Features

1. Show special construction features required to complete the project in a safe, convenient, and economical manner.

2. Trenchless Construction

a. If the construction is predominately open cut, all portions and locations of the street that must be trenchless constructed shall be clearly shown on drawings. Include designation for trenchless sections adjacent to trees with 6 inches or larger diameters located within 10 feet of water line.

b. If construction is predominately by trenchless construction:
(1) Clearly show on drawings, areas and locations in which trenchless pits will not be permitted.
(2) Clearly identify areas where special pipe material or offset sections are required to comply with these guidelines.

3. Do not locate horizontal bends within street intersections between curb returns or within 30 feet of the centerline of the outside rail.

4. Pedestrian Facilities: Include a requirement on drawings to replace any pedestrian facility that is disturbed, such as curb ramp, sidewalk, driveway or crosswalk in conformance with the latest edition of the City of Houston's Standard Details, American with Disabilities Act and Texas Accessibility Standards.

E. Future Planned Improvements.

1. When feasible, show planned improvements by City, County, TxDOT, Metro which could impact the proposed water line, or aspects of its design.

END OF CHAPTER

APPENDIX A
ADDITIONAL DESIGN REQUIREMENTS FOR LARGE DIAMETER WATER LINES

The following Appendix provides additional requirements to Chapter 7, related to the design of large diameter water lines (LDWL) which are defined as water lines 24-inches and larger. Unaltered portions of Chapter 7 shall remain in effect, but where conflicts exist, this appendix shall supersede requirements in Chapter 7.

1.01 DESIGN REQUIREMENTS AND CRITERA

A. Hydraulic Modeling:

1. Hydraulic modeling effort to be verified with Project Manager, and may be performed by Design Engineer, City, or another consultant. If model is to be provided by others, Design Engineer shall provide specific design information to modeler.

2. The following parameters shall be incorporated in the design:

a. Design Velocity:

Table A.1

Design Velocity

SIZE OF LINE	Desired (ft.sec)	Maximum (ft/sec) *
≥ 24-inch & ≤ 36-INCH	3	5
≥ 42-INCH & ≤ 96-INCH	5	7
> 96-INCH	7	12

* Maximum velocity may be adjusted with approval from Infrastructure Planning Branch (IPB).

b. Pipe Friction Factors:

Table A.2

HAZEN WILLIAMS "C" FACTOR

SIZE OF LINE	C (EXISTING LINES)	C (PROPOSED LINES)
≥ 24-inch & ≤ 36-INCH	110	120
≥ 42-INCH & ≤ 96-INCH	120	130
> 96-INCH	130	145

c. Maximum pressures anticipated are the greater of:

(1) 150% of operating pressure regardless of pipe size. Operating pressure = 100 psi.

(2) Other special design criteria as determined by modeling results, or specified by Project Manager.

Maximum system pressures are based upon the following equipment closing times:

a. Pressure reducing valves: 2.0 - 5.0 seconds (max.)

b. Check valves: 2.0 - 5.0 seconds (max.)

c. Pump control valves: 30 seconds (min.)

3. Modeling effort shall identify location and sizing of other devices, including Air Valves, Pressure Reducing Valves, and Check Valves.

4. Engineer to identify any shut down required of existing lines during construction of proposed project. Location, estimated duration, and timing of shutdown shall be provided to Project Manager and updated with each submittal milestone.

B. Transient (Surge) Analysis

1. Transient modeling effort to be verified with Project Manager, and may be performed by Design Engineer, City, or another consultant. If model is to be provided by others, Design Engineer shall provide specific design information to modeler.

2. In accordance with acceptable engineering practice (e.g. AWWA M51), air release, vacuum relief/air inlet, and/or combination air valves are to be installed at high points and such other intermediate points as determined during design. The water system is to be modeled under worst case transient scenarios to determine the effects of potential transients on the pipeline and to evaluate air valve placement and sizing.

3. General Criteria

a. Transient analysis shall, at a minimum, consider the following items to determine the appropriate surge protection methods and devices needed:

(1) Pipe material properties;

(2) Pipe wall thickness;

(3) Fluid properties; and

(4) Existing waterline alignments. Existing as-built information and other available information shall be used to develop the computer model of existing conditions.

(5) Proposed waterline alignments. Proposed pipeline design shall be added to the model and modeled based upon "worst-case" scenarios. These scenarios shall be identified in the analysis.

b. Computer modeling of the transient event scenario for each project shall be performed using the Liquid Transient (LIQT©) program or other modeling program acceptable to the City's Infrastructure Planning Branch (IPB).

c. Transient analyses shall include a table of recommended surge protection devices to be incorporated into the design drawings. The type of device and approximate station location for each device shall be identified in the table and incorporated into the Drawings.

d. The allowable surge pressure range for each analysis shall be -10 psi to 150 psi. Additional criteria and assumptions used in the analysis shall be identified in a Technical Memorandum signed and sealed by a licensed Professional Engineer registered in the State of Texas and submit to the Project Manager for review with each submittal milestone.

C. Alignment

1. Horizontal alignments shall be approved during preliminary engineering Phase I services. Evaluation of routes shall include factors including, but not limited to: traffic volumes, land use, width of right-of-way, existing utilities, pavement conditions, landscape features, proposed improvements along the route, and operational cost.

2. Proposed alignment shall minimize fittings and appurtenances, minimize impact with existing utilities and other site conditions. Remain on the same side of road within City Rights-of-Way to the extent possible. Where possible, manhole tops shall not be designed within the tire path along roadways.

3. Minimum depth of cover (depth to top of pipe) shall be 7 feet from top of curb in improved roadway areas or 9 feet measured at the water line centerline in roadways with open ditch drainage. Verify depth of cover will provide adequate space for air valve assembly and other appurtenances within manholes.

4. Normal depth of cover over tunnel shall be a minimum 1.5 x OD (outer diameter of tunnel). For shallower or deeper depths, a geotechnical analysis verifying adequacy of cover is required.

5. When a water line is placed parallel to another utility line, Water line should be designed with at least 4 feet horizontal clearance from OD to the OD of the other utility (additional requirements apply to sanitary sewer crossings). Engineer shall consider additional clearance based on material and condition of existing utility, and geotechnical conditions. Avoid overlapping of trench width of proposed water line with trench width of existing utility, to the extent possible.

6. Offsets/bends within 5 feet of a tunnel section are not allowed.

7. Locate drain line outlets at or near low point of elevation for water line, at areas that will permit draining a majority of the pipe. Place at least one drain line outlet between each set of in-line isolation valves. Design storm sewer leads from the drain line service manhole to a convenient drainage facility that is capable of accepting flow when draining the water line. System should be designed to drain by gravity, where possible.

8. To accommodate all approved pipe materials, the alignment plan and profiles (P&Ps) are to be based on the use of Prestressed Concrete Cylinder Pipe (PCCP), unless another material must be specified for sound engineering reasons.

9. In addition to graphical standards in Chapter 3, drawings shall include:

   a. Station and elevation at bends, elevation changes, and beginning and end of each drawing sheet.

   b. Arrow indicating normal direction of flow and slope of water line on the profile sheets.

   c. Valves, manholes and other appurtenances related to the proposed water line.

   d. Water line markers are to be installed where water line is placed in an easement. Markers shall be placed at a maximum spacing of 2000 feet, where there is a change in horizontal alignment, and when crossing property lines. Do not place markers within roadways.

D. Pipe Design Basis

1. Design shall be based upon combined loading conditions including operating, surge, vacuum and test pressures, as well as depth of backfill earth cover and live loads, and maximum velocity within the pipe.

2. Where different from standard specifications, design shall identify special features, such as: minimum wall thickness, special coatings, linings, shoring or joint

requirements. Unusual or unique considerations shall be described in details and/or project specifications as necessary.

3. Acceptable pipe materials for LDWL are listed below, based on currently approved diameters:

Table A.3

PIPE MATERIALS

TYPE	SIZE (INCHES)
Fiberglass Reinforced Pipe	≤ 30
High Density Polyethylene (HDPE)*	≤ 42
Ductile Iron	≤ 64
Prestressed Concrete Cylinder (PCCP)	≥ 24
Bar Wrap Concrete Cylinder	≤ 60
Steel	≥ 24

*Use of HDPE, or other materials not listed above, require City approval and additional project technical specifications.

4. Criteria used to evaluate pipe material for specific installation shall include: system flexibility, hydraulic efficiency, manufacturer and availability, surge protection, corrosion protection, special crossing requirements, operational cost, maintenance, susceptibility to environment and cost.

E. Corrosion Control

1. Corrosion control recommendations to be provided by a NACE International (formerly National Association of Corrosion Engineers) certified Cathodic Protection Specialist or certified Corrosion Specialist (referred to herein as Corrosion Engineer) in accordance with the technical standards, test methods and recommended practices of NACE International, ASTM, AWWA, and related technical societies.

2. Provide written Soil Corrosivity Study and include corrosion protection in the design.

3. Soil Corrosivity Study shall contain the following minimum elements:

   a. Project name, project number and date of study;

   b. Name and firm and signature of Corrosion Engineer;

   c. Introduction to project and scope of work;

d. Field results of soil resistivity;

e. Laboratory results of chemical analysis;

f. Interpretation of results/data;

g. Determination of likelihood of stray current;

h. Sources of AC power (when impressed current cathodic protection is recommended);

i. Soil corrosivity conclusions; and

j. Corrosion monitoring or corrosion control recommendations.

4. The following items shall be considered for corrosion monitoring and/or corrosion control recommendations. These shall not replace sound professional judgment on the part of Corrosion Engineer. The report shall be finalized upon completion of field work and laboratory testing and evaluation of results and data and appropriate corrosion control devices incorporated into the design.

a. Buried metallic and concrete pipe and reinforced structures are subject to corrosion and deterioration. Corrosion Engineer shall consider:

(1) All pipe options available to the contractor.

(2) Options for protection (sacrificial or impressed current systems). The City's Drinking Water Operations (DWO) to review and approve protection method.

(3) Isolation from adjacent projects. Unless otherwise specified, each project should be designed to be isolated from adjacent projects.

(4) Impact to and from external current sources along the alignment.

(5) Testing locations. Test stations are to be placed in easily accessible locations.

F. Valves

1. Isolation Valves

a. Valves shall isolate sections of water lines that may require repairs, maintenance or inspection or provide other operational functions.

b. Lateral lines shall have a flanged isolation valve placed directly adjacent to tee connection, unless otherwise approved by Project Manager.

c. Future accessibility to valves should be considered as part of the design. Actuator/operator manholes shall be located where they are accessible by truck-mounted mechanical valve operator, with minimal impact to traffic.

d. Maximum spacing shall correspond to Table 1.4. Additional isolation valves may be required to provide operational flexibility of the overall system:

Table A.4
ISOLATION VALVE TYPE AND SPACING

TYPICAL TYPES*	SIZES	MAX SPACING (FEET)
Gate	24-inch	2,200
Butterfly*	30-inch to 42-inch	3,000
Butterfly	48-inch and larger	4,000

* Gate valves may be used as determined by the City at critical locations and connections; Design Engineer to confirm that adequate space and depth of cover exists.

e. Foundation support details are required for pipe ends and valves. For butterfly valves, follow guidelines in AWWA C504/C516.

f. Where blind flanges or internal dished head plugs are located close to a butterfly valve, adequate spacing shall be provided to allow valve to be fully opened.

2. Air Valves

a. Inlet/outlet vent elevation shall be one foot above the 100-year floodplain elevation as established by the Federal Emergency Management Agency (FEMA), or four feet above natural ground, whichever is higher. Vent elevation greater than four feet above natural ground shall require design of support details.

b. Valves that are designed to be exposed shall be located to minimize potential for tampering and/or damage.

c. Drawings shall specify type of air valve at each location based on outcome of transient analysis. Air valve to be located within 10 feet from the bend.

3. Other Valves

a. Pressure Reducing Valves, Check Valves, or other special purpose valves may be required as determined by modeling or as instructed by the City.

G. Accessibility

1. Manholes

a. Specialty manhole details are to be provided as required.

b. Extra depth manholes and details (greater than 20 feet) shall be identified on Drawings.

2. Access Manways

a. Manways are required on water lines 30-inches in diameter and larger. Manways with air valves are counted as access locations.

b. Manways shall be no less than 24-inches in diameter and have a minimum 6-inch opening on top of each manway cover. Manway and flanges larger than 24-inches require the addition of appropriate mechanism to aid in lifting.

c. Manways shall be located on horizontal sections of the water line between isolation valves, such that access to the water line is provided at least every 1,000 feet, unless otherwise approved by Project Manager. Provide manways for access on both ends of tunnel if tunnel is deeper than 25 feet.

d. Where space permits, manways shall be designed within 10 feet on each side of the isolation valve in order to eliminate additional buried outlets for flushing and disinfection. Manholes shall not impact access to the valves or operator manhole.

e. Manways shall be placed at each end of the project limits where required to facilitate removal of dished head plugs, installed a maximum of 10-feet from the plug.

H. Thrust Restraints

1. Thrust restraint for new lines shall be provided by means of restrained joints. In special cases, primarily at connections to existing lines, supplemental restraint or blocking may be necessary and should be evaluated to be included in the design.

2. Thrust restraint calculations shall be performed to determine the minimum restrained joint lengths and be based on the use of Prestressed Concrete Cylinder Pipe (PCCP),

unless a specific pipe material is required, in which case the appropriate AWWA method for thrust restraint calculations should be used. Thrust restraint design calculations shall be signed and sealed by a professional Engineer, and provided to the Project Manager prior to final design submittal.

a. Thrust restraint calculations shall be based upon the following parameters:

(1) Internal Pressure = maximum pressure to which the pipe is subjected (including working, transient or field test pressures).

a. Working Pressure: 100 psi

b. Surge Pressure: 50 psi allowance (transient pressure total is 100 + 50 = 150 psi)

c. Field Test Pressure: 150 psi

(2) Soil Parameters: TRDP type IV soils as modified below:

a. Buoyant unit weight of soil as identified in project geotechnical report

b. Pipe to soil friction factor based on saturated soil conditions
i. PCCP, or other cement mortar coated pipe = 0.35
ii. Tape coated, polyurethane coated or epoxy coated pipe (including epoxy over cement mortar coated pipe) = 0.30
iii. For ductile iron pipe, reduce friction factor by 0.7 based on use of polyethylene encasement.

b. Calculations for specific pipe materials shall be based on the following:
(1) PCCP: AWWA M9 (latest edition) with design method as shown in the table below:

Table A.5

PCCP THRUST RESTRAINT DESIGN METHOD

Horizontal & Vertical Up Bends	Thrust Restraint Design Program (TRDP) (Latest Version)
Vertical Down Bends	AWWA M9 Eq 9-14
Dead End	TRDP Version 1.1 w/ Bend Angle = 0° or AWWA M9 Eq 9-11B
Minimum steel cylinder thickness and mortar coating thickness	AWWA C301

(2) Ductile Iron Pipe: AWWA M41 or DIPRA Thrust Restraint for Ductile Iron Pipe (latest edition).
(3) Steel Pipe: AWWA M11 (latest edition).
(4) Fiberglass Reinforced Pipe: AWWA M45 (latest edition).

I. Plant Connections and Expansions

1. Direct-bury of couplings or other similar type connections shall be avoided when possible.

2. Water plant connections and expansions shall adhere to the requirements of the City's Groundwater Plant Design Guidelines, latest edition.

J. LDWL Crossings: Comply with Section 7.03 F of this Chapter, with the following additional requirements for LDWL (Note: For the portion of the alignment that is located within Rights-of Way or easements with differing design requirements than are contained herein, the differences shall be identified to the Project Manager, and the more stringent requirements shall govern.):

1. Restrained joints shall be utilized for the entire length for all water lines at crossings, except for dedicated joints for expansion/contraction. Proposed water line shall be perpendicular to the crossing, where practical.

2. Water line markers are required at each end of buried crossings, near ROW lines.

3. Design shall comply with requirements of the ROW/easement owner, and shall be incorporated into Contract Documents as necessary. Written approval or acceptance of water line crossing design from owning agencies or companies is required to be provided to the Project Manager prior to the final design submittal.

4. TxDOT and County Road Crossings

a. Steel tunnel liner is required for proposed LDWL.

b. Refer to Title 43 of the Texas Administrative Code, Part 1, Chapter 21, Subchapter C, entitled "Utility Accommodation".

5. Railroad Crossings

a. Refer to the Manual for Railway Engineering, latest edition, prepared by the American Railway Engineering and Maintenance-of-Way Association (AREMA) for the design of railroad crossings.

6. Oil and Gas Pipeline Crossings

   a. Engineer shall coordinate with private utilities to determine the location of their facilities. Where necessary, the utility shall be probed in order to verify accuracy.

7. Harris County Flood Control District (HCFCD)

   a. Design shall identify Ultimate Channel width and depth, and accommodate for future channel improvements.

   b. Actual channel bottom elevation and geotechnical condition should be used to evaluate minimum depth of cover required for tunnels.

   c. Engineer shall determine jurisdiction and if approval is required from USACE and/or Coast Guard, and perform work as required to obtain approvals.

1.02 INSTALLATION METHODS

A. Open Cut Installation

1. Limits of special shoring shall be identified on Drawings where the use of a typical trench box is not sufficient.

2. Where utilities extend across LDWL trench, plans shall indicate if utility is to be braced or removed and replaced.

3. Design shall account for groundwater dewatering, where necessary.

B. Trenchless Installation

1. Limits of proposed trenchless crossing shall be identified on plan and profile sheets of the Drawings with beginning and end station. Design must denote if a specific trenchless method is required, and appropriate details and specifications shall be provided.

2. Tunnel liner sizing shall be based on the largest part of the pipe, such as the bell or external restraining mechanism.

3. Provide minimum liner plate / casing diameter and thickness for all carrier pipe materials.

4. Design shall evaluate ability to dewater, potential for settlement in the zone of influence, and risk to adjacent structures and pavement.

a. In areas where specific settlement criteria are necessary, a settlement monitoring plan is required and shall and include types of devices, frequency and layout where recommended in geotechnical report.

5. Crossings with tunnel liner plates:

a. For railroad crossings, liner plate design shall be consistent with Chapter 1, Part 4 of the AREMA Manual for Railway Engineering.

b. For all other crossings using tunnel liner plates, the liner plate design shall be consistent with AASHTO LRFD Bridge Design Specifications, Section 12.

c. A minimum factor of safety of 3.0 for buckling and 2.0 for seam strength, with a maximum deflection of 2%, shall be used for liner plate calculations. Larger factors of safety may be required as determined by Design Engineer.

d. Liner plate shall be specified by material type and shall provide nominal diameter and wall thickness for 2-flange and/or 4-flange.

e. Annulus between the soil and the liner plates must be grouted.

6. Crossings with smooth-wall, welded steel pipe casing:

a. For roadway crossings, live loads shall include minimum HS-20 loading conditions as defined by AASHTO.

b. Live loads at railroad crossings shall include minimum Cooper E-80 loading conditions as defined by AREMA.

c. A minimum factor of safety of 2.0 shall be used in the casing calculations. Larger factors of safety may be required as determined by the Design Engineer.

d. Casing pipe shall be specified by material type, inside diameter and wall thickness and meet the requirements of the City's Standard Specifications and AWWA standards.

e. Grouting of the annular space between the liner and carrier pipe is required for all water lines 36-inches in diameter and larger. Grouting of the annular space between the liner and carrier pipe is not required for all water lines that are 30-inches in diameter and less, so long as the liner is designed to carry all loads and the pipe and casing are covered by the cathodic protection design.

C. Above Grade Installation

1. Stand-alone bridge structures must be designed by a Structural Engineer registered in the State of Texas.

2. When the above-grade crossing structure is adjacent to an existing roadway bridge, the bridge columns shall be designed so that they are the same size and shape, and line up with the existing roadway bridge. The low and high chords of the water line bridge should fall within the limits of the roadway bridge high and low chords.

3. For bayou or channel crossings, the lowest structural member must not be less than 18-inches above the base flood elevation. If this requirement cannot be met, obtain a permit from City of Houston Floodplain Administrator per City of Houston Code of Ordinances, Section 19-43 (c)(1).

4. Pipe material for aerial crossing must be steel pipe with butt-welded joints. Thickness of steel wall to be designed based on span length.

2.01 ADDITIONAL SERVICES

A. For Geotechnical and Environmental requirements, refer to Chapter 11 of the City of Houston Infrastructure Design Manual, with the following additions.

1. Borings must be drilled on the centerline along the proposed alignment, except in areas where the LDWL will be installed by trenchless installations. In trenchless installation areas, soil borings shall be offset from the proposed water line alignment.

2. All excess core samples are to be maintained by the Geotechnical Consultant until corrosion monitoring and/or corrosion control recommendations are made. Geotechnical Consultant shall be instructed to provide excess core borings to the Corrosion Engineer when requested. The Corrosion Engineer may require samples at the proposed water line elevation and at the bottom of the boring. Geotechnical Consultant shall confirm the depth and number of samples required with the Corrosion Engineer.

B. Subsurface Utility Engineering (SUE)

1. General Criteria

a. SUE may be warranted where existing conditions are likely to significantly impact design and constructability of the proposed alignment.

2. SUE Results

a. SUE results for each location are required to be submit to the design Engineer and shall be signed and sealed by the SUE Professional Engineer, registered in the State of Texas.

b. SUE results shall provide sufficient information to ascertain the horizontal and vertical location of the existing utilities but should contain no less than the following items:

(1) Project name, location, date of field work;

(2) Owner of the utility;

(3) Type, size and material of the utility;

(4) Elevation of the top and at least one side of the utility;

(5) Elevation of existing grade over the utility at the test hole;

(6) Northing/Easting coordinates of the utility;

(7) General plan view of the utility with SUE location shown;

(8) Photographs of the site and the exposed utility; and

(9) General soil type and thickness of pavement within the test hole limits.

END OF APPENDIX A