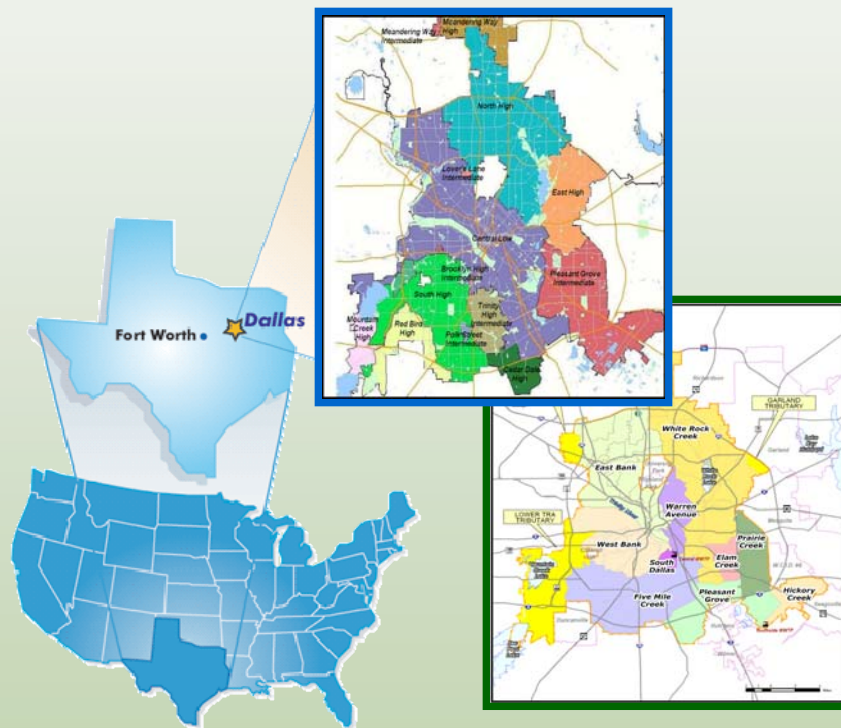




dallas water utilities
city of dallas

WATER AND WASTEWATER PROCEDURES AND DESIGN MANUAL



OCTOBER, 2011

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PREFACE

P.1 ACKNOWLEDGMENTS:

This manual replaces the previous edition of Water and Wastewater Pipeline Design Manual by Dallas Water Utilities (DWU) dated February, 2010. The chronological list of events in developing the DWU manual is summarized as follows:

1970-1989	Letters from management to design engineers
1989	Compilation of letters into first edition of the manual
May, 1998	Revision of 1989 manual to include state regulations
February, 2010	Revision of 1998 manual to include additional sections on pavement cuts, environmental approaches, trenchless technologies, and updated state regulations
October, 2011	Revision of 2010 manual to include additional sections on subsurface utility investigations, evaluating potential for contaminants, design flow estimation criteria, and reclaimed water design guidelines.

The latest edition of Water/ Wastewater Pipeline Procedures and Design Manual is written by Engineering Services, Dallas Water Utilities. This manual is available on the internet at: http://www.dallascityhall.org/dwu/dwu_design_standards.html

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Any questions or suggestions regarding to this manual should be forwarded to Engineering Services, Dallas Water Utilities.

P.2 INTRODUCTION

Dallas Water Utilities (DWU) provides water, wastewater and reclaimed water services to customers within the City of Dallas and other adjacent communities. DWU maintains or exceeds current standards as set by the Texas Commission on Environmental Quality (TCEQ) for water, wastewater and reclaimed water main design, construction, operation and maintenances (O&M). This manual is to be used by engineering professionals for use in design and construction of water, wastewater and reclaimed water mains owned and operated by DWU.

This manual applies to all distributed assets designed for City and Joint contracts where the asset(s) will be dedicated back to DWU for O&M. Additionally, pursuant to Dallas City Code Chapter 49-61(C)(5)(a), distributed assets constructed by a private party but intended for dedication back to DWU must follow the provisions of this manual.

This technical resource is not intended to substitute for any professional engineering judgment by designer who will assume ultimate responsibility for selection, reference and appropriate application of this manual.

This manual is divided into five major chapters:

CHAPTER 1: GENERAL DESIGN CRITERIA

This chapter presents general requirements at different phases of a water or wastewater main project including origination, coordination, record search, condition check, easements acquisition, investigation, surveying, plan development, traffic control, and final plan submittal.

CHAPTER 2: WATER MAIN DESIGN GUIDELINES

This chapter includes various aspects of water main design including replacement criteria, sizing, depth, embedment, location and appurtenances.

CHAPTER 3: WASTEWATER MAIN DESIGN GUIDELINES

This chapter includes various features of wastewater main design including replacement criteria, sizing, depth, embedment, location and appurtenances.

CHAPTER 4: RECLAIMED WATER MAIN DESIGN GUIDELINES

This chapter includes different aspects of reclaimed water main design including sizing, depth, embedment, location and appurtenances.

CHAPTER 5: SPECIAL DESIGN CRITERIA

This chapter represents special design criteria common to water and wastewater main including pavement cuts, highway access, railroad access, creek crossing, elevated crossing, pipe encasement, thrust restraint and trenchless technologies.

P.3 ABBREVIATIONS

AC	Asbestos Cement	NA	Not Applicable
ANSI	American National Standards Institute	NCTCOG	North Central Texas Council of Governments
AREMA	American Railway Engineering & Maintenance Association	NASSCO	National Association of Sewer Service Company
ASTM	American Society for Testing Materials	PACP	Pipeline Assessment and Certification Program
AWWA	American Water Works Association	PCCP	Pre-Stressed Concrete Cylinder Pipe
BC	Back of Curb	PL	Property Line
BM	Bench Mark	PSI	Pounds Per Square Inch
BOTOC	By Other Than Open Cut	PW	Public Works
COD	City of Dallas	PRV	Pressure Reducing Valve
CO	Clean out	PC	Point of Curvature
DART	Dallas Area Rapid Transit	PI	Point of Intersection
DI	Ductile Iron	PI	Plasticity Index
DR	Dimension Ratio	PL	Plastic Limit
DWU	Dallas Water Utilities	PT	Point of Tangent
ECI	Enamel Lined Cast Iron	PVI	Point of Vertical Intersection
EL	Elevation	PVC	Polyvinyl Chloride
EMB	Embedment	QL	Quality Level
ESA	Environmental Site Assessment	RCP	Reinforced Concrete Pipe
ETJ	Extra Territorial Jurisdiction	RCCP	Reinforced Concrete Cylinder Pipe
EX	Existing	RPMP	Reinforced Polymer Mortar Pipe
FH	Fire Hydrant	RTRP	Reinforced Thermosetting Resin Pipe
FT	Feet	STA	Station
FL	Flow Line	SSO	Sanitary Sewer Overflow
LF	Linear Feet	SD	Storm Drain
GIS	Geographical Information System	SDR	Standard Dimension Ratio
GPS	Global Positioning System	SUE	Subsurface Utility Engineering
GPCD	Gallon Per Capita Per Day	TAC	Texas Administrative Code
GPD	Gallon Per Day	TBM	Temporary Bench Mark
GPM	Gallon Per Minute	TCEQ	Texas Commission on Environmental Quality
HDPE	High Density Polyethylene	TMUTCD	Texas Manual on Uniform Traffic Control Devices
HOE	Home Owner's Extension	TXDOT	Texas Department of Transportation
HP	Horse Power	UG	Underground
I/I	Inflow/Infiltration	VCP	Vitrified Clay Pipe
ISO	Insurance Service Office	VCT	Vitrified Clay Tile
LL	Liquid Limit	W	Water
MGD	Million Gallons Per Day	WW	Wastewater
MG/L	Milligrams Per Liter	WWAD	Wastewater Access Device
MH	Manhole	WTP	Water Treatment Plant
MSL	Mean Sea Level	WWTP	Wastewater Treatment Plant

P.4 ENGINEERING CONVERSIONS

Length

1 inch	= 2.54 cm
1 ft	= 0.3048 m
1 mi	= 5,280 ft
1 mi	= 1.6093 km
1 km	= 0.6214 mi
1 chain	= 66 ft
1 mm	= 1000 microns

Area

1 acre	= 43,560 ft ²
1 acre	= 4046.9 m ²
1 acre	= 0.40469 hectare
1 mi ²	= 640 acres

Volume

1 ft ³	= 7.486 gal
1 acre-ft	= 325,851 gal
1 acre-ft	= 43,560 ft ³
1 gal	= 3.7854 L
1 gal	= 1,000,000 MG
1 MG	= 3,0689 acre-ft
1 m ²	= 264.17 gal

Power

1 hp	= 550 ft-lb/s
1 hp	= 0.746 kw
1 hp	= 6535 kwh/year
1 kw	= 1.341 hp

Discharge

1 cfs	= 449 gal/min
1 cfs	= 646,000 gal/day
1 gal/s	= 15.85 L/s
1 mgd	= 3.07 acre-ft/day
1 mgd	= 1120 acre-ft/year

Angle

180 degree	= π radian
90 degree	= 100 grad

Weight

1 lb	= 0.4536 kg
1 ton	= 2000 lb
1 oz	= 28.353 g
1 kg	= 2.2046 lb
1 slug	= 14.5939 kg
1 ft of water	= 62.4 lb
1 gal of water	= 8.34 lb

Time

1 day	= 1,440 min
1 day	= 86,400 sec

Pressure

1 psi	= 2.31 ft of water
1 psi of water	= 51.7 mm of mercury
1 atm	= 29.9 inch of mercury
1 atm	= 14.7 psi
1 bar	= 100 kilopascal
1 inch of mercury	= 1.13 ft of water
1 ft of water	= 0.443 psi

Velocity

1 ft/s	= 0.68180 mi/hr
1 ft/s	= 0.6818 mi/hr
1 cm/s	= 1.9686 ft/min

Temperature

T _F	= 9/5 T _C + 32
T _C	= 5/9 (T _F - 32)

Mics.

1 ppb	= 1000 ppm
1 N	= 100,000 dyne

CHAPTER 1

GENERAL DESIGN CRITERIA

1.1 REFERENCES

The following references are directly associated with this manual:

- Standard Drawings for Water & Wastewater Construction by DWU, Latest Edition
- Drafting Standards for Pipeline Projects by DWU, Latest Edition
- Bid Item and Cost Estimating Manual by DWU, Latest Edition
- Public Works Construction Standards for North Central Texas by North Central Texas Council of Governments (NCTCOG), Edition as adopted by DWU
- City of Dallas Addendum to the NCTCOG Standards, Latest Edition
- Standard Technical Specifications for Water & Wastewater Construction, Latest Edition

The following references shall also be reviewed in conjunction with this manual:

- 30 TAC §290: Public Drinking Water as enforced by Texas Commission on Environmental Quality (TCEQ), Latest Edition
- 30 TAC §217: Design Criteria for Domestic Wastewater System by as enforced by TCEQ, Latest Edition
- Dallas City Code: Chapter 49 (Water and Wastewater), Latest Edition
- Development Design, Procedure and Policy Manual, City of Dallas, Latest Edition
- Pavement Cut and Repair Standard Manual, City of Dallas, Latest Edition
- Traffic Barricade Manual, City of Dallas, Latest Edition
- Paving Design Manual, City of Dallas, Latest Edition
- DWU Standard Protocol for Soil and Groundwater Management on Construction Sites, Latest Edition

1.2 GENERAL DESIGN APPROACH

Flow chart of a typical pipeline design project is shown below:

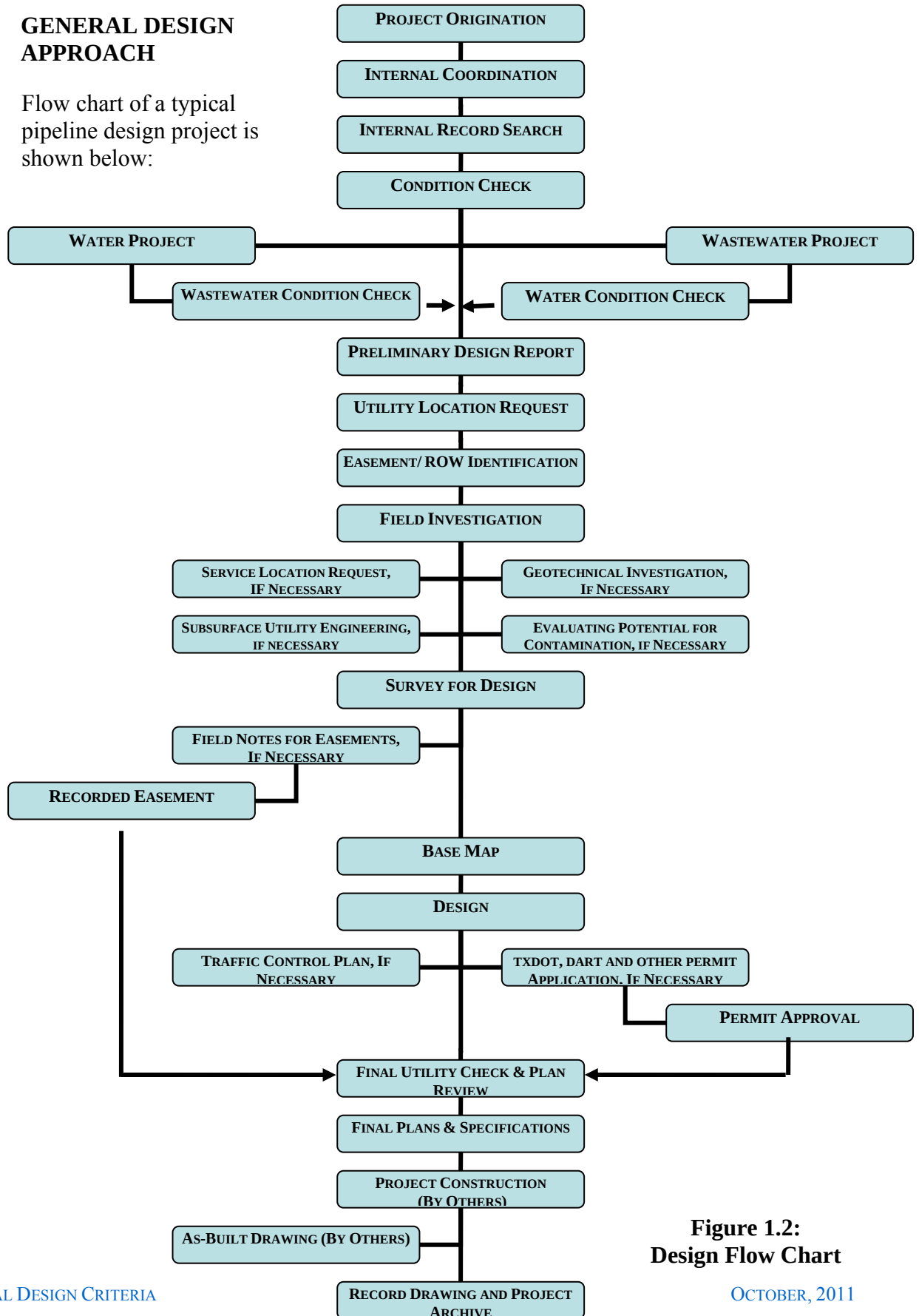


Figure 1.2:
Design Flow Chart

1.3 PROJECT ORIGINATION

DWU water and wastewater main projects generally originate due to following reasons:

- New development
- Main deterioration
- Capacity improvement
- Water quality improvement
- Regulatory compliance
- Relocation of existing mains to accommodate storm drains or paving improvements
- Water/wastewater master plans

1.4 INTERNAL COORDINATION

Internal coordination shall be conducted with all affected divisions/sections, including, but limited to, Relocations, Sustainable Development & Construction (Development Services) and Public Works (PW), prior to initiation of any work in order to accomplish the following:

- Inform other divisions of the planned activity
- Insure that proposed work is not being duplicated
- Coordinate adjacent projects

1.5 INTERNAL RECORD SEARCH

The designer shall research all pertinent DWU records including, but not limited to, the following:

1.5.1 Design Records

1.5.1.1 Water Design Plan (685 W):

These are primarily water main construction plans and do not necessarily represent as-built information.

1.5.1.2 Wastewater Design Plans (411Q):

These are primarily wastewater main construction plans and do not necessarily represent as-built information.

1.5.1.3 Water Roll Maps:

The Roll Maps show the old water lines going through open fields or rural areas in the early 1900's. Today, many of these lines are still in service and most of the previously undeveloped areas are now developed. These roll maps come in odd sizes, some in 18 inches by 15 feet, others in 12 inches by 15 feet or longer. Each water line had a number as in water line numbers 1, 2, 3, 4, etc. This numbering system was changed to 103W, 105W, and then later changed to our present prefix file number 685W. The Roll Maps are archived references that have not been updated for many years.

1.5.1.4 Wastewater Key Maps:

Maps showing existing wastewater mains cross referenced with construction plan numbers (411Q or 685W). They also show contour lines at ten foot intervals. These maps may be used to determine the location of existing wastewater mains. Full size maps are 24" X 36", scale 1"=400'. These Wastewater Key Maps are archived references that have not been updated for many years.

1.5.2 As-Built Records

As-Built Records are records that show the actual construction alignment of existing mains. These records sometimes vary from the original design due to unforeseen construction problems.

1.5.2.1 Water Permanent Maps (XX-XX-W):

These are maps, also known as water block maps, showing existing water mains with as-built horizontal ties and may be used to determine the approximate locations of existing water mains. These maps also provide a reference Water Field Books. Full size maps are 24" X 36", scale 1": 100'.

1.5.2.2 Wastewater Permanent Maps (XX-XX-S):

These are maps showing existing wastewater mains with as-built horizontal and vertical information, such as size, direction of flow, percent of grade and flow lines at manholes. This map series covers roughly half of the city and they are cross referenced with construction plan numbers (411Q or 685W). Full size maps are 24" X 36", scale 1": 100'.

1.5.2.3 Bud Holcomb Maps (BH Maps):

These maps show existing and abandoned wastewater mains that are cross referenced with construction plan numbers (411Q or 685W). Full size maps are 24" X 36", scale 1": 400'. This is an archived reference that has not been kept up to date for many years. It is no longer being updated.

1.5.2.4 Old Sewer Maps (S- Maps):

These maps show existing and abandoned wastewater mains that are cross referenced with construction plan numbers (411, 411Q or 685W) or Ledger Books (Ledger Book number, page number). These maps were used during the same time period as the ledger books and were replaced by Bud Holcomb Maps.

1.5.2.5 As-Built Water Field Books (FBK):

These are the individual field books that are referenced on the permanent water maps. The hand sketches in the field books were the original source material for production of the permanent water maps; however, they go into more detail and sometimes provide design file numbers. Field books for new contracts have not been produced since the mid-1990s.

1.5.2.6 Water Construction Field Books (FBK):

Construction Field Books contain profile information by which existing 12" and larger water mains originally were constructed. This information would supersede the design profiles. Water Construction Books have not been maintained since the mid 1990s.

1.5.2.7 Ledger Books (LBK):

Ledger Books were the old wastewater construction books from 1889 until they were replaced by the Wastewater Construction Books. They provide the same information as the Wastewater Construction Books except that one must add 321.40 to the elevations in the Ledger Books to correlate with our present U.S. Geological Survey Sea-Level Datum.

1.5.2.8 Wastewater Construction Books (CBK):

These construction books contain profile information by which the wastewater main was originally staked for construction. This information consists of survey stationing, size of pipe, percent of grade, rod reading, ground elevation, flow line, elevation, depth of cut required and any pertinent remarks. The 411Q number, the file number and the corresponding sheet number(s) of the construction plans are sometimes given. This information should be used to supersede the design plan profile.

1.5.2.9 Red-up Drawings:

Red-up Drawings are hand-annotated design plans based on field crew inspections, which occurred at or shortly after wastewater construction projects. These drawings were quite detailed, often confirming materials used, locations of service lines, and design changes, such as changes in stationing. DWU stopped producing Red-up Drawings in the mid 1990s.

1.5.2.10 Tie Copies:

Tie Copies are manually annotated design plans produced by the DWU tie crews. The Tie crews visit locations of water and wastewater construction, sometimes several years after the construction is completed in an effort to document the locations of surface features and determine document variances from design. Specific variances from design are often speculation, in the absence of construction inspection mark-ups, but are indicated as call-out sketches on the design plans. Concurrent to the production of these marked-up plans, GPS information is collected for all surface features along with estimated locations for buried features, such as tees, bends, etc.

1.5.2.11 Construction Inspection Mark-Ups:

These are construction plans as marked-ups by city inspectors to show actual construction records.

1.5.3 Other Resources

1.5.3.1 Storm Sewer Locator Maps (421Q):

These maps typically show storm sewer locations with pipe sizes and corresponding construction plan numbers. These are generally filed as 421Q at PW&T Vault.

1.5.3.2 Paving Plans (311D):

These typically show paving plans for improved street surfaces. These are generally filed as 311D in the PW&T Vault.

1.5.3.3 Water/Wastewater Master Plans:

Latest water and wastewater master plans must be reviewed to be in compliance with any recommendations.

1.5.3.4 DWU Geographical Information System (GIS):

DWU GIS integrates various geographically referenced utility infrastructure records of the City of Dallas. Currently, most of the water/wastewater main design and older as-built records can be accessed directly through DWU GIS. The water distribution and wastewater collection features were originally derived through an in-house data conversion project using the various outdated legacy paper mapping as source materials. Additional attribution was subsequently provided via the water and wastewater master plans. New and backlogged water and wastewater features are added based on the best available inputs at the time of digitizing, including design plans, GPS points, tie copies, and construction inspection mark-ups.

GIS files are available to outside parties through DWU project manager upon approval by Utility Automation and Integration (UAI) Division.

1.6 CONDITION CHECK AND PRELIMINARY DESIGN REPORT

All existing water and wastewater mains adjacent to the proposed main shall be identified from the DWU records during preliminary investigation. A condition check along with a recommendation can be requested from DWU Water and Wastewater Operation Divisions under the following criteria:

1.6.1 Wastewater Main Condition Check

If there is an existing wastewater main in the same street or vicinity as the proposed water main, a request shall be made to the Wastewater Collection (WWC) Division for a condition check of the existing wastewater main. The following information may be obtained from WWC upon request:

- TV camera inspection record along with Pipeline Assessment Certification Program (PACP) score as per National Association of Sewer Service Company (NASSCO), if available
- Permanent/temporary flow monitoring data, if available
- Recommendation regarding wastewater main and other appurtenance replacement in conjunction with proposed water main replacement.

1.6.2 Water Main Condition Check

If there is an existing water main in the same street or vicinity as the proposed wastewater main, a request must be made to the Distribution Division for a condition check of the existing water main. The following information may also be obtained from Distribution upon request:

- The location, type and size of any large water services and other appurtenances.
- The pressure and flow of any fire hydrant.
- History of water main break(s) and subsequent repair(s)
- Information on leak detection.
- Recommendation regarding water main and other appurtenance replacement in conjunction with proposed wastewater main replacement.

1.6.3 Variance:

If a condition check report is not available from DWU Operation Divisions, the designer shall be responsible for providing any recommendation for the replacement of the adjacent water and wastewater mains based on age, historical professional judgment, and other criteria as mentioned in §2.3 or §3.3.

1.6.4 Preliminary Design Report

An engineering design report detailing the proposed project along with engineering recommendation is to be prepared, as necessary. This report shall include, but not limited to, the following information:

- Project Scope: General project description along with location and limit
- Supporting Data: Summary of record search and preliminary field investigation along with necessary exhibits
- Evaluation of Alternatives: Evaluation of various alignment options along with estimated construction costs, if necessary
- Recommendations: Proposed alignment, pipe size, pipe material, method of construction (open-cut or trenchless) and other pertinent information

A copy of the Preliminary Design Report shall be submitted to DWU Distribution and Wastewater Collection Divisions for review and approval, as necessary.

1.7 UTILITY LOCATION REQUEST

The designer must conduct a comprehensive investigation of all nearby existing and proposed utilities in order to avoid possible conflicts. This shall include, but not limited to, the following utilities:

- Gas (G)
- Telephone (T)
- Underground Electric (UE) and Overhead Electric (OE)
- Cable (C)
- Fiber Optic (FO)
- Storm Drain (SD)
- Petroleum (P)

1.8 EASEMENT ACQUISITION

1.8.1 General Requirements

If it is determined that infrastructure improvements will be performed outside of existing right-of-way or existing easements, then it will be necessary to obtain a new easement. It shall be specified whether it will be for water or wastewater in the easement request. This process can take anywhere from six (6) months to several years to complete and must be started as soon as an approved pipeline alignment has been decided upon.

1.8.1.1 Pipeline Installation within the City of Dallas:

If the easement is obtained within the City of Dallas limits for the installation of a water and/or wastewater main only, the easement documents are not required to be in fee title and shall state the purposes for which they are acquired and do not include other purposes.

1.8.1.2 Pipeline Installation outside the City of Dallas:

Outside the City of Dallas limits, DWU does not have final review authority on plats. Fee title acquisition shall be considered for these cases.

1.8.1.3 Right-of-Entry:

A right-of-entry agreement can not be used in lieu of a permanent easement to place a permanent structure or facilities on private property. Good use of right-of-entry agreements are for surveying, staging, clearing/grubbing, storage, temporary construction activities and can be obtained through a request to Property Management. This document is typically signed by the property owner and has limited or no authority after the described process is completed.

1.8.2 DWU Policies

1.8.2.1 General:

Buildings, fences, trees, shrubs, or other permanent vertical improvements or growths are not allowed over DWU mains or in easements.

1.8.2.2 Standard Plat Provisions:

DWU standard plat provisions can be described as follows:

“No buildings, fences, trees, shrubs or other improvements or growths shall be constructed, reconstructed or placed upon, over or across the easements shown. Said easements being hereby reserved for the mutual use and accommodation of all public utilities using or desiring to use the same. All and any public utility shall have the right to remove and keep removed all or parts of any building, fences, trees or other

improvements or growths which in any way may endanger or interfere with the construction, maintenance or efficiency of its respective system on the easements and all public utilities shall at all times have the full right of ingress or egress to or from and upon the said easements for the purpose of constructing, reconstructing, inspecting, patrolling, maintaining and adding to or removing all or parts of its respective systems without the necessity at any time of procuring the permission of anyone.”

1.8.3 Minimum Easement Widths:

The minimum easement width required to install and maintain DWU water and wastewater mains are summarized in **Table 1.8.3**:

Table 1.8.3: Minimum Easement Width

Size of Main (inch)	Depth of Pipe* (ft)	Minimum Width** (ft)
8” through 12”	≤ 8	20
	> 8	25
16” through 24”	≤ 8	25
	> 8	35
30” through 66”	≤ 8	40
	> 8	50
72” and Larger	≤ 8	60
	> 8	70

Note: *Depth of pipe shall be measured from the top of pipe to the ground surface

** Pipes shall be centered in the easement

1.8.4 Minimum Vertical Clearance:

The minimum vertical clearance above any easement is 25 feet. This allows the typical backhoe to maneuver in the case where a repair is necessary and minimizes the risk to both DWU and the party who is granting the easement.

1.8.5 Easement Acquisition:

The easement acquisition process is summarized in **Figure 1.8.6** for projects designed by DWU in-house staff or consultants for joint and the City of Dallas projects. However, most easements for development projects are typically granted by plat and do not require an individual instrument. The developer's consultant prepares the legal description/field for easements outside the platted area and the procedure follows in this section. If any costs are associated with obtaining the easement, they will be paid by the developer.

1.8.5.1 Easement Identification:

- Easement acquisition process must be initiated as soon as a need for an easement is recognized and an exact horizontal location is identified.
- Property history as recorded in the County Records shall be researched to determine if any existing easements are in place.

1.8.5.2 Preparation of Legal Description:

Designer shall request a surveyor to prepare a legal description (field notes) as per §1.10 for the required easement. This request shall include, but not be limited to, following the information:

- Type of Easement: Permanent or temporary/construction
- Purpose of Easement: Water and/or wastewater easement
- Project Schedule: Planned advertisement and construction date
- Location Map: A map showing location of easement with coordinates and dimensions.

The legal description shall be submitted to Public Works Survey Division, for review and approval, as necessary.

1.8.5.3 Negotiation with Property Owner:

Property Management Division negotiates the purchase of the easement with the affected property owner(s). Upon receipt of legal description from surveyor, project manager shall request Property Management to obtain the easement. This request to Property Management shall include, but not be limited to the following information:

- Type of Easement: Permanent or temporary/construction
- Purpose of Easement: Water and/or wastewater easement
- Project Schedule: Planned advertisement/construction date
- Location Map: A map showing location of easement with coordinates and dimensions.
- Legal description (field note) as prepared by surveyor.

If the easement appears to enhance the owner, the Property Management may request the easement be obtained by dedication (cost of \$1).

1.8.5.4 Property Appraisal and Subsequent Funding:

- If the easement can not be obtained by dedication, a "fair market value" shall be offered to the owner.
- If the property owner agrees to "fair market value", the required funding information shall be obtained from the DWU program manager that requested the project.
- If the owner does not agree to the offer, the easement may be acquired through the eminent domain procedure. Accordingly, subsequent funding information for the necessary legal proceedings shall be obtained from the program manager that requested the project. In addition, a "White Paper" containing the explanation of the need for the easement, shall be included in the council agenda package.
- Upon preparation of the City Council agenda item, the City Attorney's office is contacted to coordinate the legal procedures in order to obtain the easement. If the property owner does not agree with the amount offered by the judge for the county, a public hearing shall be arranged upon request. The hearing board will make a recommendation on the amount to be offered. In either case, the city will deposit the money awarded by the judge for the county. The city can then use the easement as if the easement was obtained and filed.

1.8.5.5 Recording of Easement:

Upon filing at the county court, a copy of the recorded easement shall be furnished to the City Secretary by Property Management.

All easements must be shown on the design plans with county files volume and page numbers as shown on the DWU Drafting Standards for Pipeline Project, Latest Edition.

1.8.6 Easement Acquisition Process Diagram:

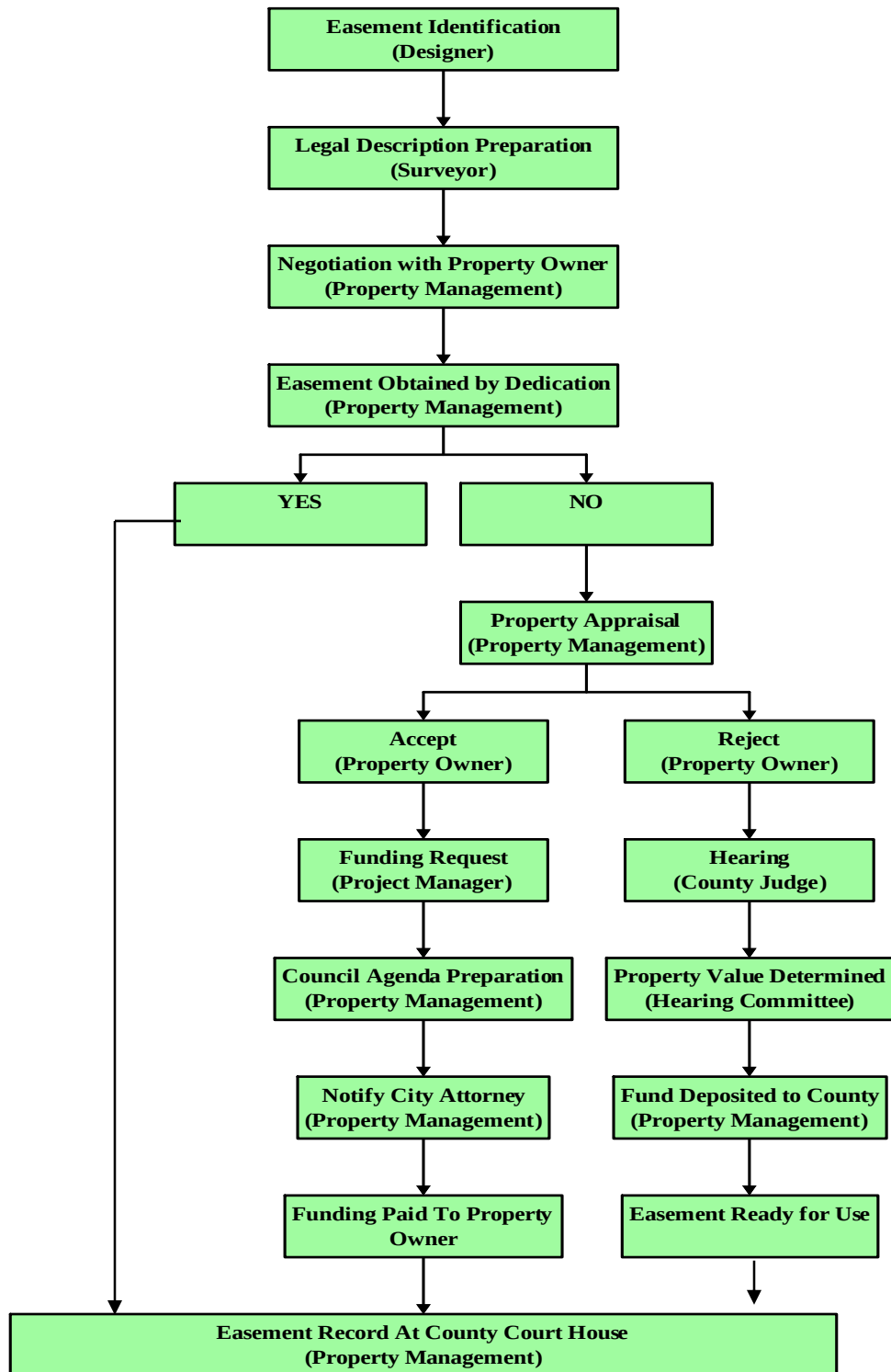


Figure 1.8.6: Easement Acquisition Process Diagram

1.9 FIELD INVESTIGATION

Field investigations including Geotechnical Investigation, Subsurface Utility Engineering (SUE) or Evaluating Potential for Contamination shall be conducted for water and wastewater main design as necessary or if requested by project manager.

1.9.1 Geotechnical Investigation

The design and construction of water and wastewater mains must account for the variability of the uncertain subsurface conditions, and the potential project cost associated with the variability. This is especially critical on large projects or projects containing complex or difficult geotechnical problems where alignment and/or grade changes may be appropriate based on geotechnical recommendations. The general criteria for geotechnical investigation, is described as follows:

1.9.1.1 Investigation Requirements:

- A geotechnical investigation may be conducted prior to design and/or construction of a project. However, data from earlier project design activity can be incorporated if sufficient and reliable for the current project.
- If required, the geotechnical report shall be prepared by a professional engineer with considerable geotechnical, design and construction experience relevant to the anticipated project.

1.9.1.2 Investigation Criteria:

1.9.1.2.1 Frequency:

- Soil borings shall be spaced no greater than 500 feet with additional borings at spaced closer to better define areas of inconsistent stratigraphy.
- Boring locations shall be within an offset distance of no more than 20 feet from the centerline alignment of the water/wastewater main or at location of proposed structure.

1.9.1.2.2 Depth:

Open Cut Construction: Minimum boring depths shall be:

- Trench depth plus five (5) feet for trenches up to ten (10) feet deep
- Trench depth plus ten (10) feet for trenches from ten (10) to twenty-five (25) feet deep
- One and half times trench depth for trench greater than twenty-five (25) feet deep. Bore and additional five (5) feet if the last planned sample is in water-bearing sand.

Trenchless Construction: Minimum boring depth shall be:

- Entry/exit pit depth plus five (5) feet
- Pipe invert plus five (5) feet

1.9.1.2.3 Report Format:

A typical geotechnical report shall include, but not limited to, following information:

Project Information:

- Project location
- Scope

Investigation Summary:

- Summary of all subsurface exploration data, including subsurface soil profile, exploration logs, laboratory or in situ test results, and ground water information

Data Analysis and Recommendations:

- Engineering analysis and recommendations for design
- Recommended geotechnical special provisions.

Attachments:

- Project map
- Field and laboratory test data
- Boring log
- Other pertinent data including, but not limited to, soil classification, plasticity index (PI), liquid limit (LL), plastic limit (PL), moisture density (MD), rock quality designation (RQD) and blow counts.

1.9.2 Subsurface Utility Engineering (SUE)

Subsurface Utility Engineering (SUE) process may be conducted in project planning, design or construction phase(s) to obtain reliable subsurface utility information. Using this technology, it will be possible to avoid many utilities relocation before construction and many unexpected encounters during construction, thereby eliminating many costly, time-consuming project delays. In addition, all existing utilities shall be located and marked prior to initiation of survey for design.

1.9.2.1 SUE Provider Requirements:

SUE shall be conducted by well-trained, experienced and capable individuals using state-of-the-art designating equipment, vacuum excavation or comparable non-destructive locating equipment; state-of-the-art surveying and other data recording equipment and software systems, as necessary.

1.9.2.2 Quality Level Attributes:

Utility Quality Level (QL) attributes are described in “Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, CI/ASCE 38-02” by American Society of Civil Engineers (ASCE), Latest Edition. Accordingly, four Quality Levels (QL) of SUE can be conducted, as needed:

- Quality Level D:
 - Information derived from existing records or oral recollections.
 - This work shall be conducted by the designer during the preliminary project planning.
- Quality Level C:
 - Information obtained by surveying and plotting visible above-ground utility features and by using professional judgment in correlating this information to Quality Level D.
 - This work shall be conducted during the survey for design.
- Quality Level B:
 - Information obtained through the application of appropriate surface geophysical methods to determine the existence and approximate horizontal position of subsurface utilities.
 - This work shall be performed to obtain horizontal location of subsurface utilities in areas with congested utilities (i.e. central business district), areas where utility information is sparse or where a specific utility of high importance is being crossed (i.e. gas line).
 - Typical Quality Level B requirements are included in **Appendix A**.

- Quality Level A:

- Precise horizontal and vertical location of utilities obtained by the actual exposure and subsequent measurement of subsurface utilities, usually at a specific point.
- This work shall be performed to obtain precise horizontal and vertical locations of subsurface utilities in areas with congested utilities (i.e. central business district), areas where utility information is sparse or where a specific utility of high importance is being crossed (i.e. gas line).
- Typical Quality Level A requirements are included in **Appendix B**.

Various levels of SUE applications are summarized in **Figure 1.9.2.2:**

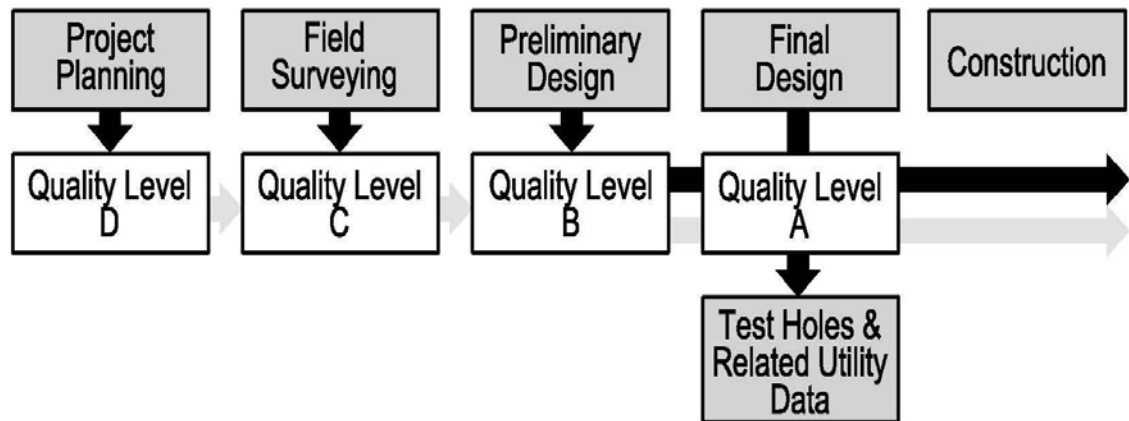


Figure 1.9.2.2: Different Levels of SUE Application

Reference (Modified): SUE Brochure, Federal Highway Association, 2007

1.9.3 Evaluating Potential for Contamination

The designer shall evaluate all available resources to identify any potential environmental issues, including possible soil or groundwater contamination, during the planning phase of water or wastewater main construction project. The designer shall follow the guidelines as specified in the “DWU Standard Protocol for Soil and Groundwater Management Plan on Construction Sites, Latest Edition” as applicable.

1.9.3.1 Step 1- Phase I Environmental Site Assessment (ESA):

The objective of conducting a Phase I ESA is to identify Recognized Environmental Condition (REC). If the project involves a property acquisition, a Phase I ESA from a qualified and experienced environmental consultant shall be requested. If the project does not involve an acquisition and no phase I ESA is available, it is recommended to skip Step 1 and proceed to Step 2 (DWU Pipeline GIS) and Step 3 (File Review/Site Screening) as necessary.

- General Requirements:
 - Phase I ESA should comply with the ASTM E1527: “Standard Practice for Environmental Site Assessment- Phase I Environmental Site Assessment Process”, Latest Edition
 - Phase I ESA is generally only good for a period of six (6) months from the date of the site inspection and record search
 - Updates of Phase I ESA are generally not acceptable. However, previous ESA can be used as information sources or supplements.
- Major Components:

A Phase I ESA should include, but not be limited to, the following items:

 - A review of historical land use of subject property
 - A review of historical aerial photos
 - Interviews with individuals with direct personal knowledge of the subject property and surrounding areas
 - A preliminary site reconnaissance of the subject property

If no RECs or suspected historical RECs are identified on the Phase I ESA, or easement acquisition or construction planning should proceed with minimal environmental complications. If a REC or suspected REC is identified in the Phase I ESA, then one of the following approaches can be implemented:

- Prepare a Soil and Groundwater Management Plan (SGMP) that provides contingencies for each REC and/or historical REC and the specific associated Chemical of Concern (COC).
- Conduct a Phase II ESA to reduce the uncertainty and refine the project planning process by specifically investigating each REC and/or historical REC identified in the Phase I ESA.

1.9.3.2 Step 2- DWU Pipeline GIS Data Search:

The DWU Pipeline GIS mapping system is intended to assist in the identification of potential contaminated sites located in the Dallas area if a Phase I ESA is not required or readily available. Prior to beginning a project, designer shall review DWU Pipeline GIS for possible environmental points of interest located on or near a project site. If the project site is located in close proximity to one of the environmental points of interest as shown in **Table 1.9.3.2** a regulatory File Review/Site Screening or Phase II ESA shall be requested from an from a qualified and experienced environmental consultant as necessary.

Table 1.9.3.2: Evaluating Project Proximity to Environmental Point of Interest

Facility Type	Order File Review /Site Screening or Phase II if Facility within Radius of:
Leaking Petroleum Storage Tank (LPST) ¹	1,000 feet
Petroleum Storage Tank (PST) ¹	500 feet
Voluntary Cleanup Program (VCP) ¹	1,000 feet
Municipal Setting Designation (MSD) ²	1,000 feet
Registered Dry Cleaner ¹	500 feet
Innocent Owner/Operator Program (IOP) ¹	500 feet
Monitoring Wells ³	200 feet
Landfills (Open or Closed) ^{4,5}	1,000 feet
Federal or State Superfund ^{6,1}	1,000 feet

¹TCEQ; ²City of Dallas OEQ; ³TWDB; ⁴City of Dallas Sanitation; ⁵NCTCOG; ⁶EPA

Source: DWU Standard Protocol for Soil and Groundwater Management on Construction Sites, Latest Edition

1.9.3.3 Step 3- File Review/ Site Screening:

If a Phase I ESA is not available and review of DWU Pipeline GIS does not provide sufficient information necessary to determine if contaminants may be located in the vicinity of the project, a File Review/Site Screening should be requested from an approved environmental consultant. However, if the DWU Pipeline GIS review proves to show obvious concern the designer may skip File Review/Site Screening and move straight to the Phase II ESA as necessary. Typically, a File Review/Site Screening shall include:

- A review of TCEQ and Federal regulatory databases
- A review of TCEQ files as applicable (e.g. VCP, LPST cases)
- A review of historical records (e.g. aerial photographs, city directories and Sanborn maps)
- A review of local records and permits
- A review of condition of project area and vicinity during limited site reconnaissance.
- A determination of whether potential environmental concern exists and whether a Phase II ESA is warranted to evaluate COCs at the site with respect to the project

1.9.3.4 Step 4- Phase II ESA:

If review of the Phase I ESA, DWU Pipeline GIS mapping system, and/or File Review/Site Screening indicates potential for contamination at the site, a Phase II ESA should be requested from a qualified and experienced environmental consultant to evaluate the concentration of COCs in the on-site soil and/or groundwater.

- General Requirements:

Phase II ESA should comply with the ASTM E1903: Standard Guide for Environmental Site Assessment- Phase II Environmental Site Assessment Process”, Latest Edition

- Major Components:

A Phase II ESA should include, but not be limited to, the following components:

- Delineation of the affected zones(s) within the project limit
- Development of the scope of work
- Assessment activities
- Evaluation and presentation of data from soil and/or groundwater samples
- Presentation of findings and conclusion along with recommendation of appropriate pipe material, gasket and trench type to be used for the project.

1.10 SURVEY

A thorough review of existing plans, information, and field investigations are required prior to requesting a survey for design or easement acquisition. The survey shall be conducted under the direct supervision of a Texas Registered Professional Land Surveyor (RPLS) in accordance with all the applicable standards, policies and criteria for the City of Dallas.

1.10.1 Horizontal Control Datum

- Horizontal control datum for City of Dallas shall be the North American Datum of 1983 (NAD83) as defined by National Geodetic Survey (NGS).
- The applicable State Plane Coordinate (SPC) zone for City of Dallas is Texas North Central Zone (Code 4202)

1.10.2 Vertical Control Datum

- Vertical control datum for City of Dallas shall be based on National Geodetic Vertical Datum of 1929 (NGVD29), as defined by National Geodetic Survey (NGS).
- Vertical control for DWU project shall be determined from the network of DWU established benchmarks (BM).

1.10.3 Topographic Survey

- Topographic survey shall be used to locate and document all information that is pertinent to the design and construction of water/wastewater main projects.
- The width of a typical topographic survey shall be as follows:
 - The typical survey along a non-street or alley area shall encompass 10 ft beyond the minimum required water or wastewater easement along the proposed alignment as specified in **Table 1.8.3**.
 - The typical survey along a street shall encompass 10 ft beyond the right-of-way.
- All submittals of survey data and drawings shall be in grid values using State Plane Coordinate (SPC) System and not to be adjusted to a local projection.
- Detail requirements of a typical topographical survey are included in **Appendix C**.

1.10.3 Boundary Survey

- Boundary survey shall be used to locate and prepare legal descriptions for fee title conveyances, right-of-way, easement, lease agreement, abandonment and licenses.
- Detail requirements of a typical boundary survey along with field notes are included in **Appendix D**.

1.11 DESIGN

Water and wastewater mains must be designed in accordance with all applicable DWU standards, policies and criteria. All drafting must be strictly in accordance with Drafting Standards for Pipeline Projects by Dallas Water Utilities, Latest Edition.

1.11.1 Base Mapping

Base map for design shall be prepared in according to the DWU drafting standards to show all the existing features as obtained from survey and further field investigation and/or record search as necessary.

1.11.2 Selection of Water and Wastewater Main Location

Water and wastewater mains shall be located within the following locations:

- Public right-of-way
- Permanent access easement with overlapping public utility easements
- Dedicated easement adjacent to and contiguous with the right-of-way
- Separate dedicated easements.

1.11.2.1 Utility Allocation Zone in Typical Street:

New water and wastewater main located in a typical street right-of-way shall be designed in accordance with the standard utility allocation zones as indicated in §4.03.1 of City of Dallas Paving Design Manual, 1998 or any revision thereafter (**Figures 1.11.2.1**). Accordingly, 12" and smaller mains are to be located six feet from the north or east side of the street right-of-way. 16" and larger mains are to be located in the major facility zone under the pavement towards the north or east side of the right-of-way. In addition, wastewater mains are to be located in the allocated zone in the center of the street. For additional details please see §2.7 and §3.7.

1.11.2.2 Utility Allocation Zone in Typical Alley

New water and wastewater main located in a typical alley shall be designed in accordance with the standard utility allocation zones as indicated in § 4.03.1 of City of Dallas Paving Design Manual, 1998 or any revision thereafter (**Figure 1.11.2.2**). Accordingly, wastewater mains are to be located in the allocated zone in the center of the alley and water mains can be located north or east side within the right-of-way. For additional details, please see §2.7 and §3.7.

1.11.2.3 Variance:

If utility allocation zones as indicated in above §1.11.2, are impractical, or if the construction is to be in the TXDOT right-of-way, a cost effective alignment shall be developed in coordination with all entities involved. In addition, where it is both physically feasible and to TCEQ/DWU design standards, the designer should

1



Source: City of Dallas Paving Design Manual, June, 1998



Source: City of Dallas Paving Design Manual, June, 1998

1.11.3 File Number Allocation

Design file number must be obtained from DWU Vault at 320 E. Jefferson Blvd, Room 215, Dallas, Texas 75203. Typically design file numbers are assigned as follows:

- Water only Project: 685W-XXX, Sh. XX
- Wastewater only Project: 411Q- XXX, Sh. XX
- Water/Wastewater Projects: 685W-XXX, Sh. XX or 411Q- XXX, Sh. XX as assigned.

1.12 FINAL UTILITY CHECK, PLAN REVIEW AND APPROVAL

A copy of pre-final plans shall be submitted to the following entities for final review, comments and/or approval, as necessary:

1.12.1 Internal Review

- Distribution Division
- Wastewater Collection
- Pipeline Project Management including Pipeline Inspection
- Other divisions or departments, as necessary

1.12.2 External Review

- All utility companies which may have potential impact
- All involved outside entities, as necessary

1.12.3 Regulatory Review

If applicable, all plan and specification shall be submitted to the following agencies for necessary approval:

- Texas Commission on Environmental Quality (TCEQ) as per 30 TAC §290, 30 TAC §217 and 30 TAC §210
- Other regulatory agencies under jurisdiction

1.13 TRAFFIC CONTROL PLAN

1.13.1 General Requirements

The designer should determine if a detailed traffic control plan is required for any project. A traffic control plan, sealed by a professional engineer, will be required in the following cases:

- Construction is in one or more lanes of a state highway or thoroughfare
- A detour is required
- Access to business property is by other than normal ingress and egress (entrance and exit)
- One or more lanes or more of an access or frontage road are closed
- Traffic through a major intersection is disrupted

1.13.2 Applicable Standards

All traffic control plans and operations shall be in accordance with following standards:

- Traffic Barricade Manual, City of Dallas, Latest Edition
- Texas Manual on Uniform Traffic Control Devices (TMUTCD), Texas Department of Transportation, Latest Edition

1.13.3 General Notes

If a traffic control plan is not required the following items shall be addressed:

- The diversion of pedestrians and vehicles during the progress of the work shall be in a manner satisfactory to City of Dallas
- All traffic variances shall be coordinated with the traffic safety coordinator of City of Dallas
- Two-way traffic shall be maintained at all times. Flagman should be used to maintain two-way traffic.
- All barricades, warning signs and traffic control devices shall conform to the City of Dallas standards.
- When closing side streets, a two working day notification shall be provided to Fire, Police, Street and Sanitation Departments.
- Access to private driveways shall be maintained at all times during construction



- Ingress and egress (entrance and exit) to a business property shall be maintained at all time. If not, specific signs along with business name and direction arrow(s) shall be used for any temporary access locations. Additional signs may be necessary if there is a detour.

1.13.4 Coordination and Approval

All traffic control plan shall be approved by traffic control division of City of Dallas Public Works or Texas Department of Transportation, as applicable.

1.14 FINAL PLANS AND SPECIFICATIONS

All plans and specifications must be prepared by the direct supervision of a Texas Professional Engineer (PE). Final project submittal by the designer should include, but not limited to, the following items:

1.14.1 Final Plans

Final plans must be done strictly in accordance with all applicable DWU standards and sealed by a Texas Professional Engineer (PE). All the plans should be plotted on 24" x 36" standard sheet of 4-mil, double matte mylar. Other sizes including 22" x 34" ANSI standard drawing sheets may be acceptable with prior approval. Following references shall be used in conjunction with final plans as applicable:

- Standard Drawings for Water & Wastewater Construction by DWU, Latest Edition
- Drafting Standards for Pipeline Projects by DWU, Latest Edition
- General Notes for Typical Water/Wastewater Main Capital Improvement Project (**Appendix E**)
- General Notes for Typical Water/Wastewater Main Joint Contract (**Appendix F**)

1.14.2 Technical Specifications

All the necessary technical specifications must be prepared by a Texas Professional Engineer. Following references shall be used in conjunction with Technical Specifications as applicable:

- Public Works Construction Standards for North Central Texas by North Central Texas Council of Governments (NCTCOG), Edition as adopted by DWU
- City of Dallas Addendum to the NCTCOG Standards, Latest Edition
- Standard Technical Specifications for Water & Wastewater Construction, Latest Edition
- Bid Item and Cost Estimating Manual by DWU, Latest Edition

1.14.3 Permits

All the required permit approval notice(s) must be included in the final submittal. These includes, but not limited to, the followings:

- TXDOT Right-of-Way Access Permit
- Executed temporary and permanent easement documents
- Approval letter from other entities or agencies under jurisdiction

When the project is completed and cross referenced, the original mylar must be forwarded to Utility Automation and Integration (UA&I) for archiving.

1.15 PROJECT CONSTRUCTION

All projects shall be constructed in conformance with approved sealed plans and specifications as possible. Any field change shall be documented in As-Built Drawings in accordance to the guideline as specified in DWU Drafting Standards for Water/Wastewater Pipeline Projects, Latest Edition:

- As-Built Drawings are to be prepared by the inspector by marking with red pen on copy of full-size plan
- As-Built disclaimer consisting of name(s) of contractor and inspector shall be posted
- As-Built Drawings shall be provided to the designer though the DWU Project Manager for preparing Record Drawings.

1.16 RECORD DRAWING AND PROJECT ARCHIVE

All as-built changes shall be incorporated in Record Drawings by the designer in accordance with the guidelines as specified in DWU Drafting Standards for Water/Wastewater Pipeline Projects, Latest Edition:

- Record Drawing shall be prepared by the designer by drafting on final design plan and to be printed on Mylar
- Record Drawing disclaimer consisting of name(s) of contractor, inspector and personnel preparing drawing to be posted
- Laying plan reference at pipe alignment on plan view if available
- Completed Record Drawing shall be submitted to the DWU Project Manager.

Upon expiration of construction warranty period, all pertinent project files shall be archived.

CHAPTER 2

WATER MAIN DESIGN GUIDELINES

2.1 REFERENCES

All water mains shall be designed in conformance with “30 TAC §290: Public Drinking Water” along with all applicable laws, regulations, codes and standards.

2.2 DWU WATER SYSTEM

2.2.1 Raw Water Sources

The City of Dallas holds water rights to several local area lakes as shown in **Figure 2.2.1**:

Western Reservoirs:

- Lake Ray Roberts
- Lake Lewisville
- Lake Grapevine

Eastern Reservoirs:

- Lake Ray Hubbard
- Lake Tawakoni
- Lake Fork
- Lake Palestine

Currently Lake Fork and Lake Palestine are not used or connected to the Dallas water system.

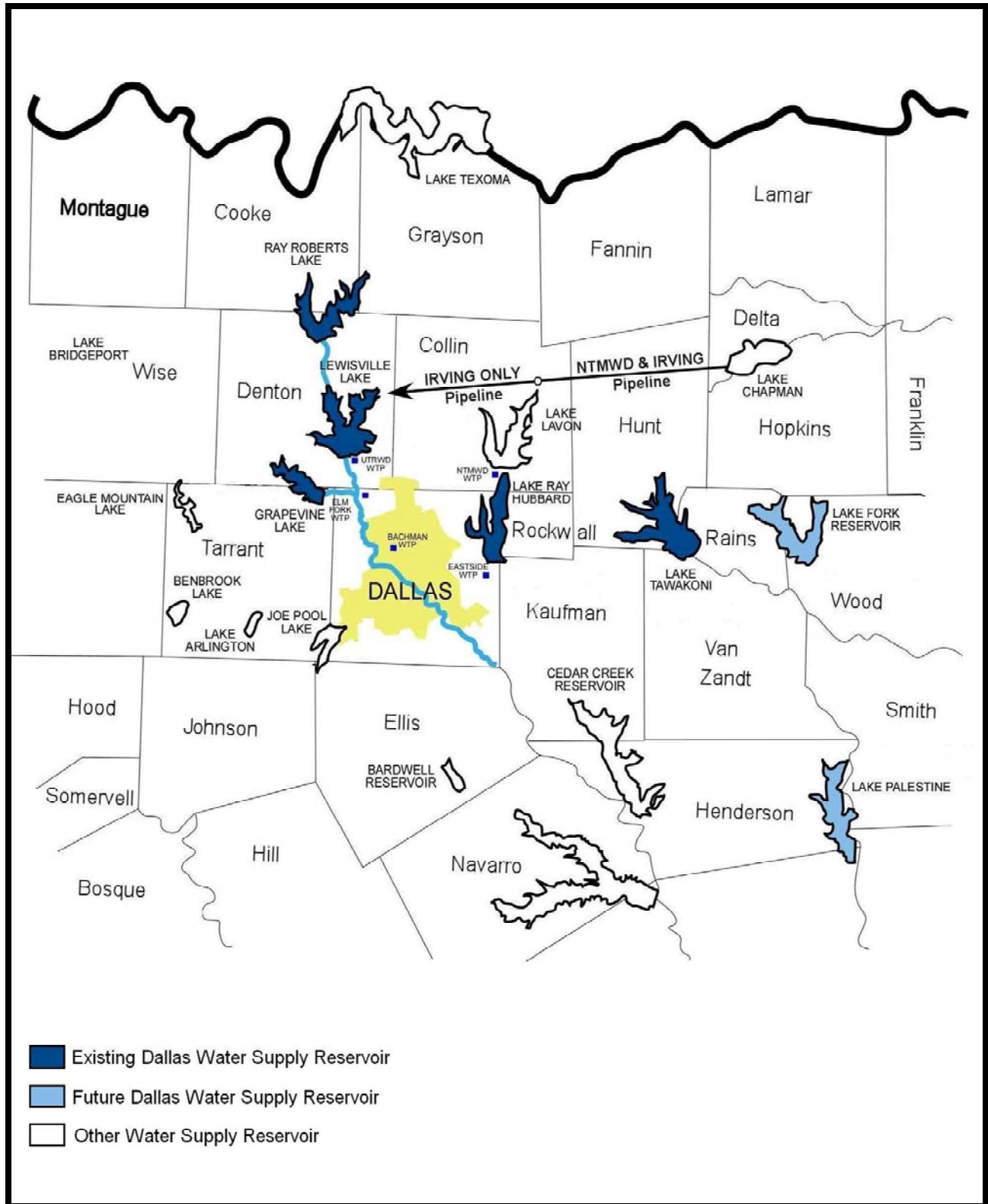


Figure 2.2.1: DWU Raw Water Sources and Treatment Facilities

Source: City of Dallas Planning and Water Supply Strategies, December 6, 2006

2.2.2 Water Treatment Facilities

DWU operates three surface water treatment plants (WTP), which treat the raw water obtained from the various lakes described above:

- East Side WTP:

The East Side WTP is located in Sunnyvale, approximately three (3) miles southwest of Lake Ray Hubbard. Raw water for the East Side WTP is pumped to the head of the plant through transmission mains from Lake Ray Hubbard and Lake Tawakoni.

- Elm Fork WTP:

The Elm Fork WTP is located in Carrollton, northwest of the intersection of Old Denton Road and Whitlock Lane. Raw water for the Elm Fork WTP is conveyed through creek channels from Lake Ray Roberts, Lake Lewisville, and Lake Grapevine. These sources all converge in the Elm Fork of the Trinity River.

- Bachman WTP:

The Bachman WTP is located just north of Love Field Airport, adjacent to Bachman Lake. Raw water for the Bachman WTP is obtained from the same sources as the Elm Fork Plant, except that the intake structure for the Bachman Plant is located upstream of the Frazier Dam.

2.2.3 Raw Water Mains

The raw water obtained from the lakes described above is conveyed to water treatment plants by two primary methods:

- Gravity through creeks and rivers
- Pump stations located at the lakes

2.2.4 Pressure Zone

Based on 2007 DWU Water Master Plan, the Dallas water distribution system is divided into 17 pressure zones in order to serve the wide range of ground elevations within the City while maintaining residual pressures within acceptable levels.

- Major/ Secondary Pressure Zones:

There are four (4) major pressure zones (Central Low, North High, South High, and East High) which comprise most of the Dallas service area. There are five (5) smaller secondary pressure zones (Cedardale, Pleasant Grove, Meandering Way High, Red Bird High, and Trinity Heights) which also serve significant portions of the Dallas service area. Each of the nine (9) major and secondary pressure zones are supplied by one or more pump stations and have elevated or ground storage facilities that establish the static hydraulic gradient for each zone.

- Intermediate Pressure Zones:

There are eight (8) intermediate pressure zones that generally serve very small, localized areas throughout the Dallas service area. These intermediate zones are supplied through pressure-reducing valves from an adjacent major or secondary pressure zone or by single, small booster pump stations. The intermediate pressure zones do not have elevated or ground storage facilities that establish their static hydraulic gradient.

DWU pressure zones are shown in **Figure 2.2.4** and summarized in **Table 2.2.4**.

2.2.5 Ground Storage Reservoir

There are twelve (12) ground storage reservoirs in DWU water distribution system to provide suction storage for the high service pumping stations. In addition to providing suction storage for high service pumps, three of the ground reservoirs are at a height that allows them to also function as elevated (floating) storage.

2.2.6 Elevated Tanks

There are eight (8) elevated storage tanks located throughout the distribution system. These tanks provide floating storage for the primary and secondary pressure zones.

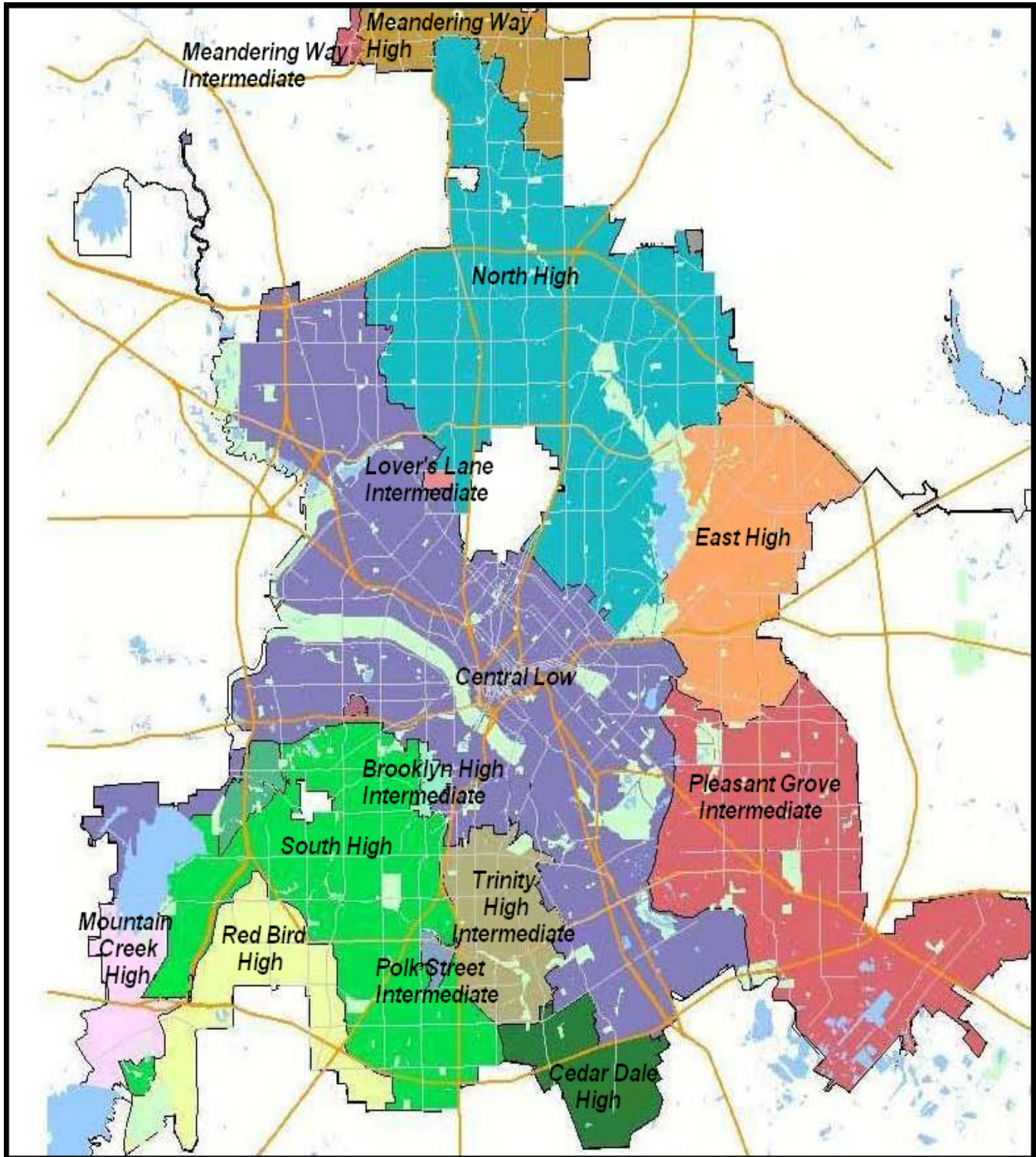


Figure 2.2.4: DWU Water Pressure Zones

Source: DWU Water Master Plan, July 2007

Table 2.2.4: DWU Water Distribution System

Pressure Zone	Elevated Tank	Overflow Elev. (ft)	Bottom Elev. (ft)	Storage Capacity (MG)
Major (4)				
Central Low	-	-	-	-
North High	Forest Lane Plano Road	751.5 751.5	716.5 716.5	2.0 2.0
South High	American Way	795.0	770.0	3.0
East High	Garland Road	714.0	679.0	2.0
Secondary (5)				
Cedardale	Cedardale	708.0	670.7	0.5
Pleasant Grove	Pleasant Grove	650.0	615.0	2.0
Meandering Way High	Highlands	820.0	780.0	2.0
Red Bird High	Red Bud	875.0	840.0	1.0
Trinity Heights	Trinity Heights	717.0	982.0	1.0
Intermediate (8)				
Arcadia Park	-	-	-	-
Brooklyn Heights	-	-	-	-
Brooklyn Heights	-	-	-	-
Hidden Valley	-	-	-	-
Lone Star	-	-	-	-
Meandering Way	-	-	-	-
Mountain Creek	-	-	-	-
Polk Street	-	-	-	-
Whispering Hills	-	-	-	-

Source: DWU Water Master Plan, July 2007

2.3 EVALUATION OF WATER MAINS FOR REPLACEMENT

Existing water mains shall be considered for replacement if they meet one or more of the following criteria as approved by DWU Distribution Division:

Table 2.3: Water Main Replacement Criteria

Criteria	DWU Measures
Structural Integrity	Pipe Age: 40 years or older mains, but age shall not be the lone factor Water Break Index (WBI): Water mains with $WBI > 1$. WBI as recorded by Distribution Division, can be defined as: WBI= (Total Breaks Over Pipe Age) / (Pipe Length/1000)*(Pipe Age) Where, Pipe Length in ft. and Pipe Age in yr.
System Capacity	Substandard Mains: Typically, smaller mains (< 8") which are inadequate to meet domestic and fire demand for existing and/or potential future development System Wide Growth: Water mains serving areas expected to gain in water usage
Regulatory/Undesirable Material	Undesirable Material or Appurtenances: Presence of following material(s) • Asbestos Cement (AC) pipe • Unlined grey iron pipe • Lead sealed joints • Lead or galvanized water services • 4-way cross fittings
Project Coordination	Water Main Condition Check: Existing deteriorated water mains in the vicinity of a proposed wastewater main Minimize Pavement Cut: Existing water mains may be replaced if future maintenance of the main requires cutting of new pavement within next 10 years. Water Master Plan: Compliance to any specific recommendations as per current DWU water master plans

2.4 WATER MAIN SIZING

2.4.1 Water Pipeline Network:

DWU water pipeline network system can be summarized as follows:

Table 2.4.1: DWU Water Main Classification

Type	Typical Size Range (in)	Direct Service Connection
Distribution Main	16" and Smaller	Permitted
Transmission Main	Larger than 16"	Not Permitted

2.4.2 Water Demand

DWU water system must be able to supply water at rates which fluctuate over a wide range during different times of year and hours of the day. Per capita usage can vary greatly depending on the area's zoning and the efforts made by the owners for water conservation. Typically, a customer with a yard will use more water than a customer without a yard. The rates most important to the design and operation of a water system are as follows:

2.4.2.1 Average Daily Flow (ADF):

Average daily demand can be defined as the total annual volume of water delivered to the water distribution system divided by the number of days in the year. This rate is not a critical demand rate for distribution system planning, but it should be considered in raw water supply planning to determine annual withdrawals and required sustainable yields from water supply sources.

The DWU per capita water use varies from year to year, primarily because of varying weather conditions and the amount and distribution of rainfall. Based on DWU Water Master Plan dated 2007, total per capita treated water use in Dallas since 1980 to 2005 has ranged from 211 gallons per capita per day (gpcd) to 259 gpcd, with an average use of 235 gpcd.

2.4.2.2 Peak Hourly Flow (PHF):

Peak hourly flow is the highest hourly rate of water use during the peak day demand period. Even though it occurs for a short time period, this rate often imposes the most severe hydraulic condition on the distribution system. Peak hourly demands are typically supplied by a combination of high service pumpage from treatment and storage facilities and by gravity flow from elevated storage facilities. Pursuant to 30 TAC §290.38(53), in the absence of verified historical data, peak hourly demand means 1.25 times the peak daily demand.

Based on DWU Water Master Plan dated 2007, the ratio of peak hourly flow to peak daily flow (PHF/PDF) for the City of Dallas (1980 to 2005) has ranged from 1.20 to 1.42, with an average ratio of 1.32. The aggregate PHF/PDF ratio for the customer cities has ranged from 0.96 to 1.09, with an average ratio of 1.03.

2.4.2.3 Peak Daily Flow (PDF):

Peak daily demand can be defined as the maximum quantity of water used on any day of the year. Raw water transmission and water treatment facilities are typically sized to meet the peak daily demand. Distribution systems shall also be designed to satisfy the peak daily demand, without depleting water from ground or elevated storage facilities. Pursuant to 30 TAC §290.38(38), in the absence of verified historical data or in cases where a public water system has imposed mandatory water use restrictions within the past 36 months, peak daily demand means 2.4 times the average daily demand of the system.

Based on DWU Water Master Plan dated 2007, the ratio of peak daily flow to average daily flow (PDF/ADF) of City of Dallas (1980- 2005) has ranged from 1.40 to 1.84, with an average ratio of 1.62. The aggregate PDF/ADF ratio for the customer cities has ranged from 1.40 to 2.05, with an average ratio of 1.74.

2.4.2.4 Fire Flow (FF):

Fire flow can be defined as the amount of water that should be available for providing fire protection at selected locations throughout a community. 2006 International Fire Code (IFC) or Latest Edition as adopted by City of Dallas shall be applicable for estimating minimum required fire flow at any facility.

The minimum fire flows required for residential and commercial areas are 1,500 gpm and 1,750 gpm, respectively. Fire flows of up to 3,500 gpm are the maximum required by the Insurance Services Office (ISO) of a utility, and these flows can be supported by existing storage facilities. This rate can be reduced if items such as internal sprinkler systems are added to the facility.

2.4.3 Sizing Criteria

The water mains must be sized in accordance with any approved master plan established for that area. If a master plan is not available, the sizing of the water main must be based on engineering analysis of initial and future demand of the area to be served. Water transmission and distribution mains must be sized to meet peak daily water demand plus any additional criteria as needed. When site-specific data is unavailable, designer shall use the most conservative data while meeting or exceeding the following minimum criteria for sizing distribution mains:

- Fire Flow: A minimum of 1500 gpm at each fire hydrant in the vicinity. Buildings in specific areas may require higher flows as per Insurance Service Office (ISO) as enforced by Dallas Fire-Rescue Department.

- Headloss: Less than one foot of head loss per 1,000 ft of main at a Hazen-Williams coefficient of $C=110$ Velocity: The velocity of distribution main shall be maintained between 5 and 8 feet per second.
- Service: The size of the services must be at least one standard size smaller than the proposed and existing water main.
- Comply with Tables 2.4.3.1 and 2.4.3.2 as applicable

**Table 2.4.3.1:
Water Design Flow Estimation with Limited Available Data**

Source	Remarks	Average Daily Water Flow (gals/person)
Municipality	Residential	180
Subdivision	Residential	180
Trailer Park (Transient)	2½ Persons per Trailer	85
Mobile Home Park	3 Persons per Trailer	110
School	Cafeteria & Showers	30
	Cafeteria/No Showers	22
Recreational Parks	Overnight User	45
	Day User	8
Office Building Factory	A facility must be designed for the largest shift	35
		28
Hotel/Motel	Per Bed	110
Restaurant	Per Meal	15
Restaurant with bar or cocktail lounge	Per Meal	18
Hospital	Per Bed	350
Nursing Home	Per Bed	180
Apartments	Per Unit	430

Table 2.4.3.2: Water Design Flow Estimation with Available Zoning/Property Data

		Zoning District	Land Use	Unit per Area*	Pop. per Unit**	Ave. Daily Demand per Capita (gpcd)	Ave. Daily Demand Per Unit (gpd)**
		A(A)	Agricultural (Agricultural, Single Family)	1 per 3 acre	3.25	200	650
RESIDENTIAL	Single Family	R-1ac(A)	Single Family	1 per 1 acre	3.25	200	650
		R-1/2ac(A)	Single Family	2 per 1 acre	3.25	200	650
		R-16(A)	Single Family	1 per 16000 sq. ft.	3.25	200	650
		R-13(A)	Single Family	1 per 13,000 sq. ft.	3.25	200	650
		R-10(A)	Single Family	1 per 10,000 sq. ft.	3.25	180	585
		R-7.5(A)	Single Family	1 per 7,500 sq. ft.	3.25	180	585
		R-5(A)	Single Family	1 per 5,000 sq. ft.	3.25	180	585
	Duplex/ Townhome	D(A)	Duplex	1 per 3,000 sq. ft.	2.5	180	450
		TH-1(A)	Townhouse	6 per acre	2.25	180	405
		TH-2(A)	Townhouse	9 per acre	2.25	180	405
		TH-3(A)	Townhouse	12 per acre	2.25	180	450
	Clustered Housing/ Multifamily	CH	Clustered Housing (Multi/Single Family)	18 per acre	2.0	180	360
		MF-1(A)	Multifamily	Min. Lot: 3,000 1,000 sq ft- E 1,400 sq ft- 1 BR 1,800 sq ft- 2 BR +200 sq ft each add BR	2.00 2.25 2.50	180	360 405 450
		MF-2(A)	Multifamily	Min. Lot: 1,000 8,00 sq ft- E 1,000 sq ft- 1 BR 1,200 sq ft- 2 BR +150 sq ft each add BR	2.00 2.25 2.50	180	360 405 450
		MF-3(A)	Multifamily	Min. Lot: 6,000 450 sq ft- E 500 sq ft- 1 BR 550 sq ft- 2 BR +50 sq ft each add BR	2.00 2.25 2.50	180	360 405 450
		MF-4(4)	Multifamily	Min. Lot: 6,000 225 sq ft- E 275 sq ft- 1 BR 325 sq ft- 2 BR +50 sq ft each add BR	2.00 2.25 2.50	180	360 405 450
		MH(A)	Mobile Home	1 per 4000 sq. ft.	2.50	180	450

Table 2.4.3.2 contd.
2

		Zoning District	Land Use	Unit per Area*	Pop. per Unit**	Ave. Daily Demand per Capita (gpcd)	Ave. Daily Demand Per Unit (gpd)**
NONRESIDENTIAL	Office	NO(A)	Neighborhood Office	0.5 FAR	1 per 400 sf	35	35 per 400 sf
		LO-1	Limited Office	1.0 FAR	1 per 400 sf	35	35 per 400 sf
		LO-2	Limited Office	1.5 FAR	1 per 400 sf	35	35 per 400 sf
		LO-3	Limited Office (Office, Lodge)	1.75 FAR	1 per 400 sf	35	35 per 400 sf
		MO-1	Mid-Range Office (Office, Lodging)	2.0 FAR	1 per 400 sf	35	35 per 400 sf
		MO-2	Mid-Range Office (Office, Lodging)	3.0 FAR	1 per 400 sf	35	35 per 400 sf
		GO(A)	General Office (Office, Lodging)	4.0 FAR	1 per 400 sf	35	35 per 400 sf
	Retail	NS(A)	Neighborhood Service	0.5 FAR	1 per 400 sf	35	35 per 400 sf
		CR	Community Retail	0.75 FAR overall 0.5 office	1 per 400 sf	35	35 per 400 sf
		RR	Regional Retail	1.5 FAR overall 0.5 Office	1 per 400 sf	35	35 per 400 sf
	Commercial/ Industrial	CS	Community Service	0.75 FAR overall 0.5 office/lodging/retail	1 per 400 sf	35	35 per 400 sf
		LI	Light Industrial	1.0 FAR overall 0.75 office/retail 0.5 retail	1 per 400 sf	35	35 per 400 sf
		IR	Industrial Research	2.0 FAR overall 0.75 office/retail 0.5 retail	1 per 400 sf	35	35 per 400 sf
		IM	Industrial Manufacturing	2.0 FAR overall 0.75 office/retail 0.5 retail	1 per 400 sf	35	35 per 400 sf
	Central Area	CA-1(A)	Central Area	20.0 FAR	1 per 400 sf	35	35 per 400 sf
		CA-2(A)	Central Area	20.0 FAR	1 per 400 sf	35	35 per 400 sf
	Mixed Use	MU-1	Mixed Use	0.8 FAR base 1.0 FAR max. + bonus for residential	1 per 400 sf	35	35 per 400 sf
		MU-2	Mixed Use	0.8 FAR base 1.0 FAR max. + bonus for residential	1 per 400 sf	35	35 per 400 sf
		MU-3	Mixed Use	0.8 FAR base 1.0 FAR max. + bonus for residential	1 per 400 sf	35	35 per 400 sf

Table 2.4.3.2 contd.

		Zoning District	Land Use	Unit per Area*	Pop. per Unit**	Ave. Daily Demand per Capita (gpcd)	Ave. Daily Demand Per Unit (gpd)**
NONRESIDENTIAL	Multiple Commercial	MC-1	Multiple Commercial	0.8 FAR base 1.0 max.	1 per 400 sf	25	25 per 400 sf
		MC-2	Multiple Commercial	0.8 FAR base 1.0 max.	1 per 400 sf	25	25 per 400 sf
		MC-3	Multiple Commercial	1.2 FAR base 1.5 max.	1 per 400 sf	25	25 per 400 sf
		MC-4	Multiple Commercial	1.6 FAR base 2.0 max.	1 per 400 sf	25	25 per 400 sf
	Urban Corridor	UC-1	Urban Corridor	10 DU/ acre 0.6 FAR base 2.0 max.	1 per 400 sf	25	25 per 400 sf
		UC-2	Urban Corridor	35 DU/acre 0.85 FAR base 3.6 max.	1 per 400 sf	25	25 per 400 sf
		UC-3	Urban Corridor	45 DU/acre 1.0 FAR base 4.5 max.	1 per 400 sf	25	25 per 400 sf
	Parking	P(A)	Parking	-	-	-	-

Note: FAR denotes to Floor Area Ratio and DU denotes to Dwelling Unit.

*** Average daily demands for non-residential units are based on the assumption of 1 person per unit and 400 square feet (sf) per unit. Actual estimation shall be based on the designed floor area, FAR and DU as necessary.*

2.4.4 Minimum Pipe Size

- General Area: Minimum 8" main shall be used for all general areas.
- Central Business District (CBD): Minimum 12" main shall be used for CBD area which is approximately bounded by IH-45, IH-30, IH-35 and Woodall Rogers Freeway.
- Industrial Area: Minimum 12" for industrial areas shall be used.
- Non-Standard Pipe Sizes: 10", 14", and 18" water pipes are considered nonstandard for the DWU system and shall not be used.

2.5 DEPTH OF COVER

The depth of cover is measured from the top of the pipe to the natural or finished ground surface above the pipe.

2.5.1 Terminology

2.5.1.1 Unimproved Area:

Unimproved area is defined as public right-of-way or easement without permanent pavement including natural ground, asphalt pavement with no base, gravel surface, and streets without curb and gutter.

2.5.1.2 Improved Area:

Improved area is defined as public right-of-way or easement with paving and base including areas behind the curb, or streets where permanent pavement is proposed in the near future.

2.5.2 Minimum Cover

The following guideline applies to water main installation in public right-of-way or easements:

Table 2.5.2: Minimum Depth of Cover for Water Main

Size of Main (in)	Min. Depth* (ft)		
	Unimproved Area	Improved Area	Highway/Railroad Crossing**
12" and Smaller	6	4	6
16"	6	5	6
20" and Larger	7	6	6

* Mains shallower than 3 feet will require special engineering evaluation and engineering controls.

** Water mains under highway and railroad right-of-way must meet all additional criteria as required.

2.6 WATER PIPE MATERIALS & EMBEDMENTS

2.6.1 Pipe Material Selection

Designers are responsible for specifying the type of pipe to be used in any design. Pipe material shall be selected on the basis of lowest life cycle cost. For smaller pipe sizes ($\leq 16''$ diameter) PVC is the material preferred by DWU. For larger pipe sizes ($> 16''$) DWU prefers reinforced concrete cylinder pipe (RCCP). Other materials such as ductile iron and steel may be specified upon approval by the Distribution Division.

Although PVC is the preferred material for smaller mains, there are some restrictions on its use. PVC may not be used within the following areas or circumstances:

- Central Business District (CBD), Dallas Love Field and Executive Airports
- Elevated crossings or situation where pipe will be permanently exposed
- Encased pipe where the method of anchoring is by means of hold-down jacks

When a metal pipe including concrete cylinder, ductile iron or steel is specified, the pipe must be protected from corrosion. Corrosion protection measures should be part of any pipeline design using these materials. For ductile iron pipes a double layer of polyethylene wrapping is required. When steel pipe is utilized, the pipe interior lining shall be cement-mortar and exterior coating shall be either cement-mortar, tape or polyurethane as approved by Distribution Division. All joints on metal pipe shall be bonded, and in locations with reactive soils or induced currents a cathodic protection system may be necessary.

2.6.2 Fittings

All PVC and ductile iron pipe shall use ductile iron fittings. Compacted fittings are not allowed. All 90 degree bends shall be avoided in the system, if possible.

2.6.3 Embedment Requirements

Designers shall specify class of embedment on design drawings. The type of embedment to be used is determined by pipe material and depth of cover. Please see DWU Standard Drawings 113-119C for the various classes of embedment.

2.6.4 Recommended Pipe Material and Embedment

The following table summarizes recommended pipe material and embedment for different water mains:

Table: 2.6.3: Recommended Water Pipe Materials & Embedments*

Pipe & Material Specification	Allowable Size (in)	Joint Specification	Embedment Class Per Depth of Cover** (ft)
PVC AWWA C900 (DR-14)	6 – 12	Bell & Spigot Joints: ASTM D3139 Gasket: ASTM F477	< 8' : C+
PVC AWWA C905 (DR-14)	16	Fusible Fusible C 900 ^(R) Fusible C 900 ^(R) Certa-Lok Certa-Lok C900/RJ ^(TM) Certa-Lok C905/RJ ^(TM)	8'-16' : B+
Ductile Iron (DI) ANSI/AWWA C151/A21.51 Class 52 or Class 54	6 – 60	Bell & Spigot/ Push On ANSI/AWWA C111/A21.11 Mechanical ANSI/AWWA C111/A21.11 Flanged ANSI/AWWA C115/A21.15	≤16-in Dia: >16-in Dia: < 8' (Rock): C < 8" : B < 8' (Earth): D+ 8'-16' : B 8'-16' : C >16' : B > 16' : B
RCCP- Bar Wrapped ANSI/AWWA C303 Class 150	16 – 42	Bell & Spigot ANSI/AWWA C303	16-in Dia: >18-in Dia: < 16' : C <16' : B > 16' : B >16' : B
PCCP- Lined Cylinder ANSI/AWWA C301 Class 150	20 – 60	Bell & Spigot ANSI/AWWA C301	< 16' : C > 16' : B
PCCP- Embedded Cylinder ANSI/AWWA C301 Class 150	54 – 144	Bell & Spigot ANSI/AWWA C301	< 16' : C >16' : B
Steel** ANSI/AWWA C200	24 – 156	Welded Joints or Bell & Spigot ANSI/AWWA C200	< 8' : C > 8' : C

* Reference to Standard Drawing 113- 119 for details and dimensions of the class of embedment

** Steel and other pipe materials can only be considered on case- by- case basis as approved by Distribution Division

2.7 LOCATION

2.7.1 New Main Installation

New water mains shall be placed in the appropriate standard allocation zone as shown in §1.11.2 and as described below:

- 12" and smaller mains are to be located six feet from the north or east side of the street right-of-way.
- 16" and larger mains are to be located in the major facility zone under the pavement towards the north or east side of the right-of-way.
- In some areas of the Central Business District (CBD) where basements extend into the right-of-way, and in areas where large service meter vaults are required, smaller mains may be located in the major facility zone. If the standard allocation zones are occupied by other utilities, new water mains may be located elsewhere in the street right-of-way, but should follow the other guidelines in this section as closely as possible.
- New water mains within highway or railroad right-of-ways must be coordinated with appropriate agency while meeting DWU criteria.

2.7.2 Main Replacement

Replacement of water mains shall be located in the standard allocation zone as per §1.11.2 and as described below:

- If the existing main is in the standard allocation zone, the replacement main may be located parallel to and no closer than three (3) feet horizontally from the existing main, as measured from the outside edge of both pipes.
- The replacement main may not be located closer than three (3) feet from the edge of the right-of-way, as measured from the outside edge of the new pipe.
- If there is not enough room to install a new main, as is often the case in narrow alleys or congested streets, the new main may be installed in the same location as the existing main. In this case a temporary water main must be installed during construction, and should be noted on the design drawings.
- Water main replacement within highway or railroad right-of-way must be coordinated with appropriate agency while meeting DWU criteria.

2.8 HORIZONTAL ALIGNMENT

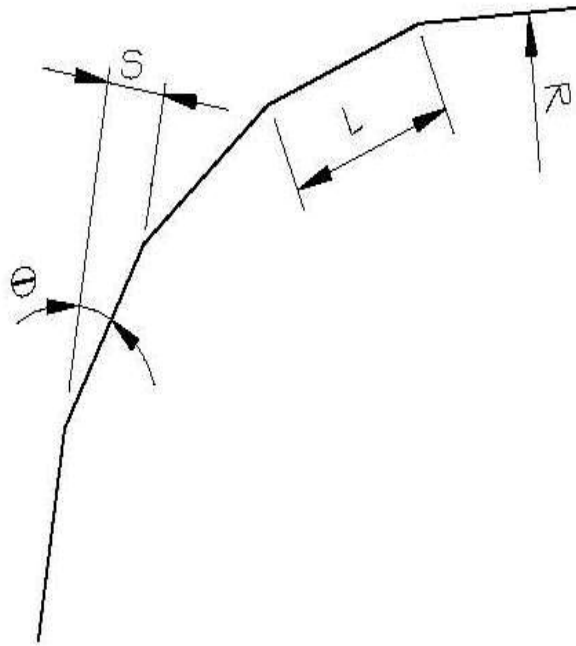
2.8.1 Pipe Laying

All water mains shall be laid as straight as possible between intersections and follow right-of-way or centerline alignment curves at a uniform distance from the right-of-way or centerline, as appropriate.

2.8.2 Joint Deflection

The maximum deflection angles of pipe joint are restricted to 80% of the manufacturer's recommendation. Otherwise, horizontal bends will be required.

The minimum curve radius due to maximum joint deflection can be calculated as shown in **Figure 2.8.2**.



Curve Radius, $R = 57.3 * L / \theta$

Where,
 L = Laying Length, ft.
 θ = Deflection Angle, Degree

Figure 2.8.2: Water Main Joint Deflection

Source: Handbook of PVC Pipe- Design and Construction by Unibell PVC Pipe Association, 4th Edition, August, 2011

Accordingly, typical minimum curve radius of various water sizes are summarized in **Table 2.8.2:**

Table 2.8.2: Minimum Water Main Curve Radius

		Recommended by Manufacturers (Typical)				Allowable by DWU***			
Type of Pipe	Size (in)	Max. Deflection		Min. Curve Radius		Max. Deflection		Min. Curve Radius	
		Angle (deg.)	Offset (in)	20' Joint (ft)	10' Joint (ft)	Angle (deg.)	Offset (in)	20' Joint (ft)	10' Joint (ft)
*PVC DR 14	6	2	8	573	286	1.6	6.4	716	358
	8	2	8	573	286	1.6	6.4	716	358
	12	1.5	6	764	382	1.2	4.8	956	478
**DI Push-On	6	5	21	230	N/A	4	15.75	306	N/A
	8	5	21	230		4	15.75	306	
	12	5	21	230		4	15.75	306	

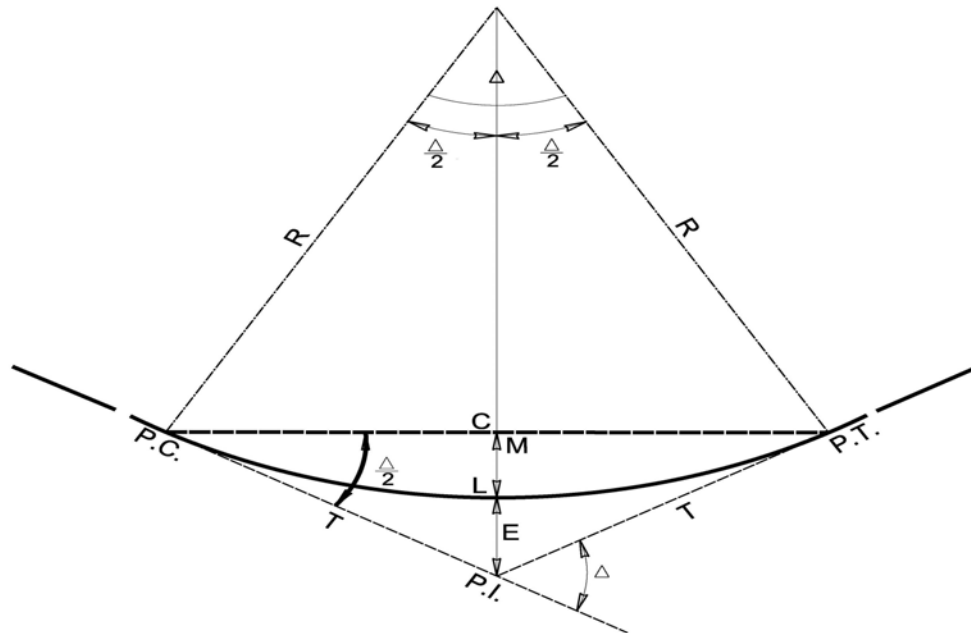
* PVC pipe data is obtained from National Pipe & Plastics, Inc.

** DI data obtained from American Ductile Iron Pipe, Inc.

*** Allowable maximum deflection by DWU is based on 80% of the typical recommended maximum deflection by the pipe manufacturer(s). Accordingly, allowable minimum curve radius by DWU is calculated and must be verified with the specific pipe manufacturer(s). Steeper curve(s) with uniform longitudinal bending of PVC pipe may be allowed if joints are blocked or restrained contingent upon manufacturer's recommendation. However, both joint deflection and axial bending on same length of pipe are not allowed.

2.8.3 Bends

Horizontal bends shall be restrained type fittings/joints and shall also be blocked with concrete as necessary. Horizontal bends shall also be placed such that the concrete blocking can be poured against undisturbed earth and will not bear against the backfill or bedding of another utility. Horizontal curve can be calculated as follows:



Where,

C	=	Long Chord	$C = 2R \sin (\Delta/2)$ $C = 2T \cos (\Delta/2)$
E	=	External Distance	$E = R (\sec (\Delta/2) - 1)$
L	=	Curve Length	$L = 2\pi R (\Delta/360^\circ)$ $L = R \Delta/57.2958$
M	=	Middle Ordinate	$M = R(1 - \cos (\Delta/2))$ $M = (C/2) \tan (\Delta/2)$
R	=	Radius	$R = T / \tan (\Delta/2)$ $R = C / (2 \sin (\Delta/2))$
T	=	Tangent	$T = R \tan (\Delta/2)$
PC	=	Point of Curvature	
PI	=	Point of intersection	
PT	=	Point of Tangency	
Δ	=	Deflection Angle	$\Delta^\circ = (L/R) (360^\circ/2\pi)$ $\Delta^\circ = (L/R) 57.2958$

Figure 2.8.3: Water Main Horizontal Curve

2.8.4 Stationing

Stations must be to the tenth of foot (Ex: STA. 1+90.5). If necessary, station equations can be used at a point along the alignment where the stationing changes. The station equation generally represents the meeting of two stationing systems or the change in authority over the centerline:

2.8.4.1 Gap Station Equation:

The gap station equation is commonly encountered in curve. A survey is run in straight line segment with a curve calculated to fit within the segment. Because the tangent segments of a curve are longer than the curve itself, an equation is necessary to adequately reference to the survey stations (**Figure 2.8.4.1**).

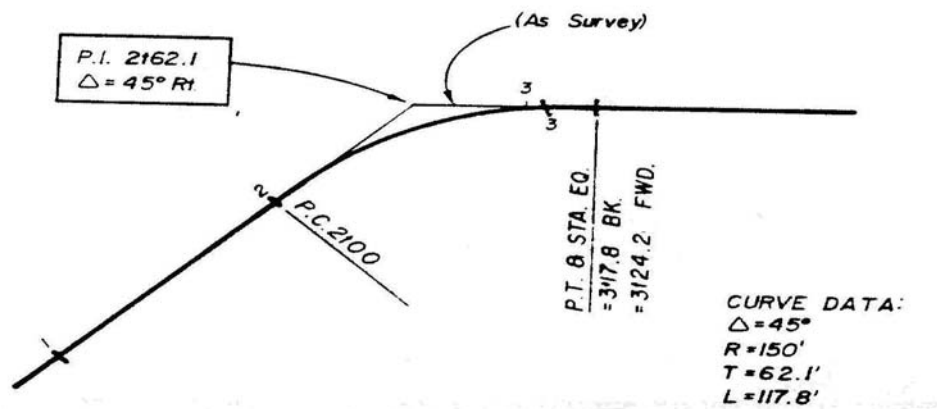


Figure 2.8.4.1: Gap Station Equation

2.8.4.2 Overlap Station Equation:

The overlap station equation is used when the pipeline, as designed, is longer the original survey. When the pipeline is realigned and placed on the survey line, or parallel to it, an equation is usually required (**Figure 2.8.4.2**).

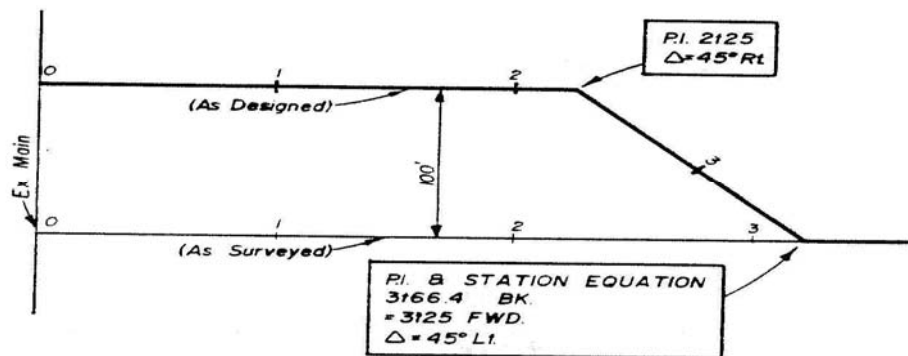


Figure 2.8.4.2: Overlap Station Equation

2.9 VERTICAL ALIGNMENT

2.9.3 Pipe Laying

Mains are to be installed as straight as possible, but excessive depths shall be avoided. For reference, excessive depths are lines designed over 20 feet. This is due to limited ability of standard equipment by operations to reach these mains.

2.9.2 High Points

Excessive high points that trap air and restrict water flow must be avoided. High points should be designed to coincide with the location of proposed fire hydrants, where possible. Where high points are unavoidable, air valves should be considered.

2.9.4 Bends

Vertical bends shall be restrained type fittings/joints and to be blocked with concrete as necessary. All DI pipe will be restrained with retainer glands and concrete blocking.

2.9.5 Combined Angle Bend

Combine angle bend can be used where horizontal point of intersection (PI) and point of vertical intersection (PVI) are located at the same point. Combined angle can be shown in **Figure 2.9.5** and calculated in **Table 2.9.5**.

$\cos A = (\cos H) (\cos V)$ $\cos A = x/m$ $\cos H = x/n$ $\cos V = n/m$	Where, A = Combined Angle H = Horizontal Angle V = Vertical Angle
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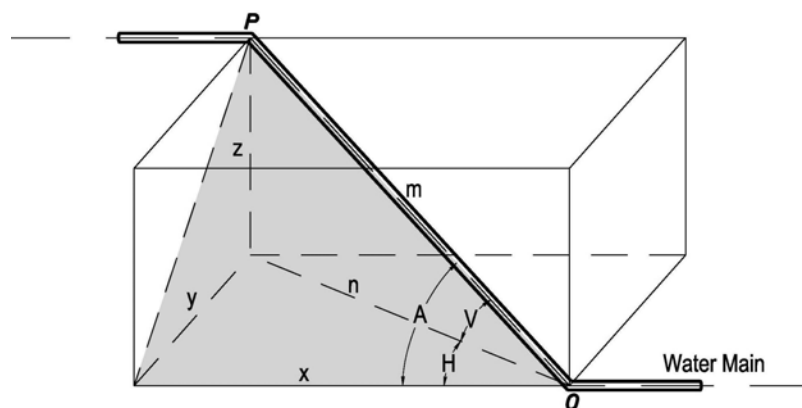


Figure 2.9.5: Combined Horizontal and Vertical Angle

Table 2.9.5: Combined Horizontal and Vertical Angle

Horizontal Angles											
5°	10 °	11°15'	15 °	20 °	22 °30'	25 °	30 °	35 °	40 °	45 °	

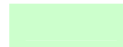
Vertical Angles	5 °	7 °04'	11 °10'	12 °18'	15 °48'	20 °35'	23 °01'	25 °28'	30 °23'	35 °19'	40 °16'	45 °13'
	10 °	11 °10'	14 °05'	14 °59'	17 °57'	22 °15'	24 °30'	26 °48'	31 °28'	36 °13'	41 °01'	45 °09'
	11°15'	12 °18'	14 °59'	15 °52'	18 °40'	22 °50'	25 °01'	27 °16'	31 °51'	36 °33'	41 °18'	46 °05'
	15 °	15 °48'	17 °57'	18 °40'	21 °05'	24 °49'	26 °49'	28 °54'	33 °13'	37 °42'	42 °16'	46 °55'
	20 °	20 °35'	22 °15'	22 °50'	24 °49'	27 °59'	29 °45'	31 °36'	35 °32'	39 °40'	43 °57'	48 °22'
	22°30'	23 °01'	24 °30'	25 °01'	26 °49'	29 °45'	31 °24'	33 °09'	36 °52'	40 °49'	44 °57'	49 °13'
	25 °	25 °28'	26 °48'	27 °16'	28 °54'	31 °36'	33 °09'	34 °47'	38 °17'	42 °04'	46 °02'	50 °09'
	30 °	30 °23'	31 °28'	31 °51'	33 °13'	35 °32'	36 °52'	38 °17'	41 °25'	44 °49'	48 °26'	52 °14'
	35°	35 °19'	36 °13'	36 °33'	37 °42'	39 °40'	40 °49'	42 °04'	44 °49'	47 °51'	51 °08'	54 °36'
	40 °	40 °16'	41 °01'	41 °18'	42 °16'	43 °57'	44 °57'	46 °02'	48 °26'	51 °08'	54 °04'	57 °12'
	45 °	45 °13'	45 °09'	46 °05'	46 °55'	48 °22'	49 °13'	50 °09'	52 °14'	54 °36'	57 °12'	60 °00'

Legends: Allowable Combined Angles for Various Standard Fittings are as follows:

11°15':



22°30':



45°:



Note: Gray areas represent horizontal and vertical components of standard combined angle (in Color) using various standard fitting.

Example: A standard fitting of 22°30' can be used for a horizontal angle of 20° and vertical angle of 15° with combined angle of to 24° 49'.

2.9.6 Slope

All water mains shall be designed to have minimum 0.1% slope in order to allow draining and flushing, if necessary. The vertical change in slopes is restricted to 80% of the manufacturer's recommended deflection. Otherwise, vertical bends will be required. Vertical bevels can be considered to accommodate long vertical curves of bevel or deflected joints in lieu of a bend for large concrete main in accordance with manufacturer's recommendations. Vertical curves are not to be less than 100 feet in length. The PVC, PVI, and PVT should be at quarter, half, or full stations (Ex: PC Sta. 0+00, PI Sta. 0+50 and PT Sta. 1+00).

2.9.6.1 Types of Vertical Curves:

Two types of vertical curves can be used in water main: (1) Crest and (3) Sag curves:

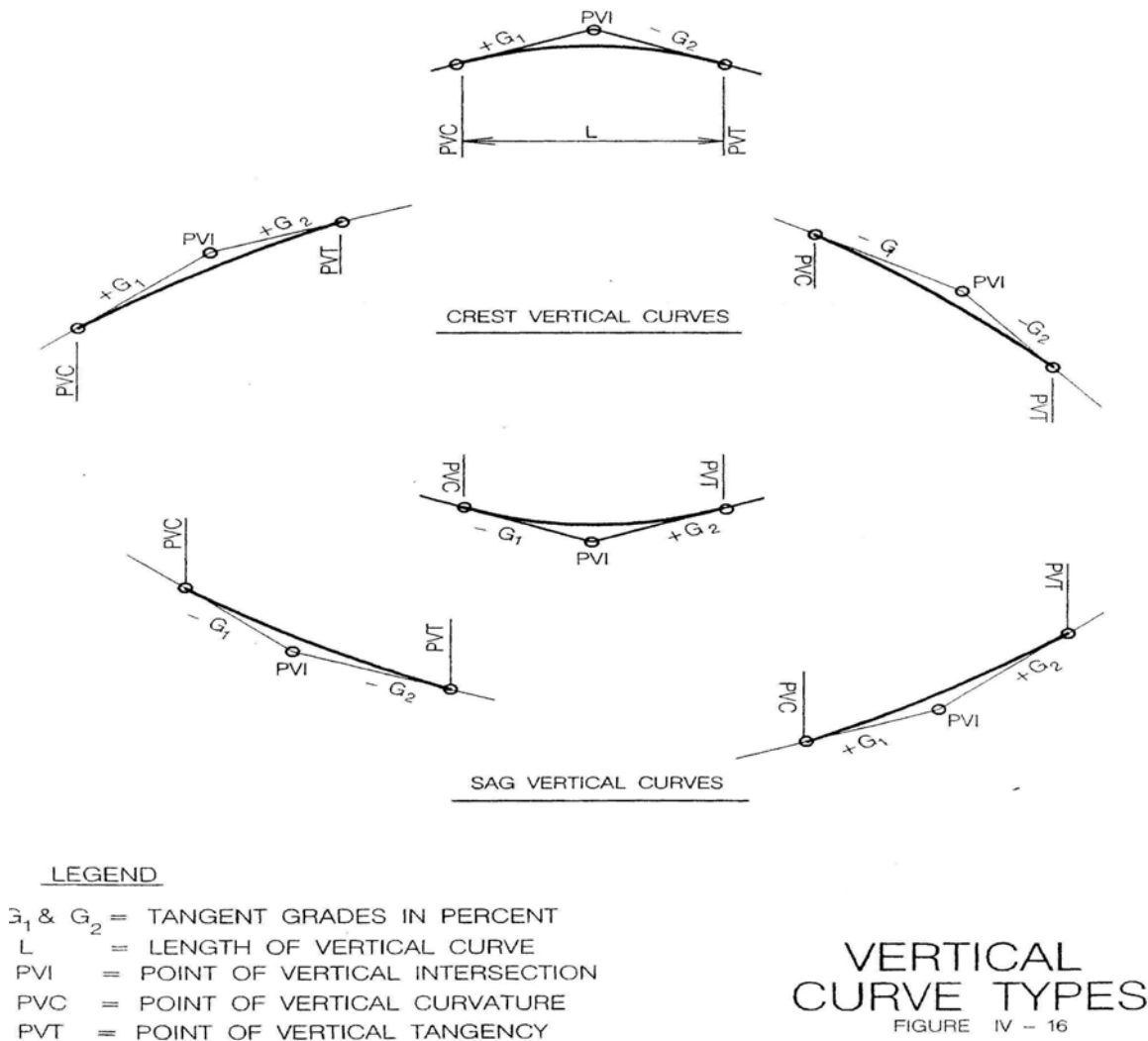


Figure 2.9.6.1: Vertical Curve Types

Source: PW&T Paving Design Manual, June, 1998

2.9.6.2 Calculation of Vertical Curve:

Vertical curves can be calculated by the following methods:

2.9.4.2.1 Algebraic Method:

$$FL\ Elev. = PVI. + \frac{1}{8} (|G_1 - G_2|) \times (L/100)$$

Example:

$$\begin{aligned} FL\ Elev. &= 495.40 + \frac{1}{8} (|5.20 - 0.80|) \times (100/100) \\ &= 495.95 \end{aligned}$$

2.9.4.2.2 Averaging Method:

$$FL\ Elev. = \{[(P.V.C. + P.V.T.) / 2] + P.V.I.\} / 2$$

Example:

$$\begin{aligned} FL\ Elev. &= \{[(495.00 + 498)/2] + 495.40\} / 2 \\ &= 495.95 \end{aligned}$$

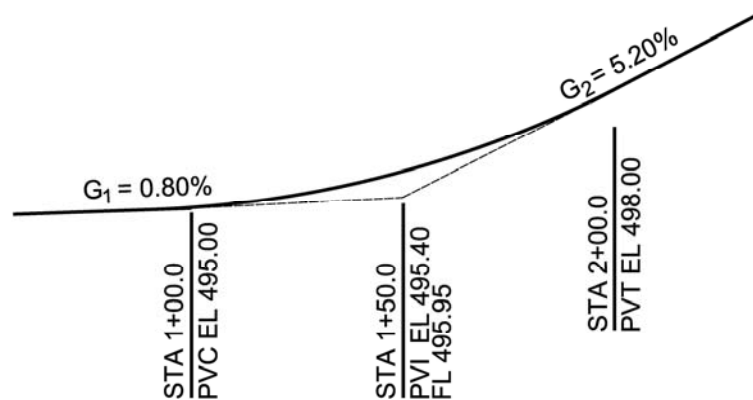


Figure 2.9.6.2: Vertical Curve

2.9.7 Profile:

- All 12" or larger water main designs must have a vertical profile.
- All 8" or larger water mains in advance of a permanent pavement and/or storm drain project must have a vertical profile in order avoid any potential conflict with proposed storm drain and pavement adjustments.
- All 8" or larger water mains installed in an unimproved street (with no curb and gutter) must have vertical profile.

2.9.8 Slope Designation:

- Design slopes shall be to the nearest hundredth of a percent (Ex: Slope 5.20%).

2.9.9 Elevation Designation:

- Elevations shall be shown to the nearest hundredth of a foot (Ex. El. 495.95).

2.10 SEPARATION DISTANCE BETWEEN WATER AND WASTEWATER MAINS

When a water main is built near an existing wastewater facility, conveyance, or appurtenance, 30TAC §290.44.e as enforced by TCEQ, governs the minimum separation distances:

2.10.1 Ideal Case

When new potable water distribution lines are constructed, they shall be installed no closer than nine feet in all directions to wastewater collection facilities. All separation distances shall be measured from the outside surface of each of the respective pieces.

2.10.2 Pipe Trench

Potable water distribution lines and wastewater mains or laterals from parallel utility lines shall be installed in separate trenches.

2.10.3 Cross Connection

No physical connection shall be made between a drinking water supply and a sewer line. Any appurtenance shall be designed and constructed so as to prevent any possibility of sewage entering the drinking water system.

2.10.4 Variances:

Where the nine-foot separation distance cannot be achieved, the following criteria shall apply as per 30TAC §290.44.e(4):

2.10.4.1 New Waterline Installation - Parallel Lines:

2.10.4.1.1 Parallel to Existing Non-Leaking Wastewater Main:

Where a new potable waterline parallels an existing, non-pressure or pressure rated wastewater main or lateral and the licensed professional engineer licensed in the State of Texas is able to determine that the existing wastewater main or lateral is not leaking, the new potable waterline shall be located at least two feet above the existing wastewater main or lateral, measured vertically, and at least four feet away, measured horizontally, from the existing wastewater main or lateral. Every effort shall be exerted not to disturb the bedding and backfill of the existing wastewater main or lateral.

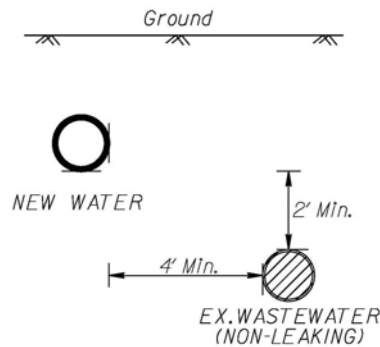


Figure 2.10.4.1.1:
New Water Main Parallel to Existing Non-Leaking Wastewater Main

2.10.4.1.2 Parallel to Existing Leaking Wastewater Main:

Where a new potable waterline parallels an existing pressure rated wastewater main or lateral and it cannot be determined by the licensed professional engineer if the existing line is leaking, the existing wastewater main or lateral shall be replaced with at least 150 psi pressure rated pipe. The new potable waterline shall be located at least two feet above the new wastewater line, measured vertically, and at least four feet away, measured horizontally, from the replaced wastewater main or lateral.

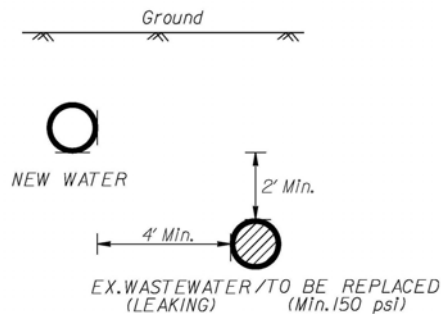
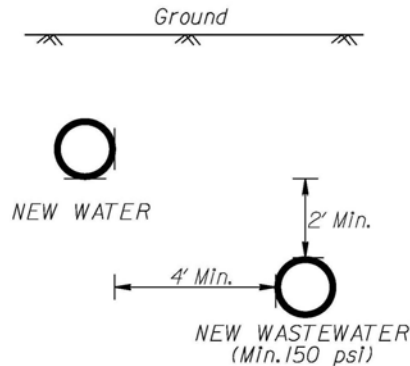


Figure 2.10.4.1.2:
New Water Main Parallel to Existing Leaking Wastewater Main

2.10.4.1.3 Pressure Rating of Wastewater Main:

Where a new potable waterline parallels a new wastewater main, the wastewater main or lateral shall be constructed of at least 150 psi pressure rated pipe. The new potable waterline shall be located at least two feet above the wastewater main or lateral, measured vertically, and at least four feet away, measured horizontally, from the wastewater main or lateral.



**Figure 2.10.4.1.3:
New Water Main Parallel to New Wastewater Main**

2.10.4.2 New Waterline Installation - Crossing Lines:

2.10.4.2.1 Crossing Existing Non-Pressure Rated Wastewater Main:

Where a new potable waterline crosses an existing, non-pressure rated wastewater main or lateral, one segment of the waterline pipe shall be centered over the wastewater main or lateral such that the joints of the waterline pipe are equidistant and at least nine feet horizontally from the centerline of the wastewater main or lateral. The potable waterline shall be at least two feet above the wastewater main or lateral. Whenever possible, the crossing shall be centered between the joints of the wastewater main or lateral. If the existing wastewater main or lateral 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.

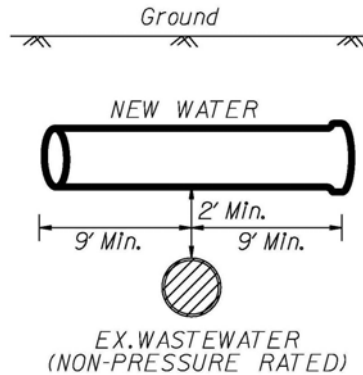


Figure 2.10.4.2.1:
New Water Main Crossing Existing Non-Pressure Rated Wastewater Main

2.10.4.2.2 Crossing Existing Pressure-Rated Wastewater Main:

Where a new potable waterline crosses an existing, pressure rated wastewater main or lateral, one segment of the waterline pipe shall be centered over the wastewater main or lateral such that the joints of the waterline pipe are equidistant and at least nine feet horizontally from the centerline of the wastewater main or lateral. The potable waterline shall be at least six inches above the wastewater main or lateral. Whenever possible, the crossing shall be centered between the joints of the wastewater main or lateral. If the existing wastewater main or lateral 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.

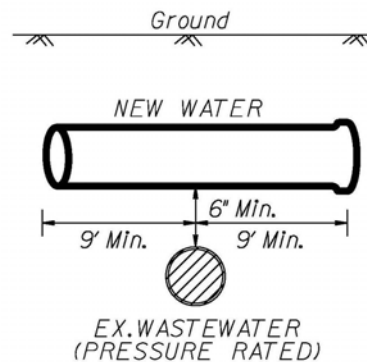


Figure 2.10.4.2.2:
New Water Main Crossing Existing Pressure Rated Wastewater Main

2.10.4.2.3 Crossing New Wastewater Minimum Pipe Segment:

Where a new potable waterline crosses a new, non-pressure rated wastewater main or lateral and the standard pipe segment length of the wastewater main or lateral is at least 18 feet, one segment of the waterline pipe shall be centered over the wastewater main or lateral such that the joints of the waterline pipe are equidistant and at least nine feet horizontally from the centerline of the wastewater main or lateral. The potable waterline shall be at least two feet above the wastewater main or lateral. Whenever possible, the crossing shall be centered between the joints of the wastewater main or lateral. The wastewater pipe shall have a minimum pipe stiffness of 115 psi at 5.0% deflection. The wastewater main or lateral shall be embedded in cement stabilized sand (see clause 2.10.4.2.4 of this subparagraph) for the total length of one pipe segment plus 12 inches beyond the joint on each end.

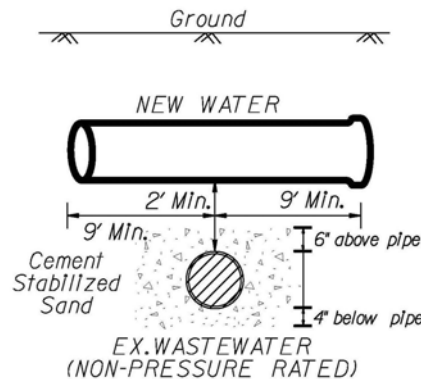
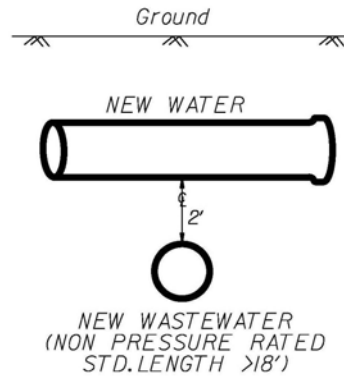


Figure 2.10.4.2.3:
Crossing New Wastewater Main Minimum Pipe Segment

2.10.4.2.4 Variance for Crossing New Wastewater Minimum Pipe Segment:

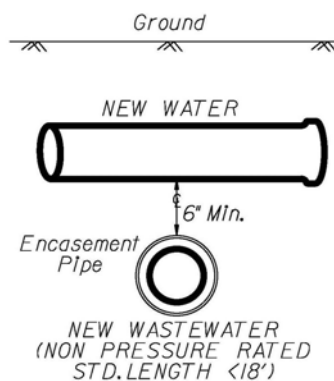
Where a new potable waterline crosses a new, non-pressure rated wastewater main or lateral and a standard length of the wastewater pipe is less than 18 feet in length, the potable water pipe segment shall be centered over the wastewater line. The materials and method of installation shall conform with one of the following options:

- 2.10.4.2.4.1 Within nine feet horizontally of either side of the waterline, the wastewater pipe and joints shall be constructed with pipe material having a minimum pressure rating of at least 150 psi. An absolute minimum vertical separation distance of two feet shall be provided. The wastewater main or lateral shall be located below the waterline.*



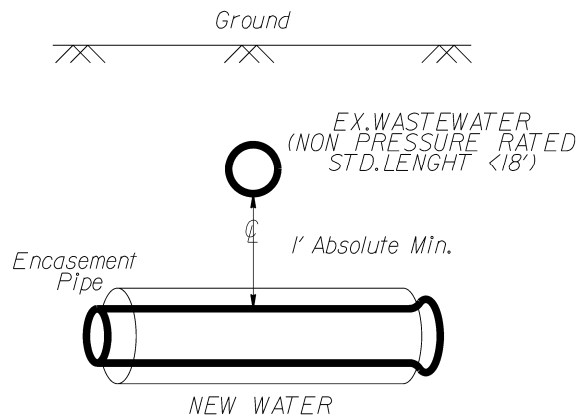
**Figure 2.10.4.2.4.1:
Variance for Crossing New Wastewater Main
with 2' Minimum Vertical Separation**

2.10.4.2.4.2 All sections of wastewater main or lateral within nine feet horizontally of the waterline shall be encased in an 18-foot (or longer) section of pipe. Flexible encasing pipe shall have a minimum pipe stiffness of 115 psi at 5.0% deflection. The encasing pipe shall be centered on the waterline and shall be at least two nominal pipe diameters larger than the wastewater main or lateral. The space around the carrier pipe shall be supported at five-foot (or less) intervals with spacers or be filled to the springline with washed sand. Each end of the casing shall be sealed with watertight non-shrink cement grout or a manufactured watertight seal. An absolute minimum separation distance of six inches between the encasement pipe and the waterline shall be provided. The wastewater line shall be located below the waterline.



**Figure 2.10.4.2.4.2:
Variance for Crossing New Wastewater Main
with 6" Minimum Vertical Separation**

2.10.4.2.4.3 When a new waterline crosses under a wastewater main or lateral, the waterline shall be encased as described for wastewater mains or laterals in subclause §2.10.4.2.4.2 of this clause or constructed of ductile iron or steel pipe with mechanical or welded joints as appropriate. An absolute minimum separation distance of one foot between the waterline and the wastewater main or lateral shall be provided. Both the waterline and wastewater main or lateral must pass a pressure and leakage test as specified in AWWA C600 standards.



**Figure 2.10.4.2.4.3:
Variance for Crossing New Wastewater Main
with 1' Minimum Separation**

2.10.4.2.5. Crossing New Pressure-Rated Wastewater Main:

Where a new potable waterline crosses a new, pressure rated wastewater main or lateral, one segment of the waterline pipe shall be centered over the wastewater line such that the joints of the waterline pipe are equidistant and at least nine feet horizontally from the center line of the wastewater main or lateral. The potable waterline shall be at least six inches above the wastewater main or lateral. Whenever possible, the crossing shall be centered between the joints of the wastewater main or lateral. The wastewater pipe shall have a minimum pressure rating of at least 150 psi. The wastewater main or lateral shall be embedded in cement stabilized sand (see clause under §10.4.2.6 of this subparagraph) for the total length of one pipe segment plus 12 inches beyond the joint on each end.

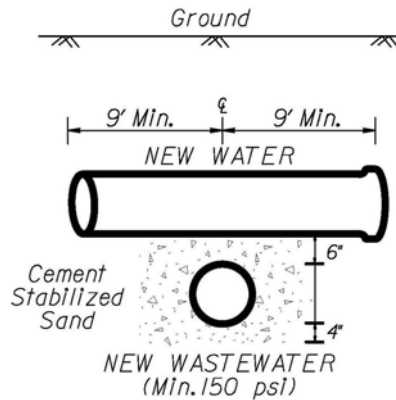


Figure 2.10.4.2.5
New Water Main Crossing New Pressure Rated Wastewater Main

2.10.4.2.6 Special Bedding Materials:

Where cement stabilized sand bedding is required, the cement stabilized sand shall have a minimum of 10% cement per cubic yard of cement stabilized sand mixture, based on loose dry weight volume (at least 2.5 bags of cement per cubic yard of mixture). The cement stabilized sand bedding shall be a minimum of six inches above and four inches below the wastewater main or lateral. The use of brown coloring in cement stabilized sand for wastewater main or lateral bedding is recommended for the identification of pressure rated wastewater mains during future construction.

2.10.5 Proximity of Wastewater Main, Lateral, Manhole or Cleanout

The separation distance from a potable waterline to a wastewater main or lateral manhole or cleanout shall be a minimum of nine feet. Where the nine-foot separation distance cannot be achieved, the potable waterline shall be encased in a joint of at least 150 psi pressure class pipe at least 18 feet long and two nominal sizes larger than the new conveyance. The space around the carrier pipe shall be supported at five-foot intervals with spacers or be filled to the springline with washed sand or grout as necessary. The encasement pipe shall be centered on the crossing and both ends sealed with cement grout or manufactured sealant.

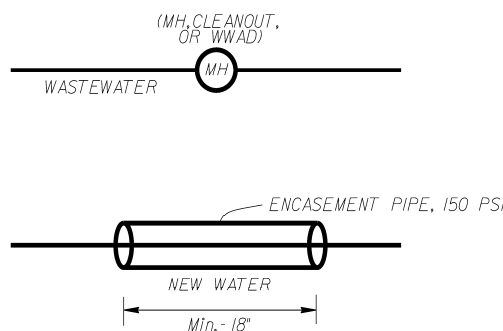


Figure 2.10.5:
Separation between Waterline and Wastewater Mains/Lateral/Manhole/Cleanout

2.10.6 Location of Fire Hydrants

Fire hydrants shall not be installed within nine feet vertically or horizontally of any wastewater main, wastewater lateral, or wastewater service line regardless of construction.

2.10.7 Location of Potable or Raw Water Supply or Suction Lines

Suction mains to pumping equipment shall not cross wastewater mains, wastewater laterals, or wastewater service lines. Raw water supply lines shall not be installed within five feet of any tile or concrete wastewater main, wastewater lateral, or wastewater service line.

2.10.8 Proximity of Septic Tank Drainfields

Waterlines shall not be installed closer than ten feet to septic tank drainfields.

2.10.9 Proximity of Reclaimed Water Mains

Water mains located adjacent to reclaimed water main shall comply with the separation criteria established in §4.10 regarding separation distance between reclaimed water and water/wastewater mains.

2.10.10 Proximity of Storm Drain and Gas Mains

- The horizontal separation distance from a potable waterline of 20" diameter or smaller to a storm drain shall be 4 feet (preferred) and 3 feet (minimum).
- The horizontal separation distance from a potable waterline of 20" diameter or smaller to a gas main shall be 4 feet (minimum).
- The separation distance for a potable waterline of larger than 20" diameter to a storm drain or gas main shall be considered on a case-by-case basis.

2.10.11 Proximity of Piers, Foundations and Vertical Structures

- The minimum horizontal separation distance between proposed water and existing/proposed piers, foundations or vertical structures shall be 10 feet from outside edge to outside edge as applicable.
- If 10 feet horizontal separation is not available, then each situation should be evaluated on case-by-case basis to allow adequate space for future maintenances.

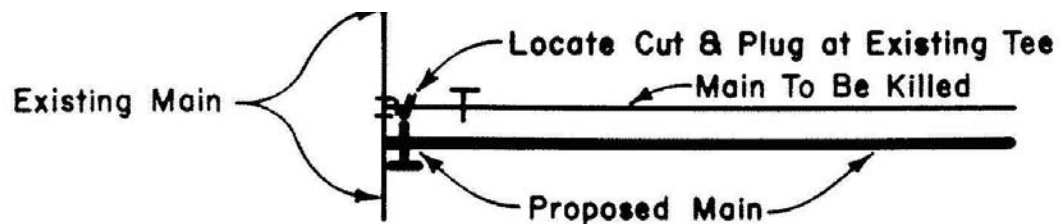
2.11 CONNECTION TO EXISTING MAINS

Services lines from properties shall only be connected directly to distribution mains unless otherwise approved by DWU Distribution Division.

2.11.1 Primary Considerations

2.11.1.1 Minimize Service Interruption:

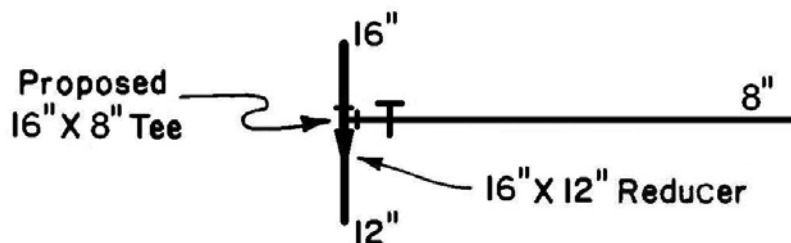
Connections are to be made in locations where existing valves can be closed to isolate the connection point while keeping as much of the surrounding system in service as possible. If not, a tapping sleeve and valve shall be used.



**Figure 2.11.1.1:
Connection to Existing Water Main by Tapping**

2.11.1.2 Minimize Headloss:

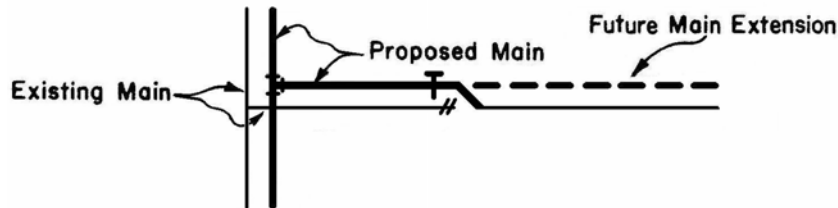
Connection types which result in unnecessary head losses are to be avoided, if possible. Connections using 90° bends should be avoided whenever possible. In addition, when connecting a larger pipe to a smaller pipe with a tee, reducers are to be placed only on the straight sides, not on the branch (Figure 2.11.1.2).



**Figure 2.11.1.2:
Placement of Reducer at Tee**

2.11.1.3 Provision for Future Replacement:

Connections are to be designed to facilitate future replacements and improvements. Additional piping, valves, and fittings shall be used where necessary to accommodate future replacements.



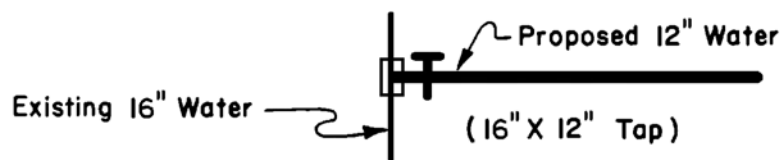
**Figure 2.11.1.3:
Connection to Existing Water Main for Future Extension**

2.11.1.4 Methods of Connection:

2.11.1.4.1 Tapping Sleeve and Valve:

Tapping sleeve and valve shall be used whenever possible for connections to existing mains in order to avoid interruption of water services.

- Taps are restricted to one standard pipe size smaller than the tapped pipe. If the existing main is 16", the largest pipe that can be tapped will be 12".

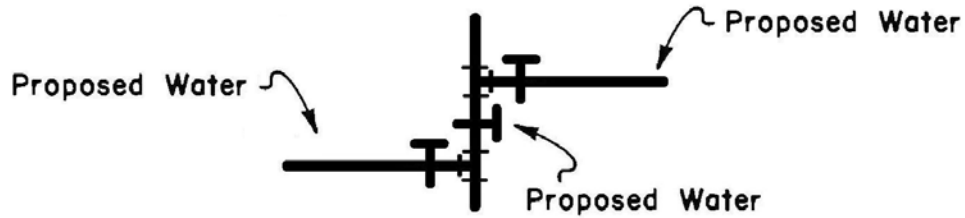


**Figure 2.11.1.4.1:
Tapping Criteria for Water Mains**

- For all concrete water mains, taps are restricted to no larger than 75% of the diameter of the tapped pipe.

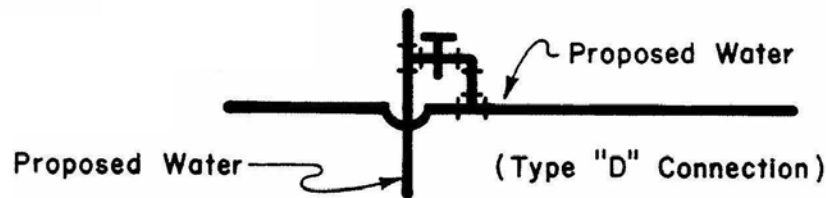
2.11.1.4.2 Connections:

- When connecting to a crossing water main, two tees with intervening valve(s) are required.



**Figure 2.11.1.4.2a:
Standard Connection**

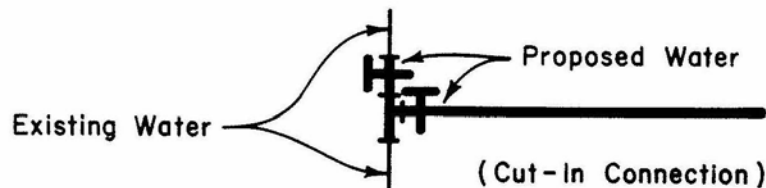
- Crosses are not permitted. However, Type-D connections may be allowed when other types of connection are not feasible.



**Figure 2.11.1.4.2b:
Type D Connection**

2.11.1.4.3 Cut-in Connection:

If a tap is not possible, or if the system needs an additional valve, then a cut-in connection with a valve and tee should be used.



**Figure 2.11.1.4.3:
Cut-In Connection**

2.12 WATER MAIN APPURTENANCES

2.12.1 Isolation Valves

2.12.1.1 Type and Spacing:

Following three (3) types of isolation valves to be considered for water mains:

- Vertical Gate Valve
- Horizontal Gate Valve
- Butterfly Valve

General criteria for various types of isolation valves are summarized in the following table:

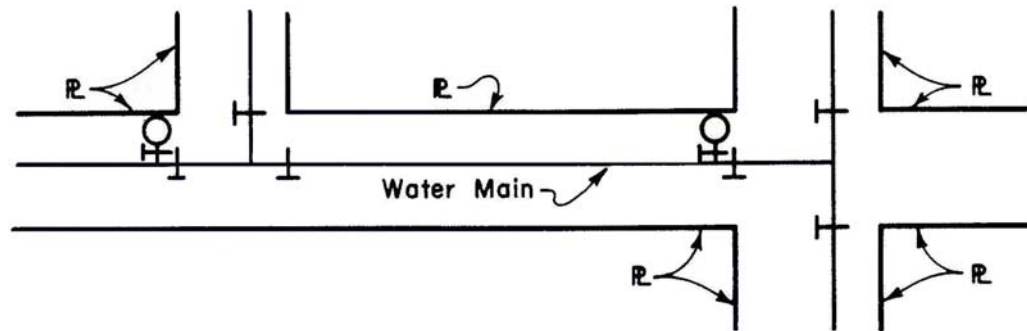
Table 2.12.1.1: Valve Spacing and Appurtenances Criteria

Valve Size (in)	Valve Type	Bypass Size (in)	Access Manhole Size (ft)	Valve Blow Off Manhole Size (ft)	Max. Spacing (ft)
16 or Smaller	Vertical Gate Valve	N/A	N/A	N/A	1000
18 thru 30	Horizontal Gate Valve w/ Integral Bypass and Access Manhole	As Per Manufacturer	5	N/A	As Per Distribution Division
36 thru 42			6	N/A	
48 thru 66	Butterfly Valve w/ External Bypass and Access Manhole	6	6	4	
72 thru 90		8	6	4	
96 or Larger		12	6	4	

2.12.1.2 Location:

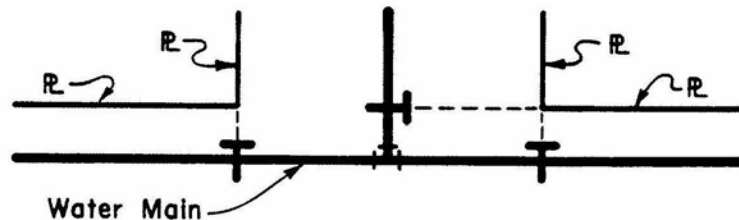
Following guideline should aid designer in placement of valves:

- 2.12.1.2.1 Valves shall be designed at locations that will not unduly impact the customer or reduce fire protection and be easy to locate.
- 2.12.1.2.2 Valves are to be located such that three valves are normally required to isolate a section of main.



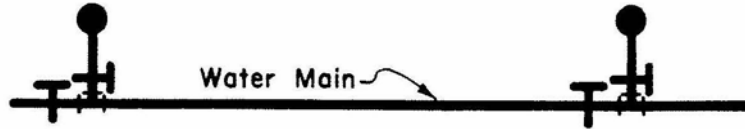
**Figure 2.12.1.2.2:
Valve Location Configuration**

- 2.12.1.2.3 The total number of valves at any water main intersection shall equal total number of lines leading out from the intersection point minus one, such as minimum two valves to be used at a tee.
- 2.12.1.2.4 Valves, except tapping sleeve and valves shall be located at street intersections at the projection of property lines projected across the water main.



**Figure 2.12.1.2.4:
Valve Location at Street Intersection**

- 2.12.1.2.5 All fire hydrants shall have a mainline valve adjacent to the fire hydrant lead or positioned such that the closing of three valves shuts down the main and only puts one fire hydrant out of service.



**Figure 2.12.1.2.5:
Valve between Fire Hydrants**

- 2.12.1.2.6 Valve shall not be located at the street gutter, roadside ditch slope or flowline.

2.12.1.3 Reference Schematics:

DWU Standard Drawing Nos. 212- 218

2.12.2 Fire Hydrants

2.12.2.1 Spacing:

The general spacing between fire hydrants are summarized in the following Table:

Table 2.12.2.1: Fire Hydrant Spacing

Dwelling Type	Spacing (ft)	Remarks*
Single Family Residential Development or Single Family Duplex	700	A fire hydrant shall be located so to reach each building with no more than 400 feet of hose along the most direct route considering all physical impediments.
All Other Areas	500	A fire hydrant shall be located so to reach each building with no more than 300 feet of hose along the most direct route considering all physical impediments.

* Maximum hose laying rule may not be applicable for extra large lots which should be evaluated on case by case basis

2.12.2.2 Location:

- Water main serving a fire hydrant must be 8" or larger and the minimum acceptable fire hydrant lead is 6"
- No more than one fire hydrant will be allowed on a dead end main.
- Fire hydrant shall be located as near to the street intersections as possible but out of the radius of curb turnouts, within 2.5 to 7.5' behind curb or projected future curb.
- Fire hydrant locations between street intersections shall be at the projection of a property line between owners.
- New fire hydrants shall be placed as near the location of the existing fire hydrant to be replaced as possible.
- Rail lines, controlled access highways, divided roadways, fences and walls will inhibit laying the fire hose in the most direct route and must be considered as barriers.
- For commercial development, provide an isolation valve at each end of fire loop requiring a fire hydrant.
- The Fire Marshall will establish or approve the location of fire hydrants in apartment complexes, platted private street developments, and other multifamily developments within the City and Extra Territorial Jurisdiction (ETJ).

2.12.2.3 Color Code:

- Typical Color to be used for fire hydrants are as follows

Table 2.12.2.3: Fire Hydrant Color Code

Main Size (in)	Fire Hydrant Color
4	Red
6	Silver
8	Blue
10+	Yellow

Note: All new water main serving a fire hydrant must be 8" or larger

2.12.2.4 Reference Schematic:

- DWU Standard Drawing No. 224.

2.12.3 Flush Points

2.12.3.1 General Requirements

- Flush Points are to be installed primarily to flush water mains as needed

2.12.3.2 Type

Two types of Flush Points are typically used for water mains:

- Manually Operated Flush Point
- Automatic Flush Point
 - Automatic Flush Points can only be installed within water quality regions where frequent flushing may be required, contingent upon Distribution approval.
 - An Automatic Flush Point can be used where it can be flushed into a storm drain, wastewater manhole lateral or natural ditch, as needed.

2.12.3.3 Location

- Deadend mains
- Backflow Preventer
- High/Low Valve Assembly

2.12.3.4 Reference Schematic

- Manually Operated Flush Point Assembly:
DWU Standard Drawing No. 207
- Automatic Flush Point Assembly
DWU Standard Drawing Nos. 207A

2.12.3 Water Services

2.12.3.1 General Requirements:

- Each lot must have its own water service which must not cross any existing or projected lot line(s).
- Water services are not to cross railroad, interstate or state highways.
- Water service shall be at least one size smaller than the proposed or existing main. Size on size connections are generally not allowed unless special permission is granted from Distribution Division.

2.12.3.2 Small Water Service:

- Typical small water services range from 3/4" through 2" in diameter. Water service over 30 feet shall be a minimum of 1" in diameter.
- Water service shall be located at the center of the lot from the main to a point beyond the curb line known as "Deadhead" until the meter box is installed.
- Apartment complex and commercial development usually will require coordination of the deadhead location with architectural or plumbing plans.
- Designer shall show all DWU service meters on drawings

2.12.3.3 Large Water Service:

- Typical large water services are greater than 2" in diameter (**Table 2.12.3.3**).
- Large service meter vaults shall be located in areas adjacent to right-of-way with easy access and with protection from vehicular traffic.
- Designer shall work with DWU Distribution on the evaluation of all large meter vaults.

Table 2.12.3.3: Large Water Service

Large Service Type	Purpose
Domestic Water	Domestic waterline through single waterline and meter
Closed Fireline	Fireline to serve automatic sprinklers only
Combined Water	Fire protection and domestic water through a single water service and meter
Irrigation Water	Single water service for irrigation without a bypass

2.12.4 Air Valves

2.12.4.1 General Requirements:

- Air valves are to be installed primarily on all treated or untreated water transmission main to exhaust and admit air to prevent vacuum conditions and air related surges.
- Air valves are not required in smaller water distribution mains of 12" or small in diameter where fire hydrants and service connections provide a means for venting trapped air.
- The designer is responsible for selection, location and sizing of air valves.

2.12.4.2 Type:

There are three (3) basic air valves to be considered as per ANSI/AWWA C512:

- Air Release Valve (ARV)
- Air/Vacuum Valve (AVV)
- Combination Air Valve (CAR)

2.12.4.3 Locations:

Following locations shall be considered for locating air valves:

- High Points: Combination Air Valve
- Long Horizontal Runs: Air Valve or Combination Air Valve at 1250- 2500 ft. intervals
- Long Descents: Combination Air Valve at 1250 to 2500 ft. intervals
- Long Ascents: Air/Vacuum Valves at 1250 to 2500 ft. intervals
- Decrease in an Up Slope: Air/Vacuum Valve
- Decrease in a Down Slope: Combination Air Valve

It should be noted that Combination Air Valves can be used at any location in lieu of Air Release or Air/Vacuum Valves to provide added air release capacity on the pipeline. It is also important to establish a smooth pipeline grade in order to avoid an excessive number of air valves and not to follow the terrain. In addition, the height of the air vent riser shall be evaluated on case-by-case basis in order to be well above 100-year flood plain.

The following **Figure: 2.12.4.2** illustrates various locations of air valves:

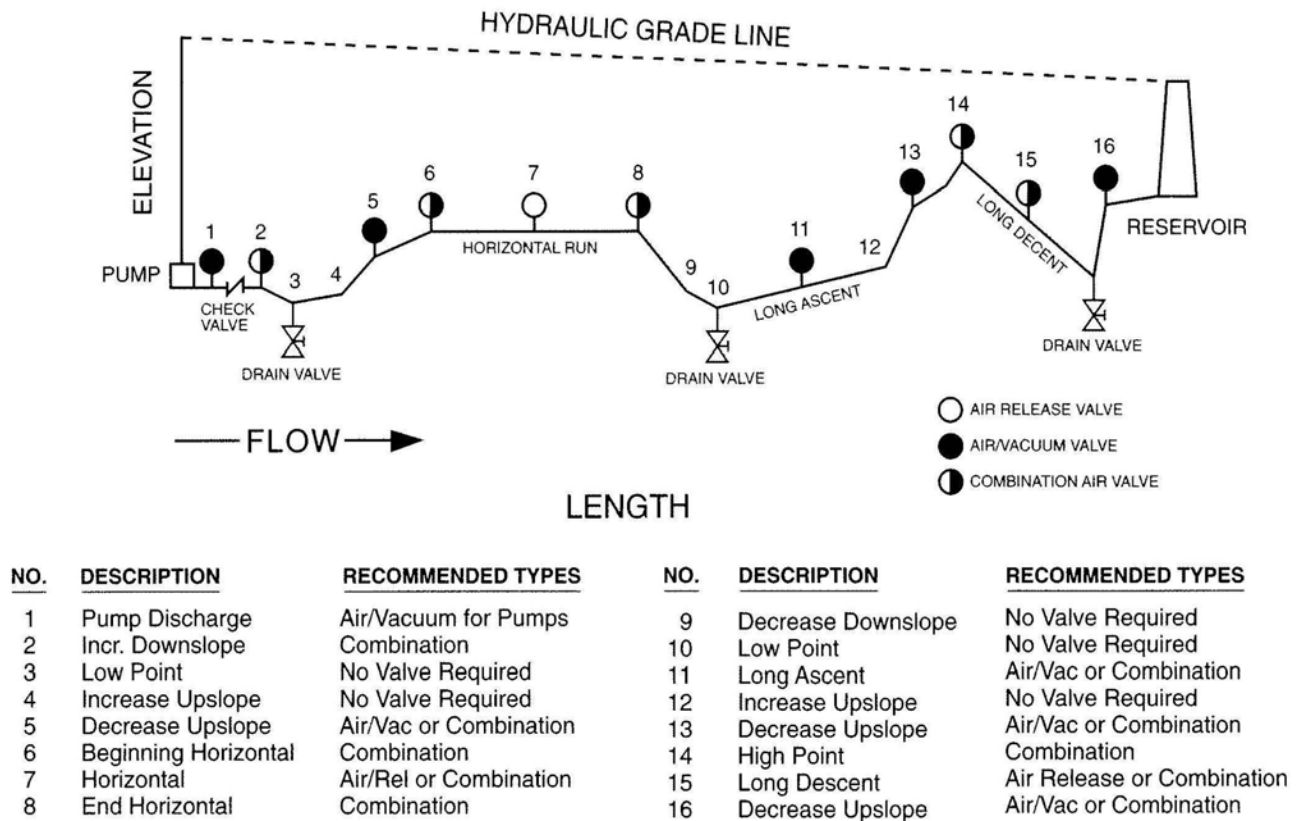


Figure: 2.12.4.2:
Sample Pipeline Profile Illustrating Air Valve Locations

Source: *Manual of Water Supply Practice, M51: Air-Release, Air/Vacuum & Combination Air Valve*
by AWWA, First Edition, 2001

2.12.4.3 Sizing:

Air valve can be sized as per “Manual of Water Supply Practice, M51: Air-Release, Air/Vacuum & Combination Air Valve by AWWA, latest edition” or other methods as applicable.

2.12.4.4 Reference Schematic

- Type I Air Release Valve Assembly:
DWU Standard Drawing No. 208 for 2” valve
- Type II Air Release Valve Assembly
DWU Standard Drawing Nos. 209-210 for large than 2” valve

2.12.5 Pitot Outlet

2.12.5.1 General Requirements:

- If requested by Distribution Division, pitot outlets can be installed on water transmission mains of 20" or larger. These outlets are typically used to calculate the flow rate, roughness coefficient, and the head loss between locations. The calculated roughness coefficient and head loss calculations indicate the condition of the interior of the pipe.
- Pitot outlets shall consist of a tube having a short right angled bend which is to be placed vertically in the large water pipe with the mouth of the bend directed upstream and used with a manometer to measure the velocity of the water.

2.12.5.2 Design Consideration:

- Pitot manholes are to be located at least 20 (twenty) pipe diameters from a bend, valve or other feature that would create turbulence.
- The location shall not be excessively deep and are to be in an area that is accessible to vehicles which transport the testing crew and equipment.
- Connections to the transmission line shall be located outside the boundary of the two manhole locations used for the test. If this cannot be accomplished, the connecting mains shall have valves that isolate them from the tested section.
- The water main between the two pitot outlets must be of same pipe size, pipe material, and approximately the same age.
- Pitot manholes are to be spaced so there will be at least ten feet of head loss. To estimate the potential head loss, assume a velocity of 3 fps and a Hazen- Williams coefficient of 130.

2.12.5.3 Minimum Spacing:

The following tables show suggested minimum spacing between pitot outlets:

**Table 2.12.5.3:
Spacing between Pitot Outlets**

Pipe Dia. (in)	Spacing Between Pitot Outlet (ft)
20	7,500
24	8,500
30	11,500
36	12,500
42	13,500
48	18,500
54	21,700
60	23,400
66	27,200
72	28,700
84	32,200
96	41,000

Note: If computer simulations, pumping rates, or other information indicates that velocities may exceed three fps, the distances shown in the table may be reduced.

2.12.5.4 Reference Schematic:

- DWU Standard Drawing. No. 220

2.12.6 Mainline Blowoff Manhole

Mainline Blowoff manhole shall be considered for all water transmission mains at the following locations in order to flush the mains, if necessary:

- At low points
- At isolation valves (>48" diameter) where the main slopes towards the valve

Minimum size of Mainline Blowoff Manhole shall be five (5) feet in diameter. However, Valve Blowoff Manhole of four (4) feet in diameter may be allowed at isolation valves where direct access to pipe is not required.

2.12.7 Access Manhole

Access manhole shall be considered for the water transmission mains of 48" or larger in diameter under following conditions, as necessary:

- Every 1000 feet
- Tunnel entry/exist locations

However, 30" flanged outlets for air release valve, blowoff valve or pitot outlets assembly can be used as access points in lieu of access manholes.

2.12.8 Backflow Preventer

Backflow preventer shall be considered at the following locations in order to protect public water system from cross contamination:

- Commercial property water service line
- Dedicated irrigation lines
- Fire Lines
- Multi-residential units

2.12.9 High/ Low Valve

The DWU water distribution network shall be isolated from adjacent pressure zones by using closed valves known as “High-Low” valves and inter-looping mains. Two flush points are typically included, one on either side of the High-Low valves. DWU As-built water maps show the designated closed valves between pressure zones. The Distribution Division also maintains a "High-Low Closed Valve Book" that identifies the pressure zone boundaries. Water mains near a pressure zone boundary are looped within their pressure district to minimize dead end mains.

A typical High-Low valve assembly is shown in **Figure 2.12.9:**

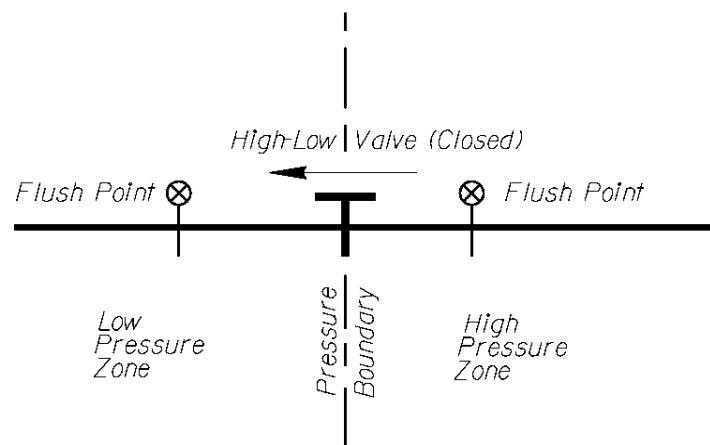


Figure: 2.12.9: High/Low Valve Assembly

2.12.10 Pressure Reducing Valves

2.12.10.1 General Requirements:

Pressure Reducing Valves (PRV) are to be designed to provide a steady pressure into a system that operates at a lower pressure zone than the supply zone as shown on **Figure: 2.2.2 and Table 2.2.2.**

- PRV shall be set for any desired downstream pressure within the design limits of the valve.
- PRV must be selected based on the flow and pressure not the size of the pipe to which they will be attached.
- PRV over sizing shall be avoided.

2.12.10.2 Configurations:

PRV can be designed with following configurations:

2.12.10.2.1 Single PRV Assembly:

This configuration is to be used to achieve basic pressure reducing application.

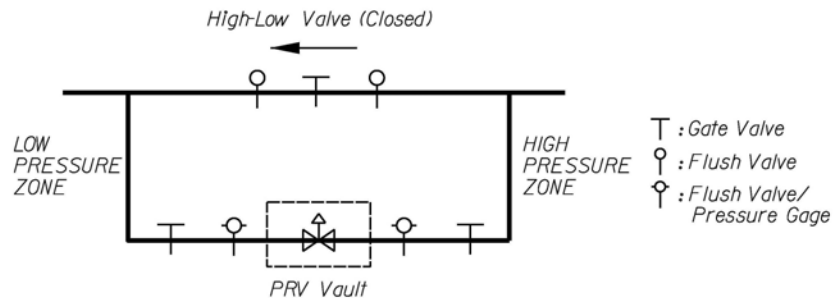


Figure 2.12.10.2.1: Single PRV Assembly

2.12.10.2.2 Two Parallel PRV Assembly:

This approach shall be used wherever there is a wide variation of reduced pressure requirements such as an apartment building where demand could be 0.5 gpm at 1am and 100 gpm at 6am and a continuous water supply must be maintained. This typical configuration shall be used at the major pressure boundaries of DWU water distribution system. However, when installing PRVs of equal diameters in parallel, the individual pressure settings cannot be equal as the valves will not respond equally and one valve will try to do most of the work. This is the most preferred PRV configuration for DWU.

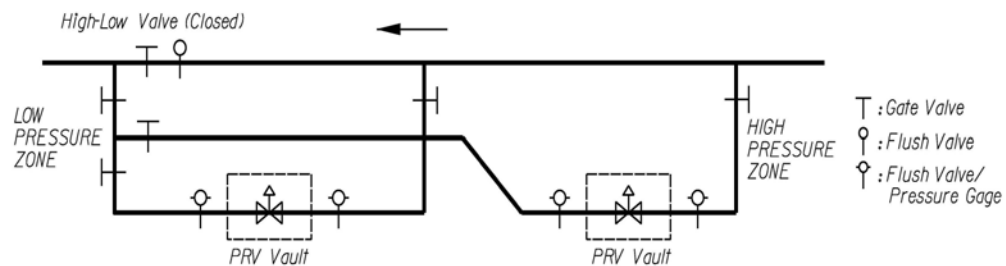


Figure 2.12.10.2.2: Two Parallel PRV Assembly

2.12.10.2.3 Two Stage Series PRV Assembly:

Two stage reduction is to be designed when initial pressures are 200 psi or greater, or when the desired pressure reduction ratio is greater than 4:1, e.g., from 200psi to 50psi, or where the inflow pressure fluctuates greatly. This configuration is not common and can only be if requested by DWU.

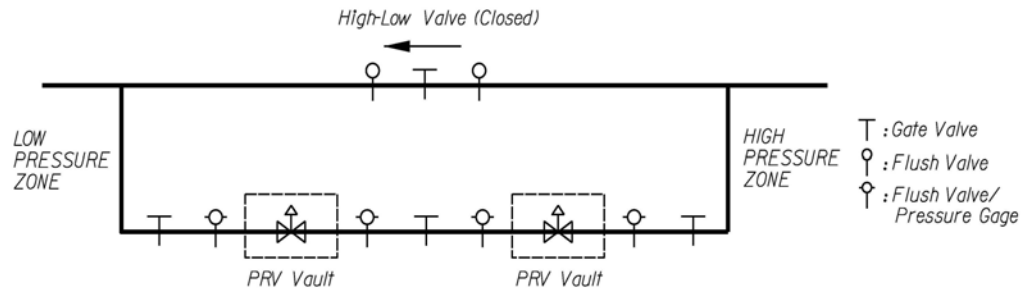


Figure 2.12.9.2.3: Two Staged Series PRV Assembly

2.12.10.3 Reference Schematic

- DWU Standard Drawing Nos. 239- 245.

2.12.11 Deadend Mains

2.12.11.1 General Requirements:

- Deadend main situations are to be avoided whenever possible since they have been known to cause taste and odor problems and low chlorine residuals.
- All deadend mains must have a provision so that it can be periodically flushed of stagnant water through a flushing device.
- If the deadend pipe is greater than 300' in length it is generally required for the line to have a fire hydrant or flush point installed at the end.

2.12.11.2 Special Consideration:

- If the deadend main is 8" or larger, a fire hydrant shall be installed five (5) feet from the end.

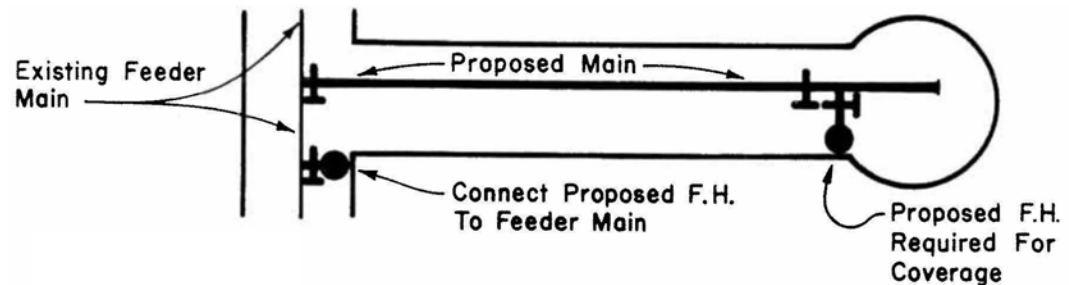


Figure 2.12.11.2: Deadend Mains

- No more than one fire hydrant shall be connected to a dead-end main
- If the dead-end is less than 8" a flushing device shall be installed.

2.12.11.3 Reference Schematics:

- DWU Drawing No. 224 for Fire hydrant
- DWU Drawing No. 207 for Flush Point

2.13 CORROSION PROTECTION

This section is applicable to all metal water pipes where corrosive environments or soil may potentially damage the pipes and appurtenances. Typically, soil resistivity less than 1000 ohms-cm can be considered as extremely corrosive soil.

2.13.1 Terminology

2.13.1.1 Corrosion Principles:

Corrosion can be defined as physical degradation of a metal due to the electro-chemical reaction involving transfer of electron between the pipe metal and the surrounding environment. For iron corroding in water with a near neutral pH, corrosion involve two half-cell reactions:

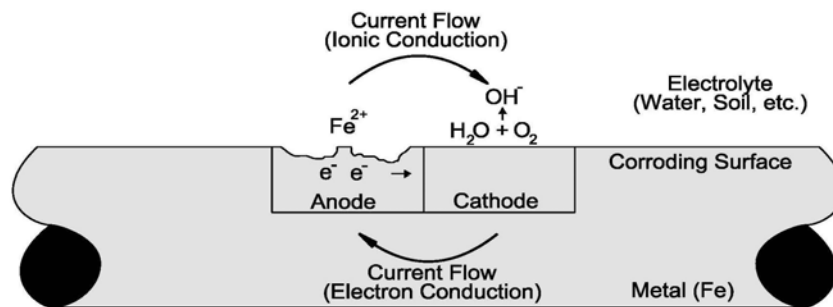
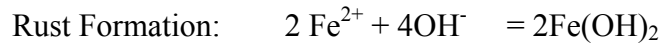
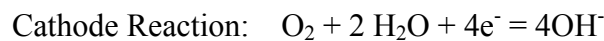


Figure 2.13.1.1: Corrosion Principle

2.13.1.2 Galvanic Corrosion:

Galvanic corrosion occurs when two dissimilar metals electrically contact each other and are immersed in an electrolyte. This is most common form of external corrosion.

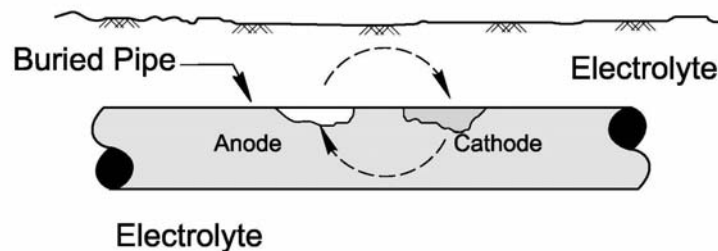


Figure 2.13.1.2: Galvanic Corrosion

2.13.1.3 Electrolytic Corrosion:

Electrolytic corrosion occurs due to outside source of direct current (DC). When stray currents from DC systems including railways, trolley bus systems or rectified protected gas mains are unintentionally picked up by a buried metallic pipeline, loss of metal will occur at any point where the current discharges from the unintended pipe (**Figure 2.13.1.3**).

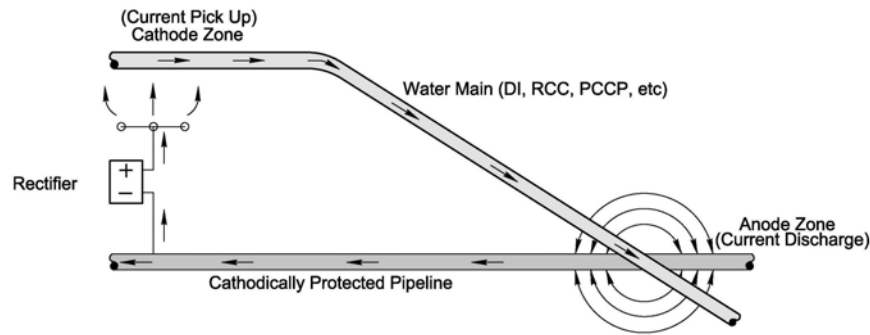


Figure 2.13.1.3: Electrolytic Corrosion

2.13.2 Preventive Requirements

2.13.2.1 Material Selection:

- PVC pipe shall be used for all mains 12" or smaller except as specified in §2.6.1.
- All RCCP, PCCP, DI, and Steel pipe shall be used with required dielectric coatings, as necessary.

2.13.2.2 Dielectric Coating:

External and internal protective coating shall be considered for all metallic pipes as necessary to limit the rate of cathodic reaction.

2.13.2.3 Electrical Isolation:

Isolating Joints by using insulating kits or other means are required to prevent galvanic corrosion for all metallic pipes in the following locations:

- Changes in pipeline materials
- Connections to existing piping, i.e. old and new piping
- Inlet and outlet piping of plant facilities
- Laterals from transmission mains
- Taps to existing RCCP, PCCP, DI, Steel pipes
- Valve to RCCP, PCCP, DI, Steel pipes
- Metallic casing spacer to RCCP, PCCP, DI, Steel pipes

2.13.2.4 Polyethylene Encasement:

- All DI pipe and fittings shall be poly wrapped.

2.13.3 Monitoring Requirements

2.14.3.1 Corrosion Test Station (CTS):

All RCCP, PCCP, DI and Steel pipe of 16" or larger shall be designed with CTS at least at every 1000 feet to measure any potential current or resistance.

2.13.3.2 Electrical Continuity:

All pipelines shall be electrically continuous between CTSs through joint bonding wires, or welded joints, as necessary.

2.13.4 Corrosion Protection System (CPS)

If necessary, water main Corrosion Protection System (CPS) is to be designed to introduce an external DC current which makes the structure a cathode. The CPS must be designed by a NACE certified professional engineer with considerable experience in corrosion engineering.

2.13.4.1 Corrosion Survey:

A detailed corrosion survey shall be conducted along the proposed or existing water main alignments. This investigation, shall include, but not be limited to the followings:

- Field soil resistivity measurements
- Soil and groundwater sample analysis
- Stray DC earth current and foreign line cathodic protection system activity
- Identification of potential corrosion problems

2.13.4.2 Data Evaluation:

All field and laboratory data obtained from the corrosion survey shall be used to develop corrosion prevention and monitoring design recommendations.

2.13.4.3 Final Design:

Based on the corrosion survey and subsequent data evaluation and approval by DWU, a corrosion protection system shall be designed, if necessary. This system may include, but not be limited to, the following methods:

2.14.4.3.1 Galvanic Protection (GP) System: Current generated from metal at higher energy level.

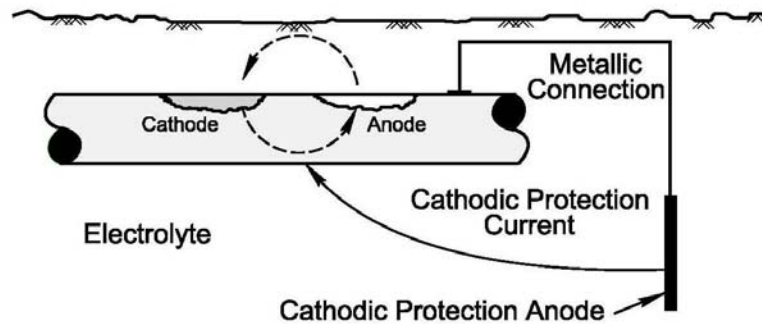


Figure 2.13.4.3.1: Galvanic Protection (GP) System

2.13.4.3.2 Impressed Current Cathodic Protection (ICCP) System: Current generated from transformer-rectifier energizing a relatively inert anode.

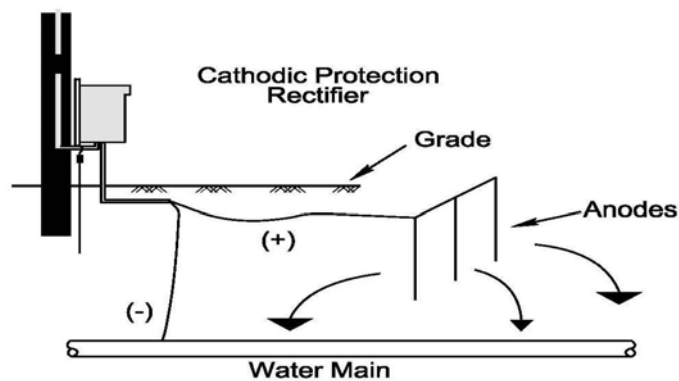


Figure 2.13.4.3.2: Impressed Current Cathodic Protection (ICCP) System.

2.14 ABANDONMENT OF WATER MAINS AND APPURTENANCES

2.14.1 Water Mains

- Mains shall be abandoned by cutting and plugging and it is not necessary to remove the existing pipe.
- The cut and plug shall be as close to the main left in service as practical unless there is other impending utility work planned that could disturb the plug. If the new main is to be constructed to connect to the existing main at the point of cut, a cut and plug is not required.
- If the main to be abandoned at a tap and valve, the abandoned tapping sleeve and valve shall be removed.
- If the construction necessitates abandoning the existing main prior to the new main being put in service, provisions must be made for temporary mains.

2.14.2 Fire Hydrants

- If a fire hydrant can be used for spare parts, the contractor will deliver the hydrant to the location as designated by the City.
- If the fire hydrant is not salvageable, it will become the property of the contractor for disposal.

2.14.3 Valves

2.14.3.1 Small Valve:

Valves smaller than 24" are not to be salvaged. Upon removal of the valve cover, stack and stem extension, the valve body must be abandoned by filling with 2 sacks per cubic yard mix of sand to a point at least 12 inches below the pavement.

2.14.3.2 Large Valve:

Valves 24" and larger may be salvaged if requested by the Distribution Division.

2.14.3.3 Reference Schematics:

- DWU Drawing No. 219 for 4"- 16" Gate Valve Abandonment

2.15 HYDROSTATIC TESTING & CHLORINATION

While this is not a requirement for design it should be considered by the designer when understanding the constructability and final acceptance of the water main. All assets must be tested an approved per TCEQ standard before placing into service.

2.15.1 General Requirements

All water mains shall be hydrostatically tested and chlorinated before being put in service. Only the City is permitted to perform the sterilization procedure.

2.15.2 Hydrostatic Testing

Hydrostatic testing of all water mains must be in accordance with Addendum to the NCTCOG Standards by DWU, Latest Edition.

2.15.3 Chlorination

Chlorination of all water mains must be in accordance with AWWA Standards as specified in Addendum to the NCTCOG Standards by DWU, Latest Edition (Ref: §506.6.2.COD-506.7.5.4.COD of the City of Dallas NCTCOG Addendum).

2.15.4 Disposal

The heavily chlorinated water can be hauled off in water trucks or discharged into wastewater manholes as approved by Wastewater Collection Division. It is important there be an air gap between the end of the discharge piping and the discharge point.

2.15.5 Flow Diagram: A typical hydrostatic and bacteriological testing process diagram of DWU water main can is shown below:

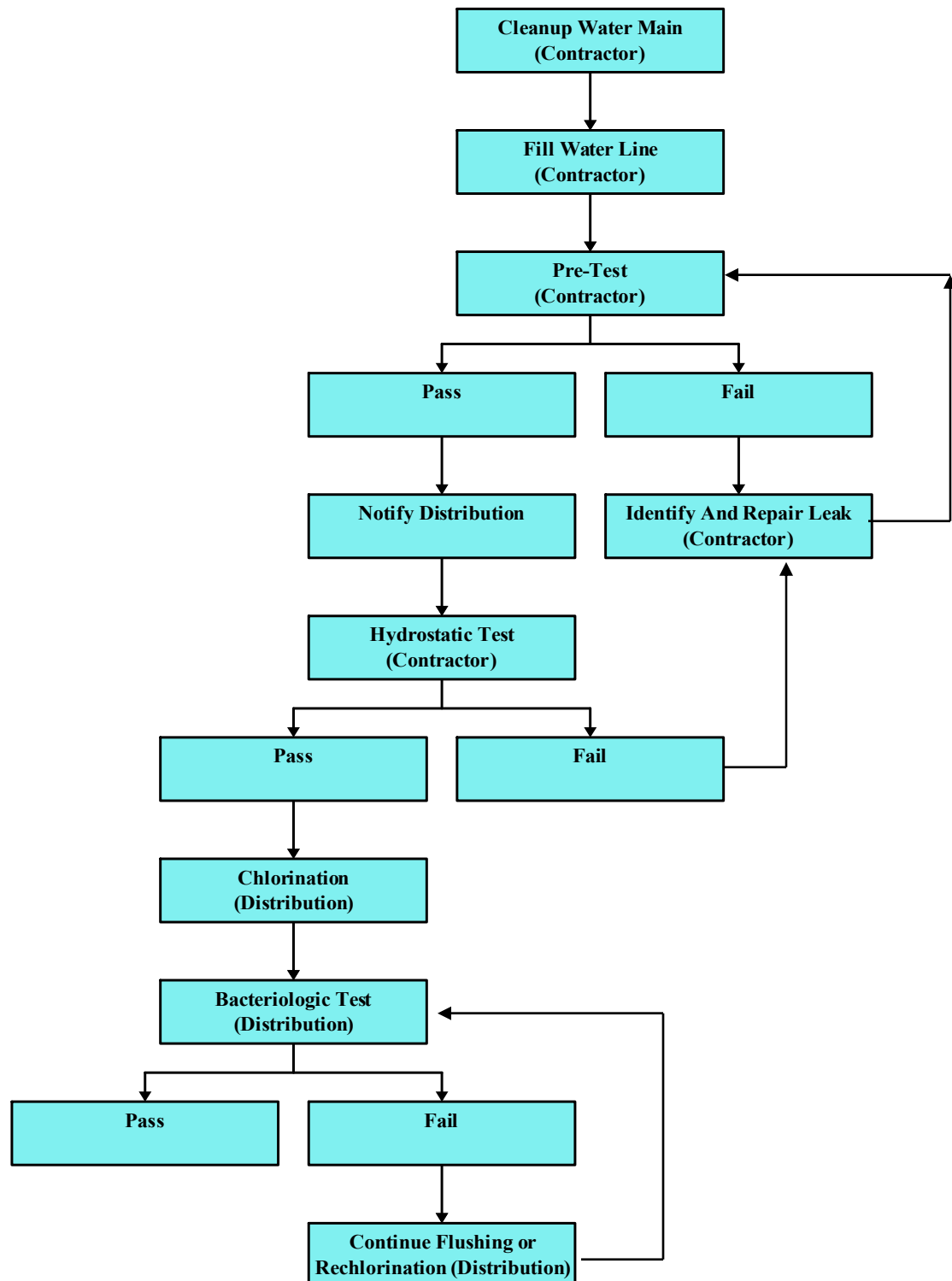


Figure 2.15.5: Flow Diagram for Hydrostatic & Bacteriological Testing Process

CHAPTER 3

WASTEWATER MAIN DESIGN GUIDELINES

3.1 REFERENCES

Wastewater main design shall be in conformance with “30 TAC §217: Design Criteria for Domestic Wastewater System” along with all applicable laws, regulations, codes and standards.

3.2 DWU WASTEWATER INFRASTRUCTURE:

3.2.1 Wastewater Basin and Wastewater Shed:

The DWU wastewater collection system is divided into a number of primary wastewater basins based on the drainage pattern for the wastewater within the basin. Based on 2007 Wastewater Master Plan, there are twelve (12) primary basins where ten (10) of the basins transport flow to DWU Wastewater Treatment Plants (WWTP). These basins are (alphabetically) the Elam Creek, East Bank, Five Mile Creek, Hickory Creek, Pleasant Grove, Prairie Creek, South Dallas, Warren Avenue, West Bank and White Rock Creek Basins. Each basin is named for, and discharges flow into, the major interceptor sewer line traversing the area. The other two primary basins transport flow to other regional sewer providers. These basins, the TRA and Garland basins, are named after the regional provider. **Figure 3.2** on the following page shows the basin delineations for the DWU wastewater service area.

The primary basins are further divided into smaller drainage basins, termed wastewater sheds. The wastewater infrastructure within these wastewater sheds consists of gravity collection mains, interceptor mains, lift stations and the permanent flow monitoring network, termed the Environmental Data Acquisition Telemetry (EDAT) system. The purpose of the EDAT system is to monitor wastewater flows in order to maximizing the performance of the City’s wastewater interceptor and treatment facilities and to give a preliminary indication of areas experiencing large or increasing amounts of inflow/infiltration (I/I). EDAT flow monitoring sites are strategically located within the collection system to collect flow data in the City’s interceptor mains.

DWU wastewater basins are wastewater sheds are shown in **Figure 3.2** and summarized in **Table 2.2**.

Table 3.2: DWU Wastewater Sheds/Basins

Basin Name/ Wastewater Shed No.	Wastewater Shed Name	Basin Name/ Wastewater Shed No.	Wastewater Shed Name
White Rock Basin		South Dallas Basin	
1	North White Rock	29	Oak Cliff
2	McKamy Branch	East Bank Basin	
3	Upper White Rock Relief	30	Shady Trail
4	Cottonwood Branch	31	Joe's Creek
5	Central Branch	32	Bachman Relief #2
6	Central White Rock	33	Bachman Relief #3
7	Ferris Branch	34	Bachman Creek Shorecrest
8			Bachman Relief #1
9	Lower West White Rock	36	Nobles Branch
10	Lower White Rock Relief #1	37	Knights Branch
11	Ash Creek	38	East Bank
12	Lower White Rock Relief #2	39	Cedar Springs Branch
13	Lower East White Rock Relief	40	Turtle Creek
14	South White Rock	41	Upper North Interceptor
15	Southside Diversion	42	Lower North Interceptor
16	Sludge Force Mains 1	43	Mill Creek
Elam Creek Basin		44	South Interceptor
17	Elam Creek	45	Lower East Bank 1
Prairie Creek		Warren Avenue Basin	
18	Prairie Creek	46	
Hickory Creek Basin		47	
19	Hickory Creek Interceptor	48	
Pleasant Grove Basin		TRA Basin	
20	Pleasant Grove Interceptor	U1	Upper TRA 1
Five Mile Basin		U2	Upper TRA 2
21	Lower Five Mile	L1	Lower TRA
22	Woody Branch	Garland Basin	
23	Upper Five Mile	G1	Garland
West Bank Basin			
24	West Bank		
25	Upper Coombs Creek		
26	Lower Coombs Creek		
27	Elmwood Branch		
28	Cedar Creek		

Source: DWU Comprehensive Wastewater Collection System Assessment, Oct 22, 2007

3.2.2 Wastewater Treatment Plants (WWTP) and Other Facilities:

DWU treats wastewater from the City and its wholesale customer cities at one of two wastewater treatment plants: the Central WWTP and the Southside WWTP (**Figure 3.2.2**). Both are advanced wastewater treatment plants producing a high quality discharge to the Trinity River.

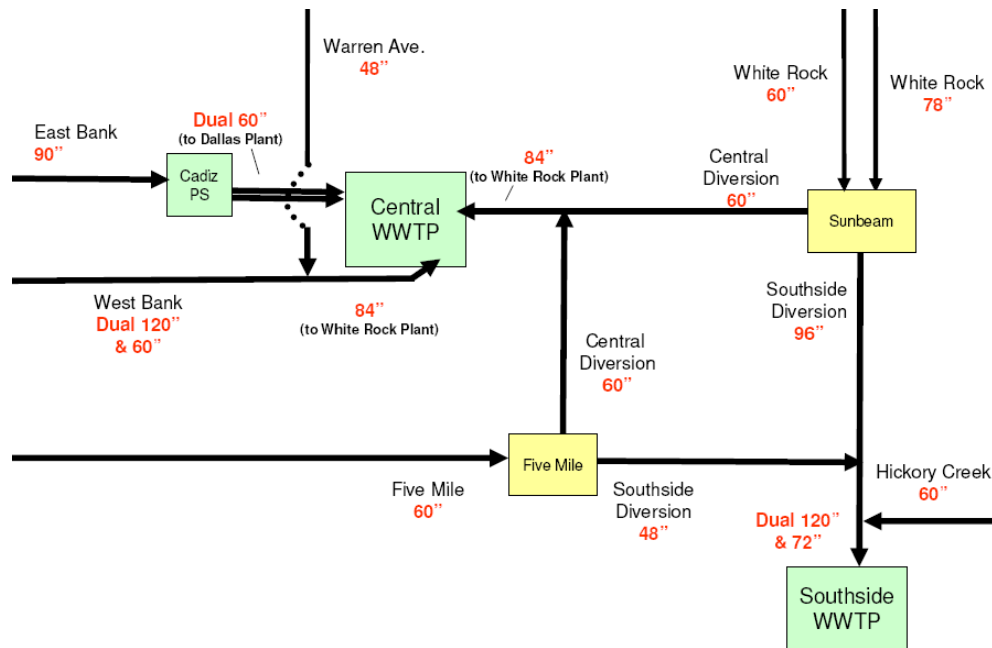


Figure 3.2.2: DWU Wastewater Treatment Plants (WTP)

Source: DWU Comprehensive Wastewater Collection System Assessment, Oct 22, 2007

In addition, there are approximately 14 lift stations and 50 permanent flow monitoring sites in the EDAT within the wastewater collection system. Locating, placing, and sizing new lift stations or permanent flow monitoring site within the system requires approval by both DWU Wastewater Collection and Engineering Services Divisions.

3.3 EVALUATION OF WASTEWATER MAINS FOR REPLACEMENT

Existing wastewater mains shall be considered for replacement if they meet one or more of the following criteria as approved by DWU Wastewater Collection System:

Table 3.3: Wastewater Main for Replacement Criteria

Criteria	DWU Measures
Structural Integrity	Pipe Age: 40 years or older mains, but age shall not be the lone factor Inflow/Infiltration (I/I): Presence of excessive sources of I/I including pipe joint offset, longitudinal or transverse pipe cracking, missing pipe, root intrusion and other defects as recorded by CCTV camera inspection, smoke testing, flow monitoring and other field investigation and data evaluation. A PACP score as per NASSCO is generally required before proceeding with the replacement of a wastewater main.
Capacity Analysis	Substandard Mains: Smaller mains (< 8") due to difficulties in maintenance and cleaning System Wide Growth: Wastewater main serving areas which is subjected to further growth
Regulatory	Sanitary Sewer Overflow (SSO): Wastewater mains subjected to backups and surcharge at adjacent manholes
Project Coordination	Wastewater Main Condition Check: Existing deteriorated wastewater mains in the vicinity of a proposed water main Minimize Pavement Cut: Existing mains shall be replaced if future maintenance of the main requires cutting of new pavement within next 10 years Wastewater Master Plan: Compliance to any specific recommendations as per current wastewater master plans

3.4 SIZING WASTEWATER MAINS

3.4.1 DWU Wastewater Collection System

Table 3.4.1: Wastewater Mains Classifications

Type of Main	Size Range (in)	Direct Service Connection
Collection	Less than 18"	Permitted
Interceptor	18" to 30"	*Not Permitted
	Larger than 30"	Not Permitted

**Note: Service connection may be allowed through a manhole upon approval from Wastewater Water Collection*

3.4.2 Wastewater Flow

Typically, 60-90% of the potable water is directed to a wastewater system. The rates most important to the design and operation of wastewater systems are as follows:

3.4.2.1 Average Daily Flow (ADF):

The average daily flow can be defined as the total annual volume of wastewater flowing into a wastewater system divided by the number of days of the year.

This rate is not used for collection and interceptor system design, but it shall be considered in wastewater system master planning and Wastewater Treatment Plant (WWTP) design.

3.4.2.2 Peak Hourly Flow (PHF):

The highest two-hour flow expected under any operational conditions, including times of high rainfall based on a two-year 24-hour storm or a prolonged period of wet weather.

Wastewater collection and interceptor and water treatment facilities are typically sized to carry the peak hourly wastewater flow.

3.4.2.2 Peak Daily Flow (PDF):

Each wastewater main shall be sized with peaking factor to appropriately handle infiltration and inflow. The peaking factor shall be evaluated by the designer from known metering and flow data for the particular basin or area under design. In absence of actual peaking flow, the following table can be used to determine the minimum peaking flow:

Table 3.4.2.2: Wastewater Peaking Factor*

Pipe Size	Peaking Factor	Depth of Flow
Less than 24"	4	Full
24" thru 42"	3	Full
Larger Than 42"	2	Full

**Peaking factors may be evaluated by the designer from known metering and flow data for the particular basin or area under design.*

3.4.3 Sizing Criteria

The wastewater mains shall be sized in accordance with any master plan established for that area. If a master plan is not available, the sizing of the wastewater pipe must be based on engineering analysis of initial and future flow of the area to be served. The collection and interceptor main shall be sized for the peak flow which is based on the estimated average daily flow. When site-specific data is unavailable, designer shall use the most conservative data while meeting or exceeding the minimum following criteria for sizing wastewater mains:

- **Velocity:** The velocity of wastewater main shall be maintained between 2 and 10 feet per second.
- **Service:** The size of the services must be at least one standard size smaller than the proposed and existing wastewater main.
- Comply with **Tables 3.4.3.1 and 3.4.3.2** as applicable

Table 3.4.3.1:
Wastewater Design Flow Estimation with Limited Available Data

Source	Remarks	Average Daily Wastewater Flow (gals/person)
Municipality	Residential	125
Subdivision	Residential	125
Trailer Park (Transient)	2½ Persons per Trailer	60
Mobile Home Park	3 Persons per Trailer	75
School	Cafeteria & Showers	20
	Cafeteria/No Showers	15
Recreational Parks	Overnight User	30
	Day User	5
Office Building Factory	A facility must be designed for the largest shift	25
		20
Hotel/Motel	Per Bed	75
Restaurant	Per Meal	10
Restaurant with bar or cocktail lounge	Per Meal	12
Hospital	Per Bed	250
Nursing Home	Per Bed	125
Apartments	Per Unit	300

Source (Modified): 30 TAC §217.32(a)(3): Design Organic Loading

Table 3.4.3.2: Criteria-2: Design Flow Estimation with Available Zoning/Property Data

		Zoning District	Land Use	Unit per Area*	Pop. per Unit**	Ave. Daily Demand per Capita (gpcd)	Ave. Daily Demand Per Unit (gpd)**
		A(A)	Agricultural (Agricultural, Single Family)	1 per 3 acre	3.25	140	455
RESIDENTIAL	Single Family	R-1ac(A)	Single Family	1 per 1 acre	3.25	140	455
		R-1/2ac(A)	Single Family	2 per 1 acre	3.25	140	455
		R-16(A)	Single Family	1 per 16000 sq. ft.	3.25	140	455
		R-13(A)	Single Family	1 per 13,000 sq. ft.	3.25	140	455
		R-10(A)	Single Family	1 per 10,000 sq. ft.	3.25	125	406
		R-7.5(A)	Single Family	1 per 7,500 sq. ft.	3.25	125	406
		R-5(A)	Single Family	1 per 5,000 sq. ft.	3.25	125	406
	Duplex/ Townhome	D(A)	Duplex	1 per 3,000 sq. ft.	2.5	125	313
		TH-1(A)	Townhouse	6 per acre	2.25	125	281
		TH-2(A)	Townhouse	9 per acre	2.25	125	281
		TH-3(A)	Townhouse	12 per acre	2.25	125	281
	Clustered Housing/ Multifamily	CH	Clustered Housing (Multi/Single Family)	18 per acre	2.0	125	281
		MF-1(A)	Multifamily	Min. Lot: 3,000 1,000 sq ft- E 1,400 sq ft- 1 BR 1,800 sq ft- 2 BR +200 sq ft each add BR	2.00 2.25 2.50	125	250 281 313
		MF-2(A)	Multifamily	Min. Lot: 1,000 8,00 sq ft- E 1,000 sq ft- 1 BR 1,200 sq ft- 2 BR +150 sq ft each add BR	2.00 2.25 2.50	125	250 281 313
		MF-3(A)	Multifamily	Min. Lot: 6,000 450 sq ft- E 500 sq ft- 1 BR 550 sq ft- 2 BR +50 sq ft each add BR	2.00 2.25 2.50	125	250 281 313
		MF-4(4)	Multifamily	Min. Lot: 6,000 225 sq ft- E 275 sq ft- 1 BR 325 sq ft- 2 BR +50 sq ft each add BR	2.00 2.25 2.50	125	250 281 313
		MH(A)	Mobile Home	1 per 4000 sq. ft.	2.50	125	313

Table 3.4.3.2 contd.
3

		Zoning District	Land Use	Unit per Area*	Pop. per Unit**	Ave. Daily Demand per Capita (gpcd)	Ave. Daily Demand Per Unit (gpd)**
NONRESIDENTIAL	Office	NO(A)	Neighborhood Office	0.5 FAR	1 per 400 sf	25	25 per 400 sf
		LO-1	Limited Office	1.0 FAR	1 per 400 sf	25	25 per 400 sf
		LO-2	Limited Office	1.5 FAR	1 per 400 sf	25	25 per 400 sf
		LO-3	Limited Office (Office, Lodge)	1.75 FAR	1 per 400 sf	25	25 per 400 sf
		MO-1	Mid-Range Office (Office, Lodging)	2.0 FAR	1 per 400 sf	25	25 per 400 sf
		MO-2	Mid-Range Office (Office, Lodging)	3.0 FAR	1 per 400 sf	25	25 per 400 sf
		GO(A)	General Office (Office, Lodging)	4.0 FAR	1 per 400 sf	25	25 per 400 sf
	Retail	NS(A)	Neighborhood Service	0.5 FAR	1 per 400 sf	25	25 per 400 sf
		CR	Community Retail	0.75 FAR overall 0.5 office	1 per 400 sf	25	25 per 400 sf
		RR	Regional Retail	1.5 FAR overall 0.5 Office	1 per 400 sf	25	25 per 400 sf
	Commercial/ Industrial	CS	Community Service	0.75 FAR overall 0.5 office/lodging/retail	1 per 400 sf	25	25 per 400 sf
		LI	Light Industrial	1.0 FAR overall 0.75 office/retail 0.5 retail	1 per 400 sf	25	25 per 400 sf
		IR	Industrial Research	2.0 FAR overall 0.75 office/retail 0.5 retail	1 per 400 sf	25	25 per 400 sf
		IM	Industrial Manufacturing	2.0 FAR overall 0.75 office/retail 0.5 retail	1 per 400 sf	25	25 per 400 sf
	Central Area	CA-1(A)	Central Area	20.0 FAR	1 per 400 sf	25	25 per 400 sf
		CA-2(A)	Central Area	20.0 FAR	1 per 400 sf	25	25 per 400 sf
	Mixed Use	MU-1	Mixed Use	0.8 FAR base 1.0 FAR max. + bonus for residential	1 per 400 sf	25	25 per 400 sf
		MU-2	Mixed Use	0.8 FAR base 1.0 FAR max. + bonus for residential	1 per 400 sf	25	25 per 400 sf
		MU-3	Mixed Use	0.8 FAR base 1.0 FAR max. + bonus for residential	1 per 400 sf	25	25 per 400 sf

Table 3.4.3.2 contd.
3

		Zoning District	Land Use	Unit per Area*	Pop. per Unit**	Ave. Daily Demand per Capita (gpcd)	Ave. Daily Demand Per Unit (gpd)**
NONRESIDENTIAL	Multiple Commercial	MC-1	Multiple Commercial	0.8 FAR base 1.0 max.	1 per 400 sf	18	18 per 400 sf
		MC-2	Multiple Commercial	0.8 FAR base 1.0 max.	1 per 400 sf	18	18 per 400 sf
		MC-3	Multiple Commercial	1.2 FAR base 1.5 max.	1 per 400 sf	18	18 per 400 sf
		MC-4	Multiple Commercial	1.6 FAR base 2.0 max.	1 per 400 sf	18	18 per 400 sf
	Urban Corridor	UC-1	Urban Corridor	10 DU/ acre 0.6 FAR base 2.0 max.	1 per 400 sf	18	18 per 400 sf
		UC-2	Urban Corridor	35 DU/acre 0.85 FAR base 3.6 max.	1 per 400 sf	18	18 per 400 sf
		UC-3	Urban Corridor	45 DU/acre 1.0 FAR base 4.5 max.	1 per 400 sf	18	18 per 400 sf
	Parking	P(A)	Parking	-	-	-	

Note: *FAR denotes to Floor Area Ratio and DU denotes to Dwelling Unit.

** Average daily demands for non-residential units are based on the assumption of 1 person per unit and 400 square feet (sf) per unit. Actual estimation shall be based on the designed floor area, FAR and DU as necessary.

3.4.4 Minimum Pipe Sizes

- The minimum pipe diameter for any public gravity wastewater collection main shall be 8 inches for maintenance and easy cleaning.
- 6" Pipe is not allowed for new wastewater mains.

3.4.5 Minimum and Maximum Slope

As per 30 TAC §217.53(l), following criteria must be used for selecting water main slope:

- All wastewater collection mains must contain slope sufficient to allow a velocity when flowing full of not less than 2 ft/sec.

- The maximum velocity of any wastewater collection system is restricted at 10 ft/sec when flowing full.

Accordingly, as per 30 TAC §217.53(2)(A), using “n factor” of 0.013 DWU acceptable slope are calculated are as follows:

Table 3.4.4: Allowable Wastewater Main Slope

Size of Pipe* (in)	Min. Slope (%)	Max. Slope (%)
6	0.50	12.35
8	0.33	8.40
10	0.25	6.23
12	0.20	4.88
15	0.15	3.62
18	0.11	2.83
21	0.09	2.30
24	0.08	1.93
27	0.06	1.65
30	0.055	1.43
33	0.05	1.26
36	0.045	1.12
39	0.04	1.01
>39	*	*

* 6" pipe will not be allowed for wastewater mains

** For pipe diameter greater than 39 inches in diameter, the slope is determined by Manning's Formula to maintain a velocity greater than 2.0 ft/sec and less than 10 ft/sec when flowing full

3.5 DEPTH OF COVER

The depth of cover is measured from the top of the pipe to the natural or finished ground surface above the pipe. The main must be deep enough to serve adjacent properties. Buoyancy of sewers shall be considered and flotation of the pipe shall be prevented with appropriate construction methods where high groundwater conditions are anticipated.

3.5.1 Terminology

- 3.5.1.1 Unimproved Area: Unimproved area is defined as public right-of-way or easements without permanent pavement including natural ground, asphalt pavement with no base, gravel surface and streets without curb and gutter.
- 3.5.1.2 Improved Area: Improved area is defined as public right-of-way or easements with paving and base including areas behind the curb, or streets where permanent pavement is proposed in the near future.

3.5.2 Minimum Cover

The following guideline applies to wastewater main installation in public right- of-way:

**Table 3.5.2:
Minimum Depth of Cover for Wastewater Main**

Size of Main		Min. Depth (ft)*	
	Unimproved	Improved	Highway/Railroad Crossing**
12" and Smaller	6	4	6
16"	6	5	6
20" and Larger	7	6	6

*** *Mains shallower than 3 feet will require special engineering evaluation and engineering controls.*

***Wastewater mains under highway and railroad right-of-way must also meet all additional criteria as required.*

3.6 WASTEWATER PIPE MATERIALS AND EMBEDMENT

3.6.1 Pipe Material Selection

Designers are responsible for specifying the type of pipe to be used in any wastewater main design. Pipe material shall be selected on the basis of lowest life cycle cost. Typically, minimum 150-psi pressured rated wastewater pipes (PVC ASTM D2241/SDR 26) or AWWA C905/DR (18) are preferred for small diameter (<18") pressure and gravity mains, as applicable.

3.6.2 Embedment Requirements

Designers shall specify the class of embedment on the design drawings. The type of embedment to be used is determined by pipe material and the depth of cover. The depth of cover is measured from the top of the pipe to the natural or finished ground surface above the pipe. Please see DWU Standard Drawing Nos. 113-119 for the details of various types of embedments.

General terminology of a typical pipe trench is as follows:

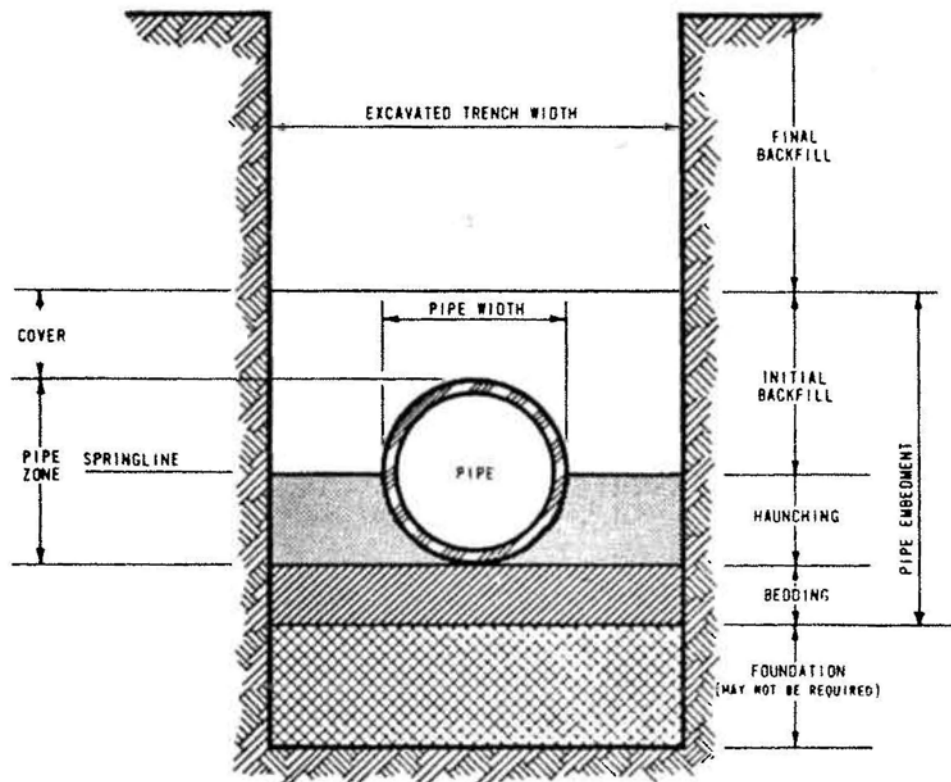


Figure 3.6.2: Typical Pipe Trench

Source: 30 TAC §217.54: Criteria for Laying Pipe

3.6.3 Recommended Pipe Material and Embedment

The following table summarizes recommended pipe material and embedment for wastewater mains:

Table 3.6.3: Recommended Wastewater Pipe Materials and Embedments

Pipe & Material Specification	Min. Pipe Stiffness (PS) (psi)	Allowable Size (in)	Joint Specification	Embedment Class Per Depth Of Cover (ft)
PVC ASTM D 3034 (SDR 35) (Solid Wall)	PS= 46	6"– 15"	Bell & Spigot ASTM D 3212	< 8' : B-1 8'- 25' : B-2 >25' : B-5 < 25' : Modified Flowable Backfill within Easement Engineering Evaluation Required
PVC ASTM F 679 (SDR 35) (Solid Wall)	PS= 46	18"– 48"		
PVC ASTM F 794 (Open Profile/ Dual Wall Corrugated Profile)	PS= 46	15"–48"		
PVC ASTM F 949 (Dual Wall Corrugated Profile)	PS= 46	6"–36"		
PVC ASTM F 1803 (Closed Profile)	PS= 46	21"–54"		
PVC- Pressure Rated* ASTM D 2241 (SDR 26)	PS= 160	6"–12"	Bell & Spigot Joints: ASTM D3139 Gasket: ASTM F477	< 8' : B-1a 8'-25': B-2a < 25' : Modified Flowable Backfill within Easement >25' : Engineering Evaluation Required
PVC- Pressure Rated* AWWA C 905 (DR 25)	PR= 165	14"– 30"	Bell & Spigot ASTM D 3139 AWWA C 905	

*Typically, minimum 150-psi pressured rated wastewater pipes [(PVC ASTM D2241/SDR 26, AWWA C905/DR (18)] are preferred for all small diameter (<18") gravity and pressure main replacements

Table 3.6.3: Recommended Materials for Wastewater Pipe and Embedment
(Contd.)

3

Pipe & Material Specification	Min. Pipe Stiffness (PS) / Stiffness No. (SN)	Allowable Size (in)	Joint Specification	Embedment Class Per Depth Of Cover (ft)
RCP*** ASTM C 76 Specify Class I, II, III, IV, V		54" – 120"	Bell & Spigot ASTM C 361	< 3.5' : G
RCP*** ASTM C 361 Specify Class A, B, C, D		54" – 102"		3.5'-10' : C >10' : B
PCCP-Embedded Cylinder AWWA C 301		54" – 144"	Bell & Spigot AWWA C 301	< 10' : C > 10' : B
HDPE ASTM F 894	PS= 46 psi	18" – 96"	Bell & Spigot Joints: ASTM D3212 Gasket: ASTM F477	< 8' : B-1 8'-25': B-2
HDPE ASTM F714 (DR 17) <i>Specify DIPS Only</i>	PS= 125 psi	6" - 30"	Fusion ASTM F2620	< 25' : Modified Flowable Backfill Within Easement
HDPE- Pressure Rated ASTM F714 (DR 11) <i>Specify DIPS Only</i>	PS= 200 psi	6" - 30"	Fusion ASTM F2620	>25' : B-5 Engineering Evaluation Required

*** RCP Pipe shall only be installed with plastic or sprayable liner as approved by Wastewater Collection Division

Table 3.6.3: Recommended Materials for Wastewater Pipe and Embedment

(Contd.)

Pipe & Material Specification	Min. Pipe Stiffness (PS) / Stiffness No. (SN)	Allowable Size (in)	Joint Specification	Embedment Class Per Depth Of Cover (ft)
RTRP^a & RPMP^b ASTM D 3262 (Fiberglass)	SN= 46 psi	18" – 102"	Bell & Spigot Joints: ASTM D3212 Gasket: ASTM F477	< 8' : B-1 8'-25': B-2 < 25' : Modified Flowable Backfill within Easement >25' : Engineering Evaluation Required
Pressure-Rated RTRP^a & Pressure-Rated- RPMP^b ASTM D 3754 (Fiberglass)	SN ≥ 150 psi	18"–102"	Bell & Spigot Joints: ASTM D3212 Gasket: ASTM F477	< 8' : B-1a 8'-25': B-2a < 25' : Modified Flowable Backfill within Easement >25': Engineering Evaluation Required
VCT ASTM C 700		6"–24"	Bell & Spigot Joints: ASTM C425 Gasket: ASTM C425	< 3 ½' : G 3 ½'-10': C >10' : B

^a RTRP denotes Reinforced Thermosetting Resin Pipe

^b RPMP denotes Reinforced Polymer Mortar Pipe

Any pipe material not listed in this table shall use the manufacturers recommended embedment and will require approval from DWU.

3.7 LOCATION

3.7.1 New Wastewater Mains

New wastewater mains shall be placed in the appropriate standard allocation zone as shown in §1.11.2:

- Mains are to be located in the allocated zone in the center of the street.
- Wastewater manholes shall not be located in the flowline of an existing creek or drainage area. The main may follow the alignment of the creek along the high bank. If necessary, two parallel mains may be designed on either sides of the creek to serve the drainage area.

3.7.2 Replacement Mains

Replacement of wastewater mains shall be located in the standard allocation zone as per §1.11.2 whenever possible:

- Install the replacement main in the same trench as the existing main at six (6)-twelve (12) inches below the existing grade, if feasible
- Install the replacement main three (3) feet parallel to the existing main, as measured from the outside edge of both.

3.8 HORIZONTAL ALIGNMENT

- All mains should be laid as straight as possible between street intersections.
- If curves are justified, the minimum radius of curve and maximum deflection angle of pipe joints are to be restricted to 80% of the manufacturer's recommendation.
- Stations shall be to the tenth of a foot (Ex: STA. 10+11.4).

3.9 VERTICAL ALIGNMENT

- Mains shall be straight between manholes, but excessive depths should be avoided. Drop manholes may be used to minimize excessive depth, as necessary
- Vertical bends are not allowed
- Design slopes shall be to the nearest hundredth of a percent (Ex: Slope 5.20%).
- Elevations shall be shown to the nearest hundredth of a foot (Ex. El. 495.95).

3.10 SEPARATION DISTANCE BETWEEN WASTEWATER AND WATER MAINS

When a wastewater main is built near an existing water facility, conveyance, or appurtenances, 30TAC §217.53.d governs the minimum separation distances.

3.10.1 Pipe Trench

Collection system pipes must be installed in trenches separate from public water supply trenches.

3.10.2 Ideal Case

Collection system pipes must be no closer than nine feet in any direction to a public water supply line.

3.10.3 Variances

If a nine-foot separation distance cannot be achieved, the following guidelines will apply as per 30TAC §217.53.d(3):

3.10.3.1 New Wastewater Installation- Parallel Lines:

If a collection system parallels a public water supply pipe the following requirements will apply:

3.10.3.1.1 Pipe Material: A collection system pipe must be constructed of cast iron, ductile iron, PVC or other materials meeting ASTM specifications with at least 150 pounds per square inch (psi) pressure rating for both the pipe joints.

3.10.3.1.2 Vertical Separation: A vertical separation must be at least two feet between the outside diameters of the pipes.

3.10.3.1.3 Horizontal Separation: A horizontal separation must be at least four feet between the outside diameters of the pipes.

- 3.10.3.1.4 Vertical Location: A collection system pipe must be below a public water supply line.

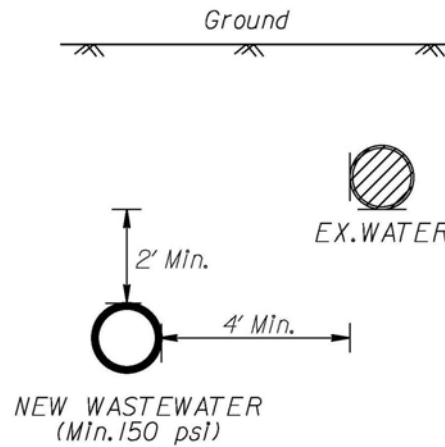


Figure 3.10.3.1:
New Wastewater Main Parallel to Existing Water Main

3.10.3.2 New Wastewater Installation- Crossing Lines:

If a collection system pipe crosses a public water supply pipe, the following requirements apply:

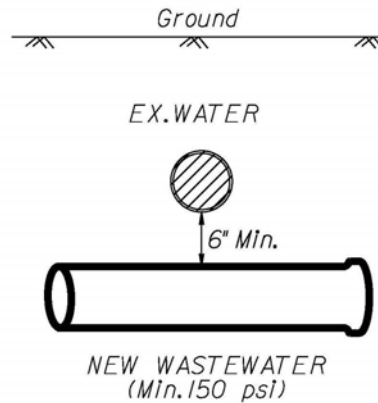
3.10.3.2 .1 Criteria for Pressure Rated Wastewater Pipe Material:

If a collection system is constructed of cast iron, ductile iron, or PVC with a minimum pressure rating of 150 psi, the following requirements apply:

3.10.3.2 .1.1 *A minimum separation distance is six inches between outside diameters of the pipes.*

3.10.3.2 .1.2 *A collection system pipe must be below a public water supply pipe.*

3.10.3.2 .1.3 Collection system pipe joints must be located as far as possible from an intersection with a public water supply line.



**Figure 3.10.3.2.1:
Criteria for Pressure-Rated Wastewater Pipe Material**

3.10.3.2 .2 Criteria for Non-Pressure-Rated Wastewater Pipe Material:

If a collection system pipe crosses under a public water supply pipe and the collection system pipe is constructed of acrylonitrile butadiene styrene (ABS) truss pipe, similar semi-rigid plastic composite pipe, clay pipe, or concrete pipe with gasketed joints, the following requirements apply:

3.10.3.2 .2.1 A minimum separation distance is two feet.

3.10.3.2 .2.2 If a collection system pipe is within nine feet of a public water supply pipe, the initial backfill around the collection system pipe must be:

3.10.3.2 .2.2.1 Sand stabilized with two or more 80 pound bags of cement per cubic yard of sand for any section of collection system pipe within nine feet of a public water supply pipe.

- 3.10.3.2 .2.2.2 *Installed from one quarter of the diameter of the collection system pipe below the centerline of the collection system pipe to one pipe diameter (but not less than 12 inches) above the top of the collection system pipe.*

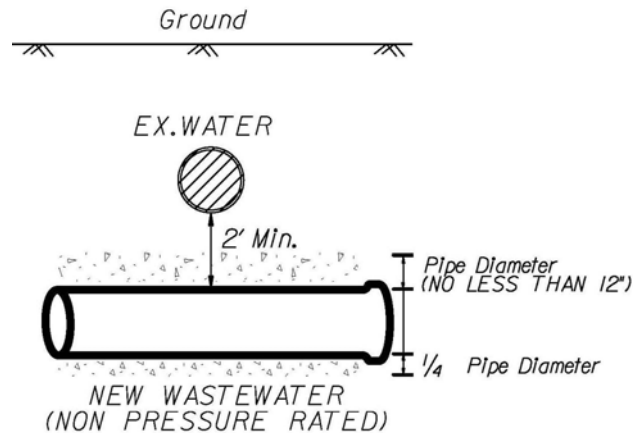


Figure 3.10.3.2.2:
Criteria for Non-Pressure-Rated Wastewater Pipe Material

- 3.10.3.2 .3 Criteria for Wastewater Pipe over Water Pipe: If a collection system crosses over a public water supply pipe, one of the following procedures must be followed:
- 3.10.3.2 .3.1 *Each portion of a collection system pipe within nine feet of a public water supply pipe must be constructed of cast iron, ductile iron, or PVC Pipe with at least a 150 psi pressure rating using appropriate adapters.*
- 3.10.3.2 .3.2 *A collection system pipe must be encased in a joint of at least 150 psi pressure class pipe that is:*
- 3.10.3.2 .3.2.1 *Centered on the crossing;*
 - 3.10.3.2 .3.2.2 *Sealed at both ends with cement grout or manufactured seal;*
 - 3.10.3.2 .3.2.3 *At least 18 feet long;*
 - 3.10.3.2 .3.2.4 *At least two nominal sizes larger than the wastewater collection pipe; and*

3.10.3.2 .3.2.5 *Supported by spacers between the collection system pipe and the encasing pipe at a maximum of five-foot intervals.*

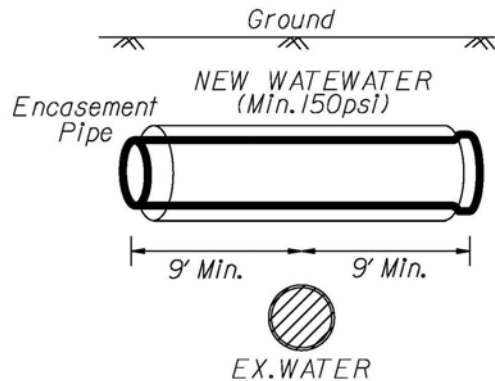


Figure 3.10.3.2.3.2:
Criteria for New Wastewater Pipe over Existing Water Pipe

3.10.4 Manhole Separation

3.10.4.1 Ideal Case:

Unless collection system manholes and the connecting collection system pipe are watertight, as supported by leakage tests showing no leakage, they must be installed with a minimum of nine feet of horizontal clearance from an existing or proposed public water supply pipe.

3.10.4.2 Variance:

If a nine-foot separation cannot be achieved, the requirements in paragraph §3.10.3 of this subsection apply.

3.10.5 Building Laterals and Taps

Building laterals and taps on an installation must:

3.10.5.1 Include a manufactured fitting that limits infiltration

3.10.5.2 Prevent protruding service lines; and

3.10.5.3 Protect the mechanical and structural integrity of a wastewater collection system

3.10.6 Reclaimed Water Mains

Wastewater mains located adjacent to reclaimed water mains shall comply with the separation criteria established in §4.10 regarding separation distance between reclaimed water and water/wastewater mains.

3.10.7 Wastewater, Storm Drain and Gas Main Separation

- The horizontal separation distance from a wastewater main of 20" diameter or smaller to a storm drain shall be 4 feet (preferred) and 3 feet (minimum).
- The horizontal separation distance from a wastewater main of 20" diameter or smaller to a gas main shall be 4 feet (minimum).
- The separation distance for a wastewater main of larger than 20" diameter to a storm drain or gas main shall be considered on a case-by-case basis.

2.10.8 Proximity of Piers, Foundations and Vertical Structures

- The minimum horizontal separation distance between proposed wastewater main and existing/proposed piers, foundations or vertical structures shall be 10 feet from outside edge to outside edge as applicable.
- If 10 feet horizontal separation is not available, then each situation should be evaluated on case-by-case basis to allow adequate space for future maintenances.

3.11 CONNECTIONS TO EXISTING MAINS

- The connection, other than at a manhole, should be made with the same type and size of pipe.
- Wastewater Laterals should not be connected to wastewater mains over 18" due to the potential of odor migrating into the property.

3.12 WASTEWATER APPURTENANCES

3.12.1 Manhole (MH)

3.12.1.1 Location:

Manholes shall be placed at:

- All points of changes in pipe alignments, grade, size and material
- At intersection of all pipes
- At end of all pipes that may be extended in the future. Manhole placed at the end of a wastewater collection system pipe that may be extended in future must include pipe stub outs with plugs.
- An intersection of three or more collection pipes

Variances

- Tunnels are exempt from manhole spacing requirements because of construction restraints
- A manhole must not be located in the flow path of a watercourse, or in an area where ponding of surface water is probable.

3.12.1.2 Material:

- A manhole must be made of monolithic, cast-in-place concrete, pre-cast concrete, fiberglass or other equivalent material as approved by DWU.
- The use of bricks to adjust manhole cover to grade or construct a manhole is prohibited.
- The inclusion of steps inside the manhole are prohibited due to history of corrosion
- Manhole should be concentric type unless otherwise approved by DWU.

3.12.1.3 Corrosion Protection:

Following minimum preventive measures shall be considered for all manholes in order to minimize microbiological induced corrosion (MIC):

- Protective lining
- Precast concrete additive

3.12.1.4 Spacing:

- Manhole may be spaced no further apart than the distance specified in the following table:

**Table 3.12.1.3:
Manhole Spacing Criteria**

Pipe Diameter (in)	Max. Manhole Spacing (ft)
6- 15	500
18- 30	800
36- 48	1000
54 or Larger	2000

- The maximum allowable manhole spacing for collection systems with horizontal curvature is 300 feet. A manhole must be at point of curvature (PC) and the point of termination of a curve (TC).

1.12.1.5 Type:

There are generally three (3) types of manholes installed in the DWU wastewater collection system:

- Standard Manholes
 - Pre Cast, Cast in Place, or Fiberglass
 - Fiberglass is used on a case by case basis as approved by DWU
- Drop Manholes
 - Inside or outside Drop Connection, Standard Drawing 307-308
 - This is used where the incoming pipe(s) is 2' or higher than the out going pipe
- Pressure Type Manholes
 - This is used where the manhole is placed in a creek or 100 year flood plain area.
 - Reference Schematics: DWU Standard Drawing Nos. 304, 313-315.

3.12.1.6 Size:

The inside diameter of a manhole must not be less than 48 inches:

**Table 3.12.1.4:
Manhole Sizing Criteria**

Pipe Diameter (in)	Min. Manhole Diameter (ft)
8- 18	4
21- 30	5
33- 48	6
48 or Larger*	As Approved by DWU

* Manholes 7'-8' in diameter may be used if approved by Wastewater Collection Division. If the distance between the outside diameter of any two pipes is less than <1' then a junction structure may be required

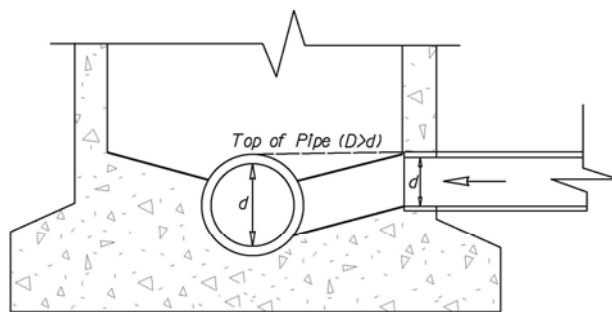
3.12.1.7 Manhole Cover:

A manhole must meet the following requirements for covers, inlets and bases as per 30TAC §217.55 (l):

- A manhole where personnel entry is anticipated requires at least 30 inch diameter clear opening.
- A manhole located within the 100 year floodplain must be installed to prevent inflow and infiltration.
- A manhole cover construction must be constructed by impervious material as approved by DWU.
- A manhole cover that is located in a roadway must meet or exceed the American Association of State Highway and Transportation Standard M-306 as approved by DWU.

3.12.1.8 Manhole Invert:

- The bottom of a manhole must contain a U-shaped channel that is a smooth continuation of the inlet and outlet pipe
- A manhole connected to a pipe less than 15 inches diameter must have a channel depth equal to at least half of the largest pipe diameter.
- A manhole connected to a pipe at least 15 inches diameter but not more than 24 inches in diameter must have a channel depth equal to at least three-fourths of the largest pipe diameter.
- A manhole connected to a pipe greater than 24 inches diameter must have a channel depth equal to the largest pipe diameter.
- A manhole with pipes of different sizes must have the tops of the pipes at the same elevation and flow channels in the invert sloped on an even slope from pipe to pipe



**Figure 3.12.1.6.5:
Crown Elevation of Different Pipe Sizes within a Manhole**

- A bench provided above a channel must slope at a minimum of 0.5 inch per foot.
- Invert must be filleted to prevent solids being deposited if a wastewater collection system pipe enters a manhole higher than 24" inches above a manhole invert.
- A wastewater collection system pipe entering a manhole more than 24 inches above an invert must have a drop connection.
- Minimum 12 inches separation measured from the outside of each pipe should be maintained among pipes at manhole.

3.12.1.9 Connections

- A manhole-pipe connection must use water tight, size on size resilient connectors that allow for differential settlement and must conform to ASTM C-923.
- A drop pipe shall be provided for a sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert shall be filleted to prevent solids deposition.
- Drop manholes should be constructed with an outside drop connection. Inside drop connections (when necessary) shall be secured to the interior wall of the manhole and provide access for cleaning.
- Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection shall be encased in concrete or granular material as necessary.
- Reference Schematics: DWU Standard Drawing Nos. 307 and 308 for outside and inside drop connections, respectively.

3.12.1.10 Venting:

An alternate means of venting must be used if manholes are spaced at 1,500 foot intervals. Gasketed manhole covers are required for more than three manholes in sequence. Venting must meet following requirements:

- Vent design must minimize inflow.
- Vents must be located above a 100-year flood elevation
- Tunnel must be vented as needed

3.12.3 Wastewater Junction Structure

A wastewater junction structure is generally required where two or more wastewater pipelines can not be connect at a manhole due to inadequate separation distance between the outer diameters of the mains (**Figure 3.12.3**). Following items, but not limited to, must be considered for designing a wastewater Junction structure:

- General:
 - Junction structures are used typically where a standard 8' diameter pre-cast manhole is not adequate.
 - The separation distance between pipes must be at a minimum of 1 foot inside junction structure.
 - All pipes entering a junction structure must be at right angle at the junction wall.
- Structural Consideration:
 - Roofs of junction structures must be structurally designed for HS-20 loading
 - Non-shrink grout shall be used between the junction structure and wastewater mains along structure wall
- Corrosion Protection:
 - Corrosion protection provisions shall be considered for all junction structures
 - All moving components of structure must be Stainless Steel 316 unless otherwise approved by DWU
- Flow Bypass:
 - A wastewater flow bypass plan must be prepared

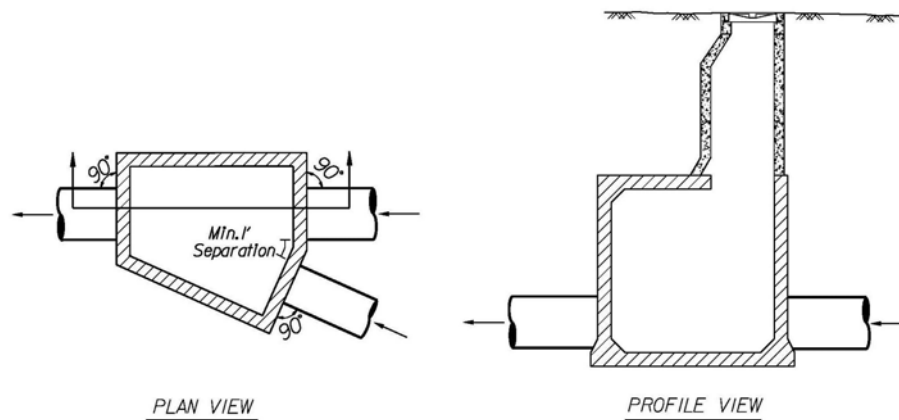


Figure 3.12.3: Typical Wastewater Junction Structure

3.12.4 Wastewater Access Device (WWAD) and Cleanout (CO)

A Wastewater Access Device or Cleanout is required at the end of all wastewater lines for accessibility in cleaning

3.12.4.1 Wastewater Access Device (WWAD):

Wastewater Access Device (WWAD) is the preferred appurtenance to use for insertion or removal of cleaning equipment. Minimum depth of cover for WWAD is 3.5 feet. It may be installed in lieu of a manhole at the end of wastewater collection system pipe if no extensions are anticipated.

3.12.4.2 Cleanout:

A cleanout (CO) may be installed where there is not enough cover or vertical clearance for a WWAD. The size of mainline cleanout must be equal to the size of the wastewater collection system, if used.

3.12.4.3 Reference Schematics:

DWU Standard Drawing Nos. 317 and 328 for Cleanout (CO) and Wastewater Access Device (WWAD) respectively.

3.12.5 Wastewater Service

3.12.5.1 General Requirements:

- Each lot must have its own wastewater service which must not cross any existing or projected lot line(s)
- Wastewater service will not be directly connected to wastewater mains larger than 18"
- Wastewater service connection to a main larger than 30" may be allowed through a manhole only upon prior approval from Wastewater Collection Division

3.12.5.2 Location:

- Wastewater service should be located ten feet downstream of the water service which is usually located at the center of the lot facing the main.

3.12.5.3 Size:

- The size of the wastewater service from the main to the property line should be six (6) inches unless other conditions warrant a larger size. The following criteria may be used as a guide:

Table 3.12.3.2:
Wastewater Lateral Sizing Criteria

Fixtures	Flow (gpm)	Size (in)
0- 720	0- 180	6
720- 2640	180- 4000	8
2640- 4680	4000- 7000	10
4680- 8200	7000- 11600	12

3.12.5.4 Depth:

- The wastewater service should be at a depth sufficient to insure the dwelling to be connected, will be served using a minimum lateral grade of 2 % and minimum cover of 2 feet
- The top of the downstream manhole should be a minimum of 18 inches below the finish floor (FF) elevation of the dwelling to be connected. In cases where this is not achievable approval must come from Wastewater Collection and will generally require a backflow prevention device and damage waiver from the property owner. A typical wastewater service is shown in shown in **Figure 3.12.3.3**.

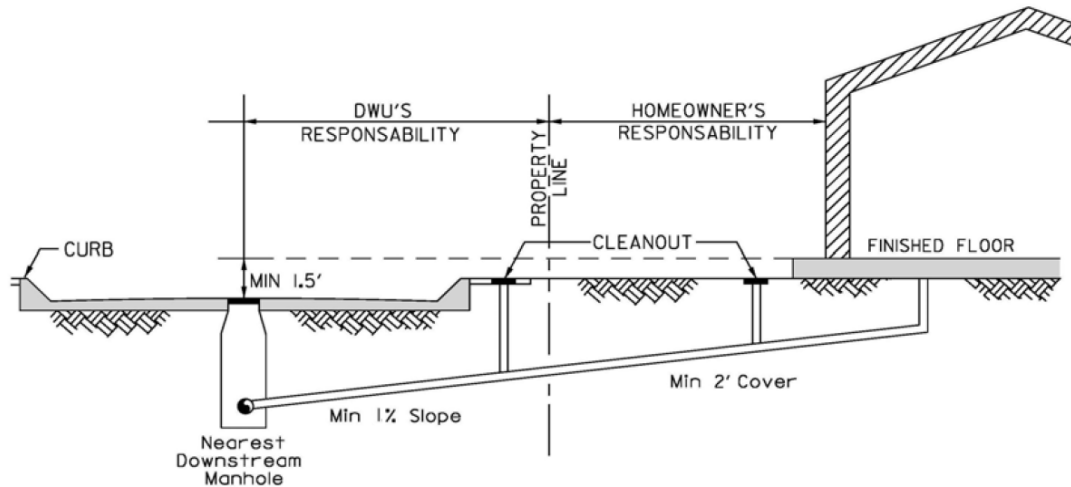


Figure 3.12.3.3: Typical Wastewater Service Lateral

3.13 INVERTED SIPHONS

An inverted siphon is applied to a portion of a wastewater main which dips below the hydraulic grade line to avoid such obstructions as a drainage structure, utility, tunnel or stream. It shall only be considered where avoidance or adjustment of the obstructing utility or structure is not practical. All siphons shall be designed in accordance to the following criteria:

- General:
 - Useful design life shall be 50 years
 - Design flow shall be the hydraulic capacity of the upstream flow or the future projected flow as per latest DWU Wastewater Master Plan, whichever is greater.
 - Design for minimum headloss
 - When going across a depression, all siphons shall be completely buried with a minimum of 48" of cover.
 - Maximum slope of the downstream (rising) leg of the siphon shall be 15%
 - Because an inverted siphon includes slopes of zero and adverse values, head losses through the structure shall be calculated by hydraulic grade analysis.
- Conduits:
 - Typically, the conduit size through the inverted siphon shall be the same size as either the approaching or exiting conduit.
 - The siphon shall consist of two or more conduits with a minimum pipe diameter of 8 inches.
 - The siphon pipes must be sized and designed with sufficient heads to achieve a velocity of at least 3 ft/sec at initial and design flows. The arrangement of inlet and outlet details must divert the normal flow to one conduit.
 - Pressure rated pipes and fittings shall be used.
- Additional Features:
 - Two manholes or junction structure must be designed including one upstream and one downstream with adequate clearance for cleaning equipment, inspection, and flushing.
 - The design must allow any conduit to be taken out of service for cleaning.
 - Siphon pipes, manholes and junction structures must be designed to minimize nuisance odors. Provisions must be made to allow cleaning across each bend with equipment available to Wastewater Collection Division.

3.14 WASTEWATER LIFT STATION AND FORCE MAIN

3.14.1 General

- All wastewater lift stations shall be designed strictly in accordance with 30 TAC §217:59- 63 while meeting or exceeding following Special Design Criteria.

3.14.2 Special Design Criteria

- Depending on the projected flow, a duplex lift station should be installed as a minimum. A design implementing submersible pumps is preferred. Each pump should have its own discharge pipe feeding into one common header. If additional flow is anticipated in the future, a triplex station should be constructed so that a parallel third pump can be easily added at a later time. For a triplex lift station, it is recommended that the lift station be constructed to run with two pumps installed initially.
- The dimensions of the wet well should be designed to provide storage above the minimum required volume. The additional storage would result in decreased pump cycles that will increase pump life, save electricity and most importantly, provide more response time when there is a station failure. All check valves, ball valves and gate valves must be located in a dry pit or valve vault. Valves are not allowed in the wet well.
- The finished grade of the lift station shall be designed so that storm water drainage will not collect on or flow across the finished grade of the lift station. The adjacent ground surrounding the station shall be graded so that storm water will not wash dirt and/or any other debris on top of the station during rain storms.
- All electrical and electronic lift station equipment must be located above ground level so that a confined space entry permit is not required to service the lift station controls and telemetry equipment. The control panel should be ready to accommodate additional controls for a third pump if a triplex lift station is required.
- Hardware that is subject to corrosion such as the control panel, wet-well guide rails, brackets, and lifting chain should be constructed of stainless steel. Swing type check valves with external levers must be provided and any gate valves must be the rising-stem type. Any ladders and hatches that provide access to below-ground confined spaces should incorporate fall protection cages and grates.
- The lift station must incorporate a telemetry system such as radio communications or an approved auto-dialer unit and a phone line to provide failsafe notification of alarms and failures. All electrical conduit, fittings and supports must be Class 1, Division II rated to meet the 2008 Electrical Code or Latest Edition.

- A water source must be made available for washing down pumps and general cleaning of the lift station.
- New lift stations should provide a full capacity backup generator with an automatic transfer switch. The generator should run on direct fed natural gas, or diesel fuel for the second choice. Another option for electric backup is to double feed the station from two separate sources. If neither of the previous is practical, a minimum of a manual transfer switch and a mobile generator plug connection must be installed.
- Odor control ventilation should be considered for the wet well, depending on the location of the lift station.
- New lift station plans must be reviewed and approved by the Wastewater Collection Division before the construction process begins.

3.15 WASTEWATER FORCE MAIN

All wastewater lift station shall be designed strictly in accordance with 30 TAC §217:64-68.

3.16 ABANDONMENT OF WASTEWATER MAINS AND APPURTENANCES:

3.16.1 Wastewater Mains:

- Wastewater mains shall be abandoned by cutting and plugging and it is not necessary to remove the existing pipe.
- If the construction necessitates abandoning the existing main prior to the new main being put in service, provisions must be made for temporary bypass.

3.16.2 Manhole, Cleanout and Wastewater Access Device:

- Manhole, cleanout and wastewater access device shall be abandoned by filling with sand and/or gravel compacted to 90% (95% in pavement) of maximum standard proctor dry density.
- The bottom of manhole, cleanout and wastewater access device shall be filled with class B concrete upto the top of wastewater pipe(s).

2.16.3.3 Reference Schematics:

- DWU Drawing No. 316: Abandonment of manhole in and out of Pavement

CHAPTER 4

RECLAIMED WATER MAIN DESIGN GUIDELINES

4.1 REFERENCES

Reclaimed water main shall be designed in conformance with “30 TAC §210: Use of Reclaimed Water” along with all applicable laws, regulations, codes and standards.

4.2 DEFINITIONS

- **Reclaimed Water**

Domestic or municipal wastewater which has been treated to a quality suitable for a beneficial use pursuant to the provisions of applicable TCEQ rules and permits is commonly known as reclaimed, recycled or reuse water.

- **Type I Reclaimed Water Use**

Use of reclaimed water where contact between humans and the reclaimed water is likely and which, therefore requires more stringent water quality.

- **Type II Reclaimed Water Use**

Use of reclaimed water where contact between humans and the reclaimed water is unlikely and thus does not require the stringent water quality of Type I.

4.3 DWU RECLAIMED WATER SYSTEM

- Dallas Water Utilities is currently evaluating closely at opportunities to use highly treated effluent or recycled water to augment other sources of water in meeting current and future water demands. A reclaimed water master plan entitled “Recycled Water Implementation Plan, dated August 30, 2005” was developed consisting of the evaluation of two options for the use of reclaimed water: direct, non-potable reuse and indirect potable reuse through the augmentation of raw water supplies.
- A preliminary design report consisting of project scope, supporting data, evaluation of various alignment alternatives and recommendation must be prepared and submitted to DWU for approval prior to any detail design of reclaimed water main (Ref: §1.6.4).

4.4 RECLAIMED WATER MAIN SIZING

The reclaimed water mains must be sized in accordance with any approved master plan established for that area. If a master plan is not available, the sizing of the main must be based on engineering analysis of initial and future demand of the reclaimed water user(s). The designer shall meet or exceed the minimum following criteria for sizing reclaimed water mains:

- **Velocity:** The velocity of reclaimed water main shall be maintained between 2 and 10 feet per second.
- **Service:** The size of the services must be at least one standard size smaller than the proposed and existing raw water main.

4.4.1 Pressurized Main:

Reclaimed water pressure mains shall be designed with the same criteria as potable water mains as outlined in Chapter 2 relating to water main design guideline unless otherwise specified in this Chapter. The designer shall consider methods to prevent or maintain lines to mitigate the effect of the deposition of solids in such lines.

4.4.2 Gravity Main:

Reclaimed water gravity mains shall be designed with same criteria as gravity wastewater mains as outlined in Chapter 3 relating to wastewater main design guideline unless otherwise specified in this Chapter. The designer shall consider methods to prevent high velocity scour or maintain line fluid velocity to mitigate the effects of the deposition of solids in the gravity conveyance.

4.5 DEPTH OF COVER

The depth of cover is measured from the top of the pipe to the natural or finished ground surface above the pipe.

4.5.1 Terminology:

4.5.1.1 Unimproved Area:

Unimproved area is defined as public right-of-way or easement without permanent pavement including natural ground, asphalt pavement with no base, gravel surface, and streets without curb and gutter.

4.5.1.2 Improved Area:

Improved area is defined as public right-of-way or easement with paving and base including areas behind the curb, or streets where permanent pavement is proposed in the near future.

4.5.2 Minimum Cover:

The following guideline applies to reclaimed water main installation in public right-of-way or easements:

Table 4.5.2: Minimum Depth of Cover for Reclaimed Water Main

Size of Main (in)	Min. Depth* (ft)		
	Unimproved Area	Improved Area	Highway/Railroad Crossing**
12" and Smaller	6	4	6
16"	6	5	6
20" and Larger	7	6	6

* Mains shallower than 3 feet will require special engineering evaluation and engineering controls.

** Reclaimed water mains under highway and railroad right-of-ways must meet all additional criteria as required.

4.6 RECLAIMED WATER PIPE MATERIALS & EMBEDMENTS

4.6.1 Pipe Material Selection:

Designers are responsible for specifying the type of pipe to be used in any design. Typically all reclaimed water pipe shall be pressure rated with a minimum working pressure rating of 150 psi unless otherwise approved by DWU. For smaller pipe sizes ($\leq 16''$ diameter) PVC is the material preferred by DWU. For larger pipe sizes ($> 16''$) DWU prefers reinforced concrete cylinder pipe (RCCP). Other materials such as ductile iron and steel may be specified contingent upon approval by the Distribution Division.

Although PVC is the preferred material for smaller mains, there are some restrictions on its use. PVC may not be used within the following areas or circumstances:

- Central Business District (CBD), Dallas Love Field and Executive Airports
- Elevated crossings or situation where pipe will be permanently exposed
- Encased pipe where the method of anchoring is by means of hold-down jacks

When a metal pipe including concrete cylinder, ductile iron or steel is specified, the pipe must be protected from corrosion. In addition, all reclaimed water mains must be designated with a purple coloration. They may be fabricated from purple base materials, painted purple, or encased in a purple polyethylene sleeve. In addition to the purple color or purple sleeve all pipe materials shall have the words “Non-Potable” painted on them in 2” high letters every two feet.

4.6.2 Fittings:

All PVC and ductile iron pipe shall use ductile iron fittings with a minimum working pressure rating of 150 psi. Compact fittings are not allowed. All 90 degree bends shall be avoided in the system, if possible.

4.6.3 Embedment Requirements:

Designers shall specify class of embedment on design drawings. The type of embedment to be used is determined by pipe material and depth of cover. Please see DWU Standard Drawings 113-119C for the various classes of embedment.

4.6.4 Recommended Pipe Material and Embedment:

The following table summarizes recommended pipe material and embedment for different reclaimed water mains:

Table: 4.6.3: Recommended Reclaimed Water Pipe Materials & Embedments*

Pipe & Material Specification	Allowable Size (in)	Joint Specification	Embedment Class Per Depth of Cover** (ft)
Purple PVC AWWA C900 (DR-14)	6 – 12	Bell & Spigot Joints: ASTM D3139 Gasket: ASTM F477	< 8' : C+
Purple PVC AWWA C905 (DR-14)	16	Fusible Fusible C 900 ^(R) Fusible C 900 ^(R) Certa-Lok Certa-Lok C900/RJ ^(TM) Certa-Lok C905/RJ ^(TM)	8'-16' : B+
Ductile Iron (DI) w/Seal Coat Purple Polyethylene PolyWrap, 8-mil ANSI/AWWA C151/A21.51 Class 52 or Class 54	6 – 60	Bell & Spigot/ Push On ANSI/AWWA C111/A21.11 Mechanical ANSI/AWWA C111/A21.11 Flanged ANSI/AWWA C115/A21.15	≤16-in Dia: >16-in Dia: < 8' (Rock): C < 8' (Earth): D+ <8" : B 8'-16' : C 8'- 16' : B > 16' : B >16' : B
RCCP- Bar Wrapped Cement Mortar w/Purple Dye ANSI/AWWA C303 Class 150	16 – 42	Bell & Spigot ANSI/AWWA C303	16-in Dia: >18-in Dia: < 16' : C <16' : B > 16' : B >16' : B

Table: 4.6.3: Recommended Reclaimed Water Pipe Materials & Embedments*

(Contd.)

Pipe & Material Specification	Allowable Size (in)	Joint Specification	Embedment Class Per Depth of Cover** (ft)
PCCP- Lined Cylinder Cement Mortar w/Purple Dye ANSI/AWWA C301 Class 150	20 – 60	Bell & Spigot ANSI/AWWA C301	< 16' : C > 16' : B
PCCP- Embedded Cylinder Cement Mortar w/Purple Dye ANSI/AWWA C301 Class 150	54 – 144	Bell & Spigot ANSI/AWWA C301	< 16' : C > 16' : B
Steel Cement Mortar w/Purple Tape Coating** ANSI/AWWA C200	24 – 156	Welded Joints or Bell & Spigot ANSI/AWWA C200	< 8' : C > 8' : C

* Reference to Standard Drawing 113- 119 for details and dimensions of the class of embedment

** Steel and other pipe materials can only be considered on case- by- case basis as approved by Distribution Division

4.7 LOCATION

- Location of all new reclaimed water mains shall be considered on case-by-case basis while meeting the criteria of the chapter.
- New reclaimed water mains within highway or railroad right-of-ways must be coordinated with appropriate agency while meeting DWU criteria.

4.8 HORIZONTAL ALIGNMENT

Horizontal alignment of reclaimed water mains shall be conducted in accordance with §2.8 of this manual relating to horizontal alignment of water main.

4.9 VERTICAL ALIGNMENT

Vertical alignment of reclaimed water mains shall be conducted in accordance with §2.9 of this manual relating to vertical alignment of water main with the following exception:

- All 6" or larger reclaimed water main designs must have a vertical profile.

4.10 SEPARATION DISTANCE BETWEEN RECLAIMED WATER AND WATER/WASTEWATER MAINS

- When a reclaimed water main is built near an existing water/wastewater facility, conveyance, or appurtenance, 30TAC §210.25(c)-(e) as enforced by TCEQ, governs the minimum separation distances:

4.10.1 Ideal Case:

- Reclaimed water piping shall be separated from potable water piping by a horizontal distance of at least nine (9) feet. All separation distances shall be measured from the outside surface of each of the respective pieces.
- Where a reclaimed water main parallels a wastewater main, the horizontal separation distance shall be three (3) feet (outside to outside) with the reclaimed water main at the level of or above the sewer line.

4.10.2 Pipe Trench:

- Reclaimed water main and potable water distribution mains or laterals from parallel utility lines shall be installed in separate trenches.
- Reclaimed water lines which parallel wastewater lines may be placed in the same benched trench contingent upon approval by DWU.

4.10.3 Cross Connection:

No physical connection shall be made between a reclaimed water line and potable water or wastewater lines. Any appurtenance shall be designed and constructed so as to prevent any possibility of cross contamination.

4.10.4 Variances:

- Where the nine (9) foot separation distance from water main cannot be achieved, the reclaimed water piping must meet the line separation requirements of 30TAC §290.44(e) as specified in §2.10 of this manual.
- Where a reclaimed water line crosses a wastewater main, the requirements of §2.10.5 relating to “New Waterline Installation- Crossing Lines” shall be followed, with “reclaimed water line” substituted in §2.10.5 of this title (relating to Location of Water Line) for “water line”.

4.11 CONNECTION TO EXISTING MAINS

Typically service lines from individual properties are not allowed to be connected to a reclaimed water main unless otherwise approved by DWU Distribution.

4.12 RECLAIMED WATER MAIN APPURTENANCES

Any appurtenance connected to the reclaimed water main that is accessible from the surface shall have a sign affixed to it that says “Non Potable” in both English and Spanish. If the appurtenance is inside a manhole, vault or meter box the sign may be affixed to the inside wall. Any appurtenance that has a lid or cover shall have the label “Non Potable” cast into the outside surface or permanently inscribed with the same label in some other manner.

4.11.1 Isolation Valves

Isolation valves on reclaimed water lines shall typically be standard double-disk gate valves, but shall open in the clockwise direction.

4.11.2 Hose Bib and Faucet

- All hose bibs and faucets shall be painted purple and designed to prevent connection to a standard water hose.
- Hose bibs shall be located in locked, below grade vaults which shall be clearly labeled as being of non-potable quality. As an alternative to the use of locked, below grade vaults with standard hose bibs services, hose bibs may be placed in a non-lockable service box which can only be operated by a special tool so long as the hose bib is clearly labeled as non-potable water. One of the following requirements must be met by the user or provider, for any area where reclaimed water is stored or where there exist hose bibs or faucets:
 - Signs having a minimum size of eight inches by eight inches, as shown in **Figure 4.11.2** shall be posted at all storage areas and on all hose bibs and faucets reading, in both English and Spanish, "Reclaimed Water, Do Not Drink" or similar warning.
 - The area shall be secured to prevent access by the public.



DO NOT DRINK THE WATER
NO TOMAR EL AGUA

**Figure 4.11.2
Reclaimed Water Warning Sign**

4.11.3 Backflow Preventer

Backflow preventer shall be installed at each delivery point in order to protect reclaimed water system from potential cross contamination.

4.11.4 Exposed Piping

All exposed piping and piping within a building shall be manufactured in purple, painted purple, taped with purple metallic tape, or bagged in purple. All exposed piping should be stenciled in white with a warning reading "Non-Potable Water." All exposed or buried reclaimed water piping constructed at a wastewater treatment facility is exempt from the color coding requirements of this section

4.11.5 Storage Tanks

All ground level and elevated storage tanks shall be designed, installed and constructed in accordance with current AWWA standards with reference to materials to be used and construction practices to be followed, except for health-based standards strictly related to potable water storage and contact practices, where appropriately less standards may be applied contingent upon approval by DWU.

In the event that a storage tank, basin, or other water storage facility for reclaimed water will also have a potable water connection, the potable water connection must always have a twelve (12) inch minimum air gap between the potable water outlet and the maximum surface elevation of the stored reclaimed water.

4.13 HYDROSTATIC TESTING

- All reclaimed water mains shall be hydrostatically tested in accordance with §2.15 of this manual before being put in service. However, no chlorination will be required unless otherwise requested by DWU.
- Hydrostatic testing of all reclaimed water mains must also be in accordance with Addendum to the NCTCOG Standards by DWU, Latest Edition.

CHAPTER 5

SPECIAL DESIGN CRITERIA

5.1 GENERAL

This chapter addresses various special design criteria common to water and wastewater projects.

5.2 PAVEMENT CUT AND REPAIR CRITERIA

5.2.1 Authority

The pavement cut due to construction of water and wastewater mains, and subsequent repair must be in compliance with all applicable DWU standards and required criteria or variance as approved by City of Dallas Public Works and Transportation (PW&T). Following reference must be reviewed in conjunction with this manual:

- Pavement Cut and Repair Standards Manual by PW&T, Latest Edition.

The most current “Pavement Cut and Repair Standards Manual” dated October, 2003 by PW&T, was published in response to a January 24, 2001 Dallas City Council amendment to Chapter 43 of the Dallas City Code. Where it is both physically feasible and to TCEQ/DWU design standards, the designer should investigate placing both water and wastewater in a location that minimizes the replacement of pavement in order to reduce construction costs, extend the life of pavement, and minimize traffic impacts.

Two separate approaches should be used for pavement cut and repair: the first approach is where the pavement is more than 5 years old and the second is where the pavement is less than 5 years old. Pavement age can be obtained from PW&T database. In case of unavailability, engineer’s judgment, historical records, and record drawing information can be used to determine pavement age.

5.2.2 Pavement Types and Cut Limit

The size of the pavement repair will typically always be larger than the size of the excavated area. Pavement cut for the installation of water and wastewater mains must be done in two steps. Initial pavement cut shall be along the proposed water/wastewater main trench. Final pavement cut beyond the firm bank of the trench, will follow upon installation, backfill and necessary testing of water/wastewater mains.

5.2.2.1 Concrete Pavement:

Following pavement types shall be removed to a line at least one (1) foot back of the firm banks of the trench of water/wastewater main:

- Full Depth Concrete Pavement: Pavement consists of 6- 10" thickness of concrete surface (Figure 4.2.2.1.1).

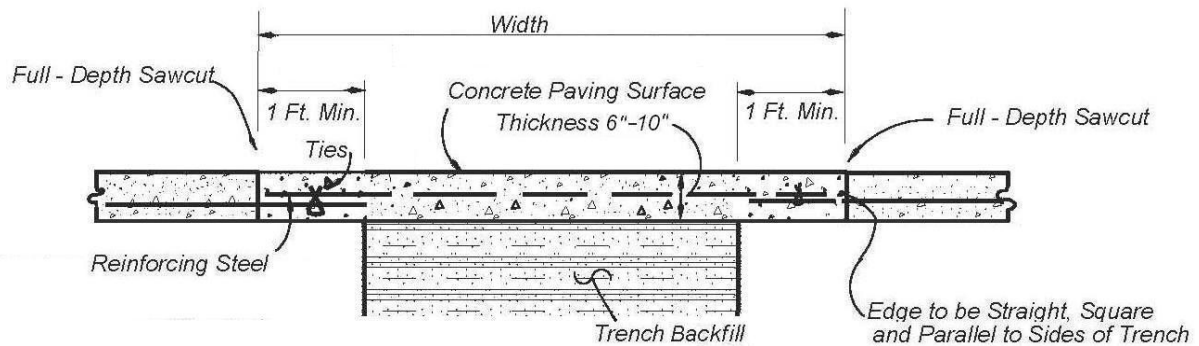


Figure 5.2.2.1.1:
Full Depth Concrete Pavement

Source: Pavement Cut and Repair Standards Manual by PW&T, 2003

- Asphalt Concrete Pavement with Concrete Base: Pavement consists of 6- 10" of concrete base with 2" asphaltic concrete surface course (Figure 5.2.2.1.2)

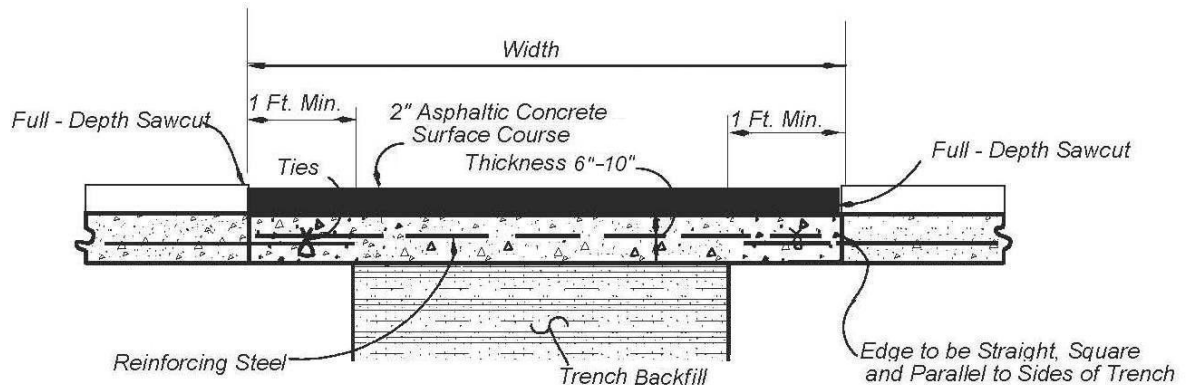


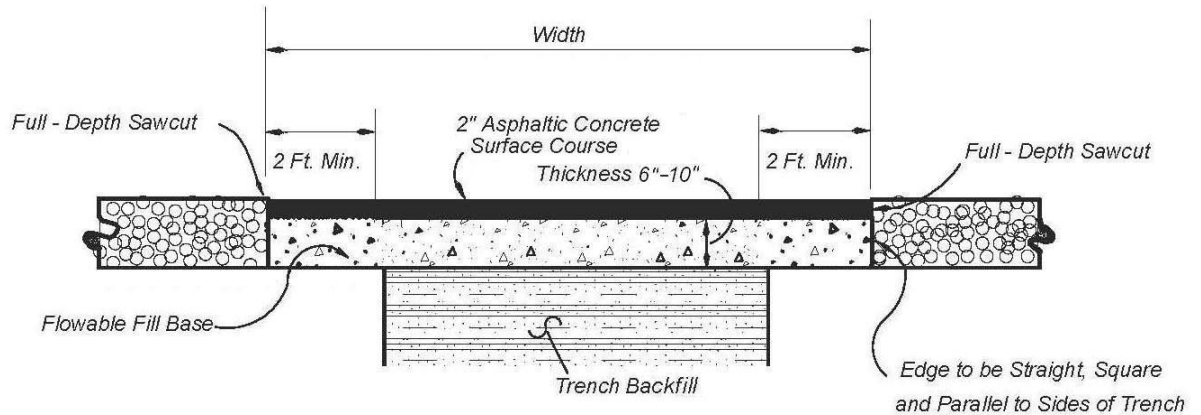
Figure 5.2.2.1.2:
Asphalt Concrete Pavement with Concrete Base

Source: Pavement Cut and Repair Standards Manual by PW&T, 2003

5.2.2.2 Asphalt Pavement:

Following pavement types shall be removed to a line at least two (2) feet back of the firm banks of the trench of water/wastewater main:

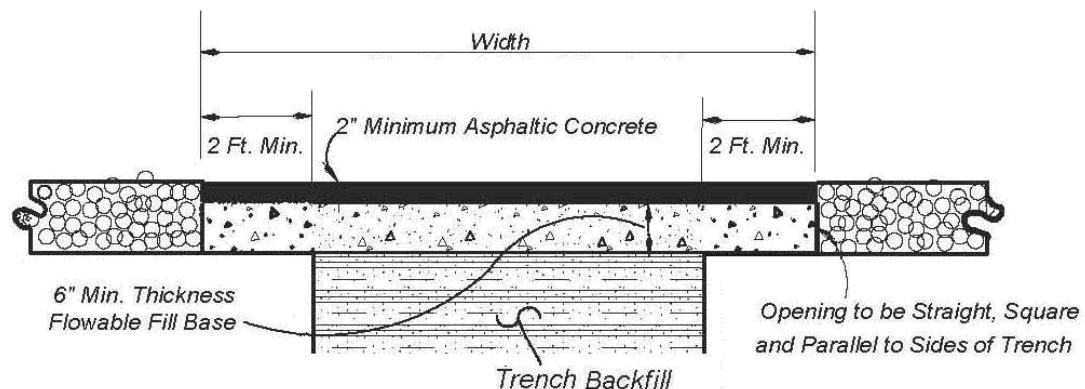
- Full Depth Asphaltic Concrete Pavement on Natural Soil Base: Pavement consists of 6- 10" of natural base with 2" asphaltic concrete surface course (**Figure 5.2.2.2.1**)



**Figure 5.2.2.2.1:
Asphalt Pavement**

Source: Pavement Cut and Repair Standards Manual by PW&T, 2003

- Asphalt Concrete on Flexible Base: Pavement consists of minimum 6" flexible base with 2" asphaltic concrete surface course (**Figure 5.2.2.1.2**).



**Figure 5.2.2.2.2:
Asphalt Concrete on Flexible Base**

Source: Pavement Cut and Repair Standards Manual by PW&T, 2003

- Penetration Type Pavement on Flexible Base: Pavement consists of 6" flowable fill base with 2" asphaltic concrete surface course or two course penetration asphaltic surface (**Figure 5.2.2.2.3**).

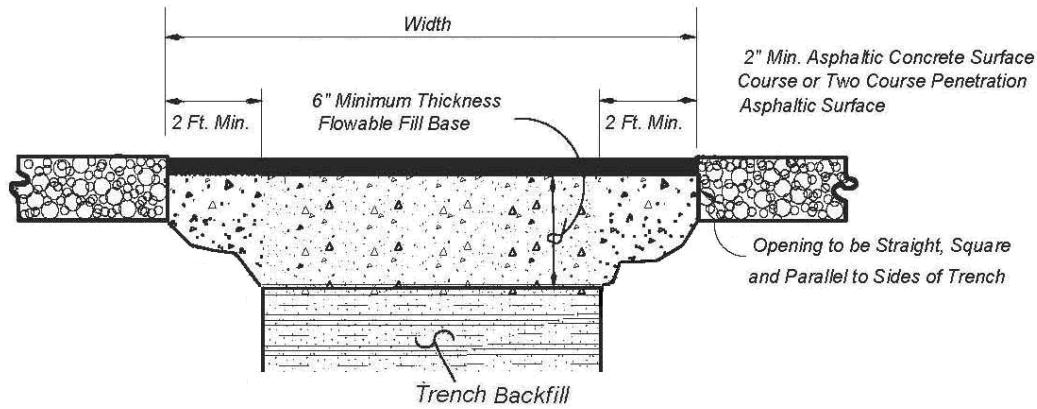


Figure 5.2.2.2.3:
Penetration Type Pavement on Flexible Base
Source: Pavement Cut and Repair Standards Manual by PW&T, 2003

5.2.2.3 Special Pavement:

Special pavements are those with a surface of brick, stone, exposed aggregate, manufactured paving blocks or other surface designed to present unique visual images, color or designs (**Figure 5.2.2.3**).

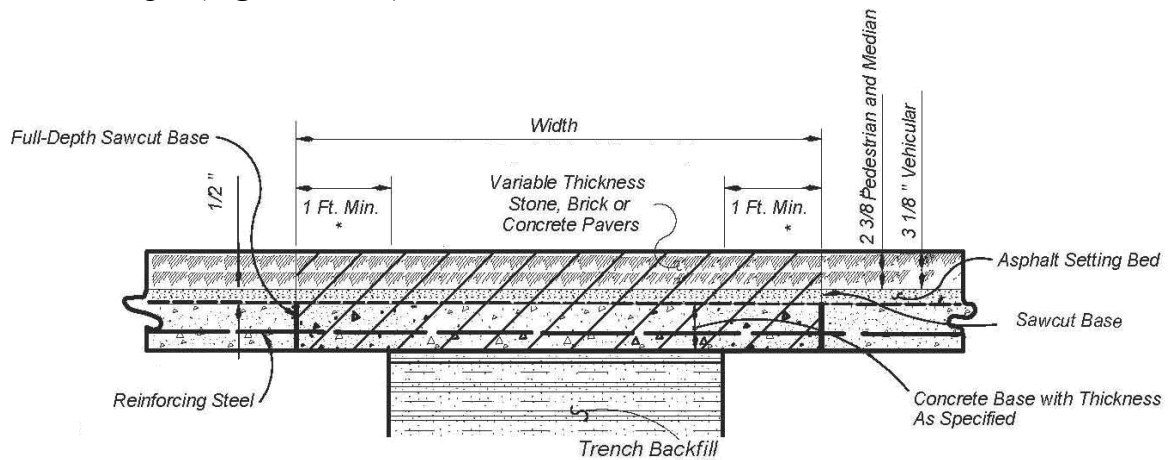


Figure 5.2.2.3:
Special Pavement
Source: Pavement Cut and Repair Standards Manual by PW&T, 2003

Following criteria shall be considered for cutting special pavements:

- Cuts or excavations in these special pavements shall be avoided whenever possible, by accomplishing repairs through boring or tunneling.
- Whenever a cut or excavation in a special pavement in a street alley, median or sidewalk of the public street right-of-way is unavoidable, the contractor shall, in addition to complying with the requirements of all applicable preceding repair standards, take whatever additional measures are necessary to restore the pavements area to a condition equal to or better than the preexisting condition.
- Removal shall be from joint or back of curb to joint or back of curb. Saw cutting of special pavement shall not be permitted.

5.2.3 Trench Backfill:

All water and wastewater trenches shall be backfilled with select materials from the excavation or flowable fill as per Pavement Cut and Repair Standards Manual by PW&T, Latest Edition.

5.2.4 Repair Criteria for Streets of More Than 5 Years Old:

5.2.4.1 General Considerations:

- Remove and replace a minimum 3' (concrete) and 4' (asphalt) longitudinal and 1' (concrete) and 2' (asphalt) from the edge of trench, whichever is greater.
- If within 3' of an existing joint, then remove to the existing joint.
- Multiple locations are to be a minimum of 10' apart from edge of repair to edge of repair, if less than 10 feet apart, a continuous section must be replaced.
- A gutter of at least 12' may remain, provided that the curb and gutter is not damaged by the construction activity.
- Exact pavement removal location to be approved by the City prior to construction.

5.2.4.2 Residential Street of 30' or Greater:

- Option 1: Trench edge plus 1 feet (concrete) or 2 feet (asphalt) is greater than 5 feet from pavement centerline and within 10 feet from pavement edge:

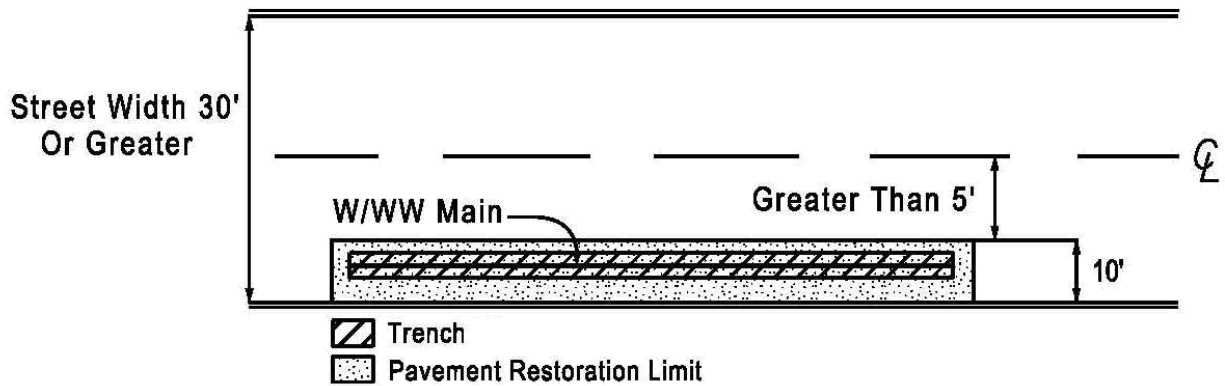


Figure 5.2.4.2.1:
Option 1: Pavement Cut and Repair Extent for Residential Street of 30 Feet or Greater

- Option 2: Trench edge is less than 5 feet from center line but greater than 1 feet (concrete) or 2 feet (asphalt) from centerline:

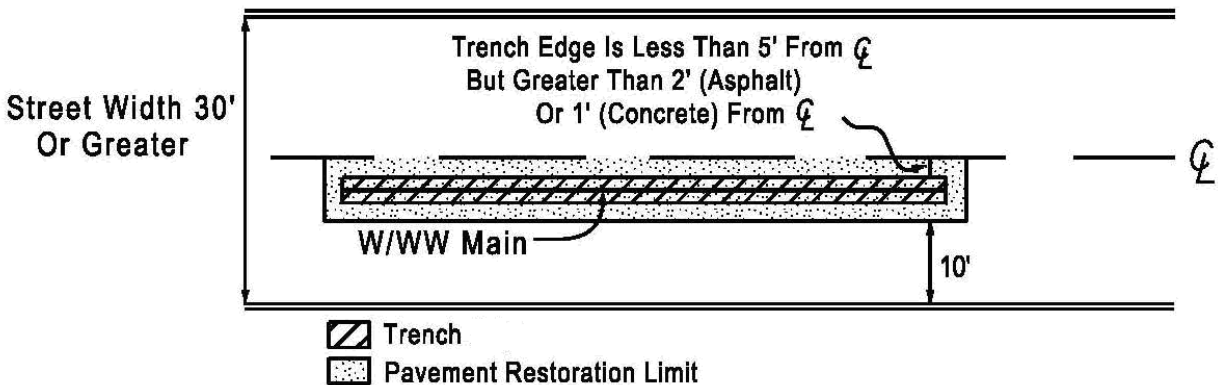


Figure 5.2.4.2.2:
Option 2: Pavement Cut and Repair Extent for Residential Street of 30 Feet or Greater

5.2.4.3 Residential Street of Less Than 30':

- Trench edge is less than 5 feet from center line but greater than 1 foot (concrete) or 2 feet (asphalt) from centerline:

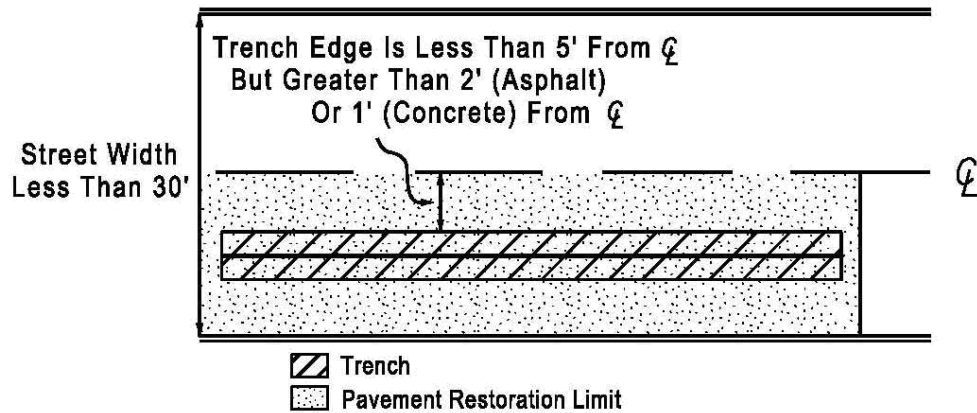


Figure 5.2.4.3:
Pavement Cut and Repair Extent for Residential Street
of Less Than 30 Feet

5.2.4.4 All Residential Streets:

- Trench edge is less than 1 foot (concrete) or 2 feet (asphalt) from the centerline:

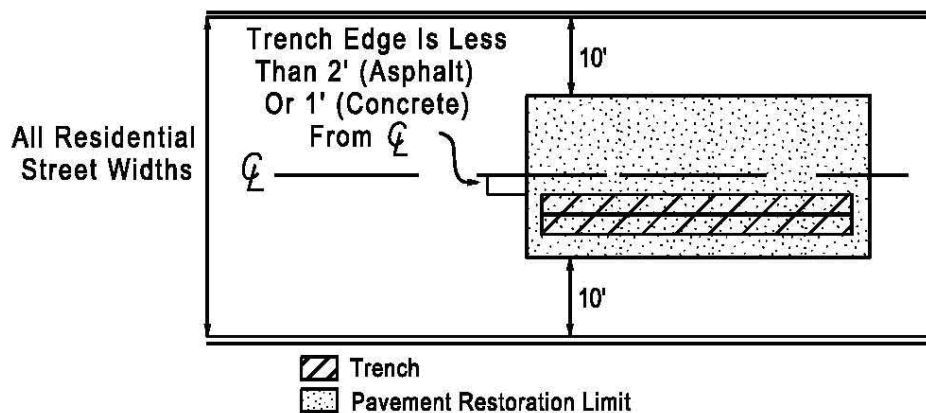
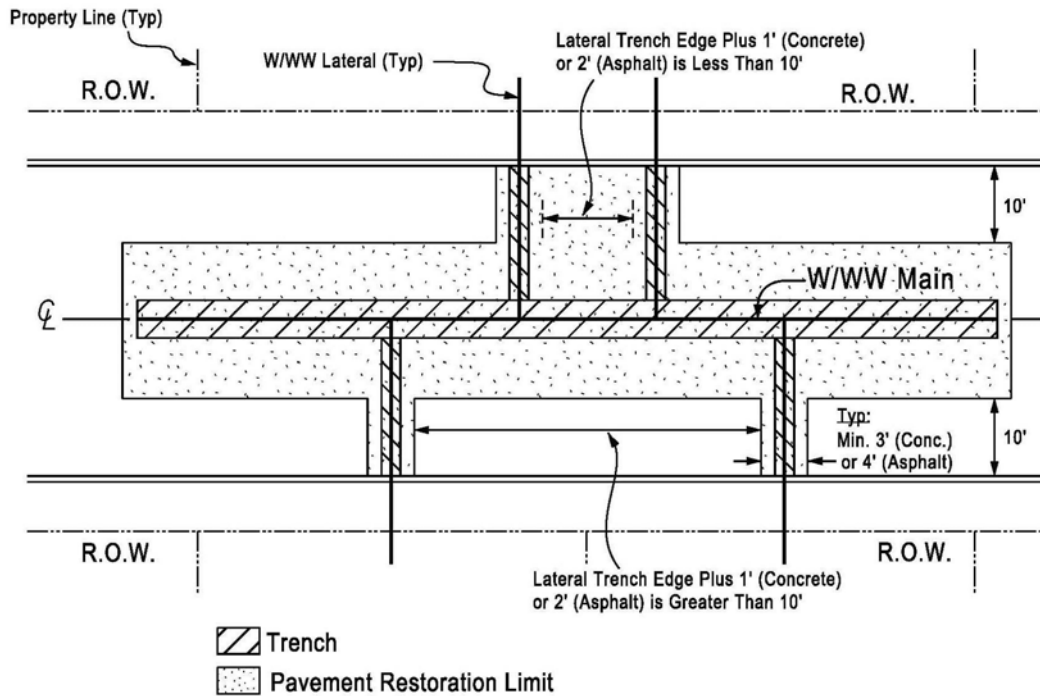


Figure 5.2.4.4:
Pavement Cut and Repair Extent for All Residential Streets

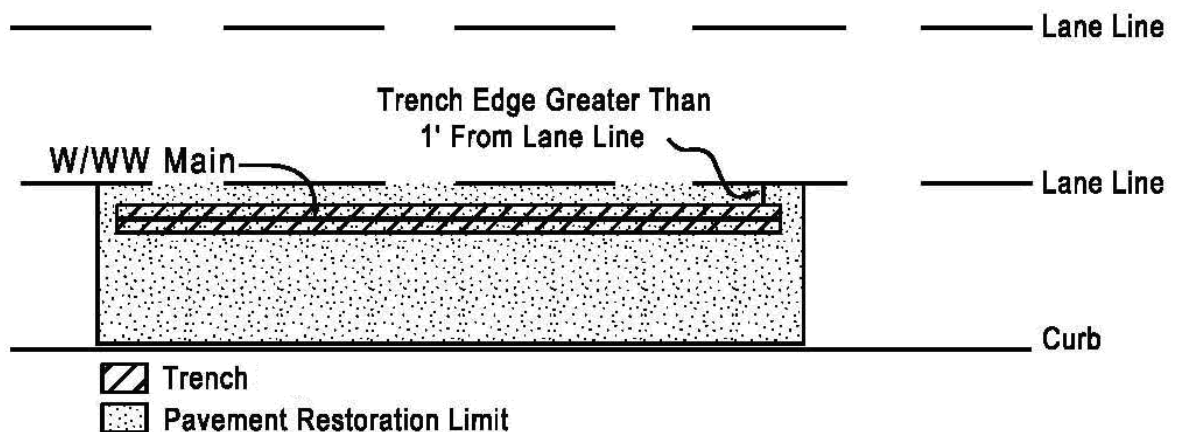
5.2.4.5 All Service Laterals:



**Figure 5.2.4.5:
Pavement Cut and Repair Extent for Service Laterals**

5.2.4.6 Multiple Lane Concrete Street:

- Option 1: Trench edge is greater than 1 feet from lane line:



**Figure 5.2.4.6.1:
Option 1: Pavement Cut and Repair Extent for Multiple Lane Concrete Streets**

- Option 2: Trench edge is less than 1 foot from lane line:

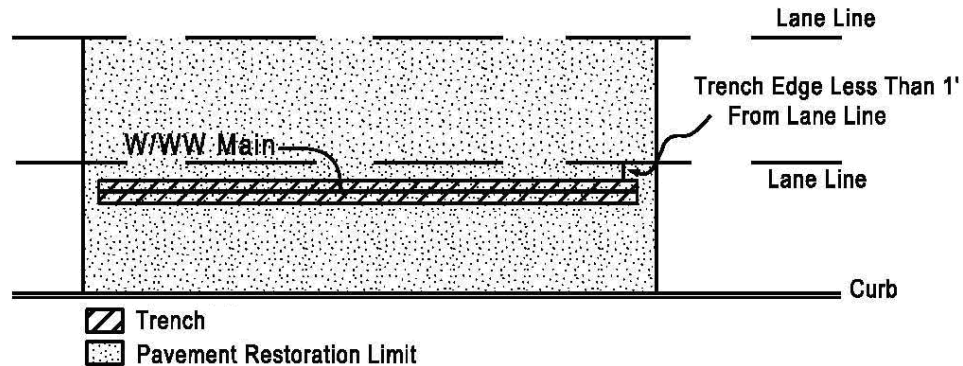


Figure 5.2.4.6.2:
Option 2: Pavement Cut and Repair Extent for Multiple Lane Concrete Streets

5.2.4.7 Multiple Lane Asphalt Street:

- Option 1: Trench edge plus 2 feet is less than $\frac{1}{2}$ lane width:

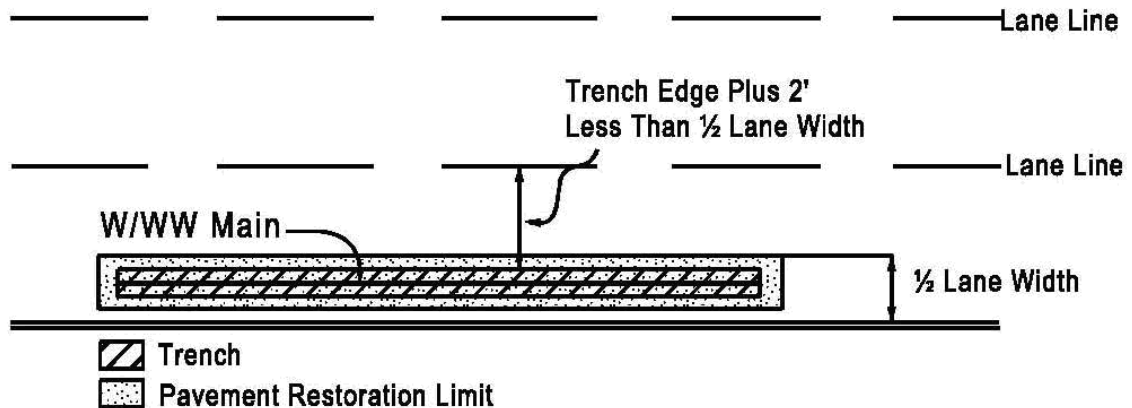


Figure 5.2.4.7.1:
Option 1: Pavement Cut and Repair Extent for Multiple Lane Asphalt Streets

- Option 2: Trench edge is less than $\frac{1}{2}$ lane width but greater than 2 feet from lane line:

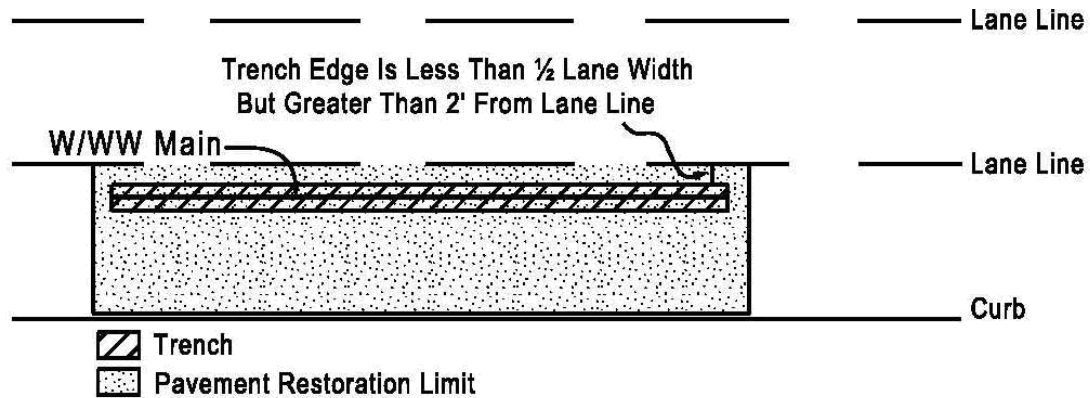


Figure 5.2.4.7.2:

Option 2: Pavement Cut and Repair Extent for Multiple Lane Asphalt Streets

- Option 3: Trench edge is less than 2 feet from lane line:

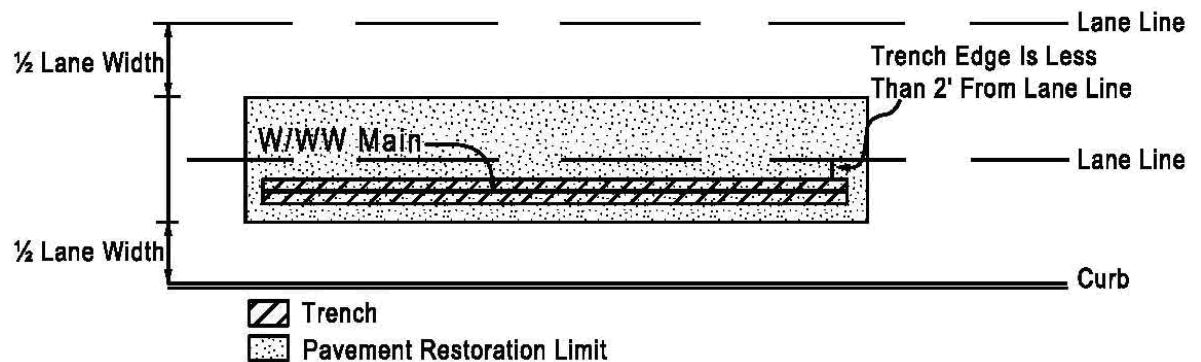


Figure 5.2.4.7.3:

Option 3: Pavement Cut and Repair Extent for Multiple Lane Asphalt Streets

5.2.5 Repair Criteria for Streets of Less Than 5 Years Old

Replacement of pavements in a newly constructed, reconstructed or resurfaced street may not be made for 5 years after substantial completion of the work unless otherwise approved by PW&T.

5.2.5.1 Concrete Street:

If approved by PW&T, the removal limit for concrete streets will extend beyond the edge of the cut to the nearest expansion, construction or dummy joint or to the point halfway between the joints where the edge of the cut terminates, whichever is less. The cut width includes the required 1 foot ledge to undisturbed soil on both sides of the trench excavation.

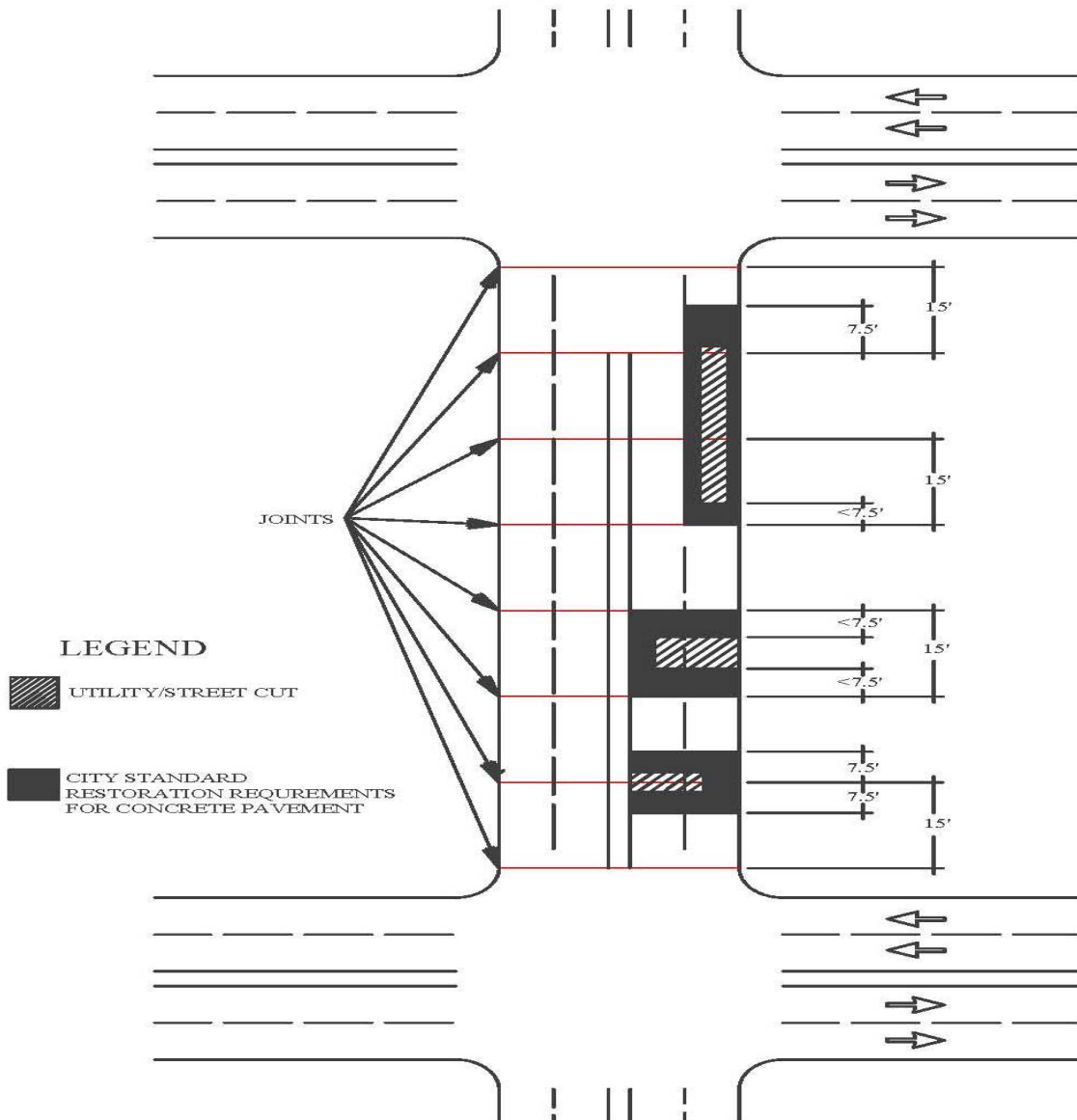


Figure 5.2.5.1:
Pavement Cut and Repair Extent for Concrete Streets of Less Than 5 years Old

5.2.5.2 Asphalt Street:

If approved by PW&T, the restoration limit for asphalt streets will be no less than one lane width and extend no less than 3 (three) in the longitudinal direction from the edge of the cut. The cut width includes the required 2 (two) feet ledge to undisturbed soil on both sides of the trench excavation.

For asphalt streets, the contractor will be required to slurry seal or micro-surface the asphalt pavement for uniformity, or other acceptable method to match the pavement color. The determination shall be made by the City. The treatment will be made for the entire block in which the cut was made.

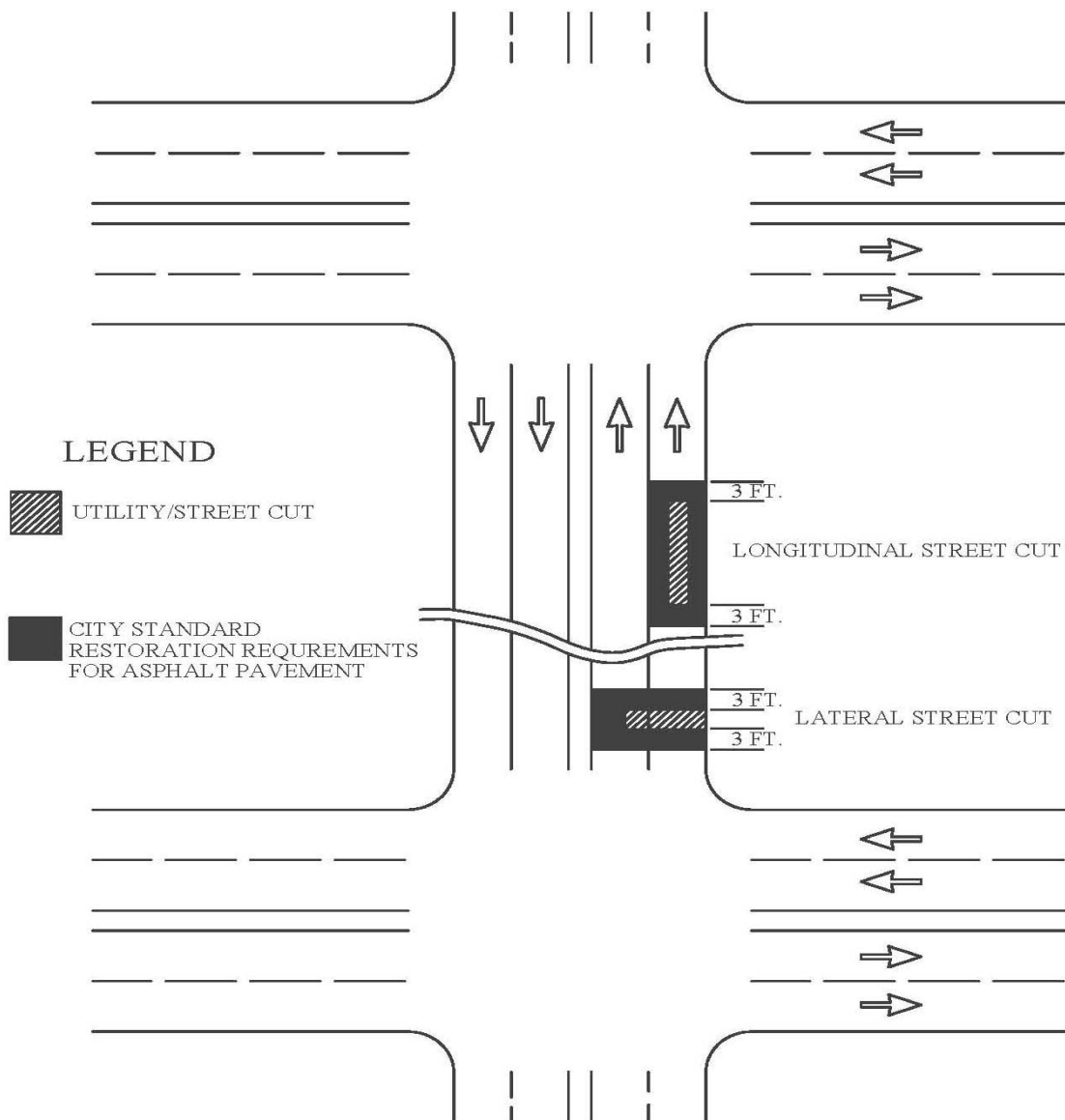


Figure 5.2.5.2:
Pavement Cut and Repair Extent for Asphalt Multilane Streets of Less Than 5 years Old

5.3 HIGHWAY ACCESS CRITERIA

5.3.1 Authority

The design and construction of water and wastewater mains within a state highway must be in compliance with all applicable DWU standards and required criteria or variance as approved by the Texas Department of Transportation (TXDOT). The following reference must be reviewed in conjunction with this manual:

- 43 Texas Administrative Code §21-Subchapter C: Utilities Accommodation by Texas Department of Transportation, Latest Edition.

5.3.2 Location

5.3.2.1 General Requirements:

Water and wastewater mains shall be located so as to avoid or minimize the impact for future highway projects and improvements, to allow other utilities in the right-of-way, and to permit access to utility facilities for their maintenance with minimum interference to highway traffic.

5.3.2.2 Transverse Installation:

New water and wastewater mains crossing a highway shall be installed at approximately 90 degrees to the centerline of the highway, if possible.

5.3.2.3 Longitudinal Installation:

- Longitudinal installation, if allowed shall be located on uniform alignments to the right-of-way line to provide space for future highway construction and possible future utility installation.
- Water and wastewater mains on controlled access highways or freeways shall be located so as to permit maintenance crews access from frontage roads, nearby or adjacent roads and streets, trails along or near the right-of-way line without access from lanes or ramps. Mains shall not be located longitudinally in the center median or outer separation of control access highways or freeways.
- On highways with frontage roads, longitudinal main installations may be located between the frontage road and the right-of-way line. Mains shall not be placed or allowed to remain in the center median, outer separation or beneath any pavement, including shoulders.

5.3.3. Material Type

All material type used for water and wastewater mains shall conform to applicable DWU standards as shown in §2.6 and 3.6 of this manual, as approved by TXDOT.

5.3.4. Depth of Cover

The minimum depth of cover for water and wastewater mains shall conform to applicable DWU standards as shown in §2.4 and §3.4 of this manual, as approved by TXDOT.

5.3.5. Encasement

5.3.5.1 Water Main Crossing:

All water mains crossing under paved highways within the limits of the right-of-way shall be placed in an encasement pipe, unless otherwise approved. The encasement may be omitted under center medians and outer separations that are more than 76 feet wide. Encasement under side road entrances may be omitted in consideration of traffic volume and condition of highway as approved by TXDOT.

5.3.5.2 Wastewater Main Crossing:

Pressurized wastewater mains crossing under paved highways within the limits of the right-of-way shall be placed in steel encasement pipe. Gravity wastewater mains not conforming to the minimum 30" cover or 18" below any pavement structure shall be encased in steel or concrete. The encasement may be omitted under center medians and outer separations that are more than 76 feet wide.

5.3.5.3 Uncurbed Highway Crossing:

For rural, uncurbed highway crossings, all borings shall extend beneath all travel lanes. Unless precluded by right-of-way limitations, the following are required for rural highway crossings:

- Thirty (30) feet from all freeway main lanes and other high-speed (exceeding 40 mph) the edge of pavement of high speed, high volume highways.
- Sixteen (16) feet for high-speed highways with current average daily traffic volume of 750 vehicles per day or fewer
- Sixteen (16) feet for ramps
- Ten (10) feet for low speed (40 miles or less) highways

5.3.5.4.1 Curbed Highway Crossing:

For curbed highway crossings, all borings shall extend beneath travel and parking lanes and extend beyond the back of curb, plus

- Thirty (30) feet from facilities with speed limits of 40 mph or greater
- Five (5) feet from facilities with speed limits of less than 40 mph, plus any additional width necessary to clear an existing sidewalk.

5.3.5.5 Appurtenances:

- Water valves, manhole and other appurtenances shall not be placed in the pavement or shoulder of highway.
- When feasible, fire hydrants and blow-off valves are to be located at the right-of-way line. Fire hydrants shall not be placed in the sidewalk or any closer than five feet from the back of the curb. Valve locations shall be placed so as not to interfere with the maintenance of the highway.
- The maximum inside diameter of the water manhole chimney shall not exceed 48 inches. The outside diameter of the manhole chimney at the ground level shall not exceed 36 inches. The manhole lid shall be installed flush with the ground, meet HS-20 loading and weigh at least 175 pounds.
- Manholes serving wastewater mains up to 12 inches shall have a maximum inside diameter of 48 inches. For mains larger than 12 inches, the manhole inside diameter may be increased an equal amount, up to a diameter of 60 inches. Manholes for large interceptor mains shall be designed to keep the overall dimensions to a minimum. The outside diameter of the manhole chimney at the ground level shall not exceed 36 inches.
- Individual service meter shall be placed outside the limit of right-of-way. Master meters for a point of services connection may be placed as approved by TXDOT.

5.3.5.6 Permit

- All applicable permits should be obtained by the designer prior to any construction. All permit information must be shown on design plans as show in DWU Standard Drafting Manual, Latest edition.
- Any variance to criteria set forth in 43 TAC §21 must be preapproved by TXDOT and other jurisdictions as necessary prior to any construction.

5.3.5.7 Construction:

While entry (bore) and exit (receiving) pits are not generally designated on the plans the designer must consider the location, size and depth of these when he/she chooses the beginning and ending stations for borings. Location of the entry pit is preferred at the lower elevation end of the tunnel when there is a slope. This will allow any groundwater or any boring slurry to flow by gravity from the tunnel into the entry pit where it can be pumped out during construction. Entry and exit pits must be located beyond the limits of paving.

5.4 RAILROAD ACCESS CRITERIA

5.4.1 Authority

The design and construction of water and wastewater mains within a railroad right-of-way must be in compliance applicable DWU standards and required criteria or variance as approved by appropriate railroad authority. Railroad crossings are generally unique for each railroad company. The challenge is determining which railroad company right-of-way is being crossed because of the continual merger of railroads. It is important that the designer determine which railroad company right-of-way is being crossed and obtain their utility accommodation policies prior to beginning the design. The following references, as applicable, must be reviewed in conjunction with this manual:

- Utility Accommodation Policy by Burlington Northern Santa Fe (BNSF), Latest Edition.
- Dallas Area Rapid Transit (DART) Design Criteria Manual, Latest edition.
- American Railway Engineering & Maintenance Association (AREMA), Latest edition

5.4.2 Location

Water and wastewater mains shall be located so as to avoid or minimize the need for future railroad projects and improvements, to allow other utilities in the right-of-way and to permit access to utility facilities for their maintenance with minimum interference to railroad service.

5.4.2.1 Transverse Crossing:

New mains crossing the railroad shall be installed at approximately 90 degrees to the centerline of the railroad, if possible.

5.4.2.2 Longitudinal Crossing:

- Longitudinal installation, if allowed shall be located on uniform alignments to the right-of-way line to provide space for future railroad construction and possible future utility installation.
- All new mains shall be located on top of back slope at the outer limits of railroad property.
- If main is located forty (40) feet or less from centerline of track, the mains shall be encased in a steel pipe as approved by the railroad authority under jurisdiction. No pipe may be placed closer than twenty-five (25) feet from the centerline of the track.

5.4.3 Material Type

All materials used for water and wastewater mains shall conform to applicable DWU standards as shown in §2.6 and 3.6 of this manual, as approved by railroad authority under jurisdiction.

5.4.4 Depth of Cover

The minimum depth of cover for water and wastewater mains shall conform to applicable DWU standards as shown in §2.4 and §3.4 of this manual, as approved by railroad authority under jurisdiction.

5.4.5 Encasement

5.4.5.1 General Requirements:

- All mains crossing under railway track shall be placed in an encasement pipe, unless otherwise approved by railroad authority.
- Casing pipe and joints shall be made of metal capable of withstanding the railroad loadings and other loads superimposed upon them.

5.4.5.2 Variances:

In circumstances where it is not feasible to install encasement from right-of-way line to right-of-way, casing pipe under railroad track and across railroad property shall extend to greater of the following distances, measured at the right angles to the centerline of the track:

- Two (2) feet beyond toe of slope
- Three (3) feet beyond ditch line.
- Twenty-five (25) feet from centerline of outside track when casing is sealed at both ends
- Forty-five (45) feet from centerline of outside track when casing is open at both ends.
- If additional track is planned for future construction, casing must be extended far enough to meet above distances given the additional track requirement.

5.4.6 Appurtenances

Due to difficulty in maintenance, all new water and wastewater manholes, valves and other appurtenances shall be located outside the railroad property when possible. No appurtenance shall be located in the shoulder, shoulder slope, ditch or backslope or within 25 feet of the centerline of track, and shall not protrude above surrounding ground without approval from railroad authority.

5.4.7 Permit

- All applicable permits should be obtained by the designer prior to any construction.
- Any variance to above criteria and or applicable railroad policy must be preapproved by railroad authority under jurisdiction prior to any construction.

5.4.8 Construction

While entry (boring) and exit (receiving) pits are not generally designated on the plans the designer should consider the location, size and depth of these when he chooses the beginning and ending stations for pits. Location of the entry pit is preferred at the lower elevation end of the tunnel when there is a slope. This will allow any groundwater or any boring slurry to flow by gravity from the tunnel into the bore pit where it can be pumped out during construction. Entry and exit pits must be located beyond the limits of railroad tracks.

5.5 CREEK CROSSING

Following items must be considered for a water or wastewater main crossing under a flowing stream or semi-permanent body of water such as a marsh or pond:

5.5.1 Material and Appurtenances

- A watertight encasement pipe with a manhole on each side of the crossing should be used for wastewater mains.
- Watertight encasement pipe for water main with a valve on each side of the crossing should be used.

5.5.2 Erosion Control

- Proper erosion control must be incorporated in the design. As a minimum, cement stabilized backfill shall be used from bank to bank. The cement stabilized backfill shall be covered with riprap if the velocity of the flowing water is anticipated to be greater than ten (10) feet per second.
- In areas where there is a planned channel improvement, the stabilized backfill shall be used up to the line of planned improvement. The area above this planned line of improvement shall be compacted fill. In addition, the main must be designed with a minimum clearance from the top of the pipe to the bottom of the channel of four (4) feet.

5.5.3 Reference Schematic

DWU Standard Drawing No. 102: Stabilized Backfill and Rip-Rap Detail for Embankment Slope Protection.

5.6 ELEVATED CROSSING

5.6.1 General Option

- Bridge Attachment: Pipeline to be attached to an existing or proposed roadway bridge.
- Utility Bridge: Bridge constructed to support pipeline.

5.6.2 Design Considerations

- Provisions must be made for thrust restraints at the points of transition from a buried pipe to an exposed pipe.
- Water main must be fully restrained at changes in alignment and at fittings, as necessary
- Wastewater mains shall be fully restrained across aerial section with manholes at each end.
- The designer must evaluate the increased loading on the bridge created by a full main and its supports.
- Access to the main must be considered.
- Provisions for corrosion control must be considered.
- PVC pipe shall not be used for the exposed portion of the main.
- The designer must consider freeze potential for small, low flow, mains.
- As a minimum, each joint of pipe will have two supports with one support near the bell. The pipe supports shall be constructed of either stainless or galvanized steel.
- Air relief provisions shall be considered at the high points.
- A minimum of one expansion joint shall be designed which shall coincide with an expansion joint on the bridge unless push-on ductile iron pipe is used.
- The force of the flow of the stream during flooding shall be considered.

5.7 Pipe Encasement

Water/wastewater main shall be considered for encasement under following condition:

- Highway/railroad crossing
- Water/wastewater main crossing
- Creek/water body crossing
- As required by the design

5.7.1 General Consideration

- Location of Excavation Pits: The location, size and depth of the boring pits shall be evaluated during design. Location of the entry pit is preferred at the lower elevation end of the tunnel when there is a slope. This will allow any groundwater or any boring slurry to flow by gravity from the tunnel into the bore pit where it can be pumped out during construction.
- Size of Encasement Pipe: The minimum of size of encasement pipe shall be at least two (2) to three (3) standard pipe sizes larger than the carrier pipe.
- Loading: Encasement pipe and joints shall be designed to withstand the imposed loading.
- Annular Space: The annular space between the encasement and carrier pipe shall be filled by slurry grout or other materials as approved by DWU.
- Corrosion Protection: Encasement pipe shall be protected against corrosion. Where both carrier pipe and casing pipe are metallic, they shall be separated electrically by using insulated spacers.
- Reference Schematics: DWU Standard Drawing No. 101- 109A.

5.7.2 Encasement Materials

Following encasement materials can be used as approved by the appropriate authority under jurisdiction:

5.7.2.1 PVC Casing Pipe:

5.7.2.1.1 Applicability:

- Water/wastewater main crossing with carrier pipe 12" or smaller within DWU R.O.W. or easement
- Other applications as approved by DWU

5.7.2.1.2 Minimum Specifications:

- Pressure rated PVC C900 or C905 with minimum pressure rating 150 psi

5.7.2.2 Reinforced Concrete Casing Pipe:

5.7.2.2.1 Applicability:

- Water/wastewater main crossing
- Open cut application or shorter length (<20 LF)
- Other applications as approved by DWU

5.7.2.2.2 Minimum Specifications:

- Reinforced Concrete Pipe C76, Class IV

5.7.2.3 Ductile Iron Casing Pipe:

5.7.2.3.1 Applicability:

- Water/wastewater main crossing
- Open cut application or shorter length (<20 LF)
- Other applications as approved DWU

5.7.2.3.2 Minimum Specifications:

- Ductile Iron Pipe, ANSI/AWWA A21.50, Class 51
- The pipe shall be connected with mechanical type joint

5.7.2.4 Steel Casing Pipe:

5.7.2.4.1 Applicability:

- Highway/Railroad crossing
- Large utility or structure crossing
- Creek/Water Body Crossing
- Water/wastewater main crossing
- Other applications as approved DWU

5.7.2.4.2 Minimum Specifications:

Designer shall be responsible for determining the minimum wall thickness of steel encasement pipe as required for any specific application with following minimum conditions:

- Steel pipe with minimum yield strength of 35,0000 psi
- Minimum thicknesses of steel encasement pipe for different diameters are shown under **Table 5.7.2.4.2**, which must be verified by the designer. These wall thicknesses shall be increased by at least 0.063 inch for uncoated casing and by at least 0.063 inch for coated or uncoated steel casing to be installed by jacking or boring.

Table 5.7.2.4.2: Minimum Thickness of Steel Encasement Pipe

	DWU*	DART**			BNSF Railroad***	
Encasement Pipe I.D. (in)	Minimum Thickness (Coated) (in)	Minimum Thickness (Coated) (in)			Minimum Thickness For E-80 Loading (in)	
		Cover Depth				
		>20'	16-30'	>42'	Coated	Non-Coated
12	0.188	0.25	0.344	0.438	0.188	0.188
14		0.25	0.344	0.438	0.188	0.281
15	0.25	0.25	0.344	0.438		
16		0.25	0.344	0.438	0.250	0.281
18	0.25	0.25	0.344	0.438	0.250	0.312
20		0.25	0.344	0.438	0.281	0.344
21	0.312	0.312	0.438	0.562		
22		0.25	0.438	0.562		
24	0.375	0.25	0.438	0.562	0.312	0.375
27	0.438	0.25	0.438	0.562	0.344	0.406
28		0.25	0.438	0.562	0.75	0.438
30	0.438	0.25	0.438	0.562	0.406	0.469
32					0.438	0.500
34-36	0.50				0.469	0.531
38-42	0.50				0.500	0.563
44			0.500		0.531	0.594
46			0.625		0.531	0.594
48			0.625		0.563	0.625
50			0.625		0.594	0.656
52			0.750		0.625	0.688
54			0.750		0.656	0.719
56-58			0.813		0.688	0.750
60					0.719	0.781
62					0.750	0.813
64					0.713	0.844
66-68					0.813	0.875
70					0.844	0.906
72					0.875	0.938

* Minimum thickness as acceptable by DWU must be verified by designer for any specific application

** Minimum thickness as per Dallas Area Rapid Transit (DART) Design Criteria Manual, November 2002. Latest updates must be verified.

*** Minimum thickness as per Utility Accommodation Policy by Burlington Northern Santa Fe (BNSF), May 5, 2007. Latest updates must be verified

5.7.2.5 Liner Plate:

5.7.2.5.1 Applicability:

- Highway crossing/railroad crossing
- Large utility or structure crossing
- Water/wastewater main crossing with minimum casing size of 48 inch
- 2- flange liner plate typically applicable for construction by hand mining
- 4-flange liner plate typically applicable for construction by mechanical means including Tunnel Boring Machine (TBM).
- Other applications as approved by DWU

5.7.2.5.2 Design Criteria:

All liner plate must be designed in accordance with AASHTO Design Specifications for Tunnel Liner Plates, Section 15, Latest Edition:

- Seam/Joint Strength: The seam/joint strength of liner plates must be sufficient to withstand the thrust developed from the total load supported by the liner plate.
- Installation Stiffness: The liner plate ring shall have enough rigidity to resist the unbalanced loads of normal construction including grouting pressure, local slough-ins, and miscellaneous construction loads.
- Critical Bucking: The wall bucking of the liner plate shall not exceed the critical bucking.
- Deflection: Deflection of a tunnel depends significantly on the over-excavation of the bore and is affected by delay in backpacking or inadequate backpacking. Where the tunnel clearances are important, the designer should oversize the structure to provide for a normal deflection.
- Safety Factors: Minimum allowable factors of safety for liner plate design are as follows:

Table 5.7.2.5.2.1: Factor of Safety for Liner Plate Design

Criteria	Factor of Safety (AASHTO)
Seam/Joint Strength	3
Installation Stiffness	3
Critical Bucking	2
Allowable Deflection	3%

- Minimum thicknesses of tunnel liner plate for different diameters are shown under **Table 5.7.2.5.2.2**, which must be verified by the designer for any specification application. Steel tunnel liner plates shall be of heavier gage or thickness or protected by coatings or other means when required for resistance to abrasion or corrosion.

Table 5.7.2.5.2.2: Minimum Thickness of Liner Plates*

	2- Flanged Liner Plate		4- Flanged Liner Plate	
Nominal Diameter (in)	Inside Diameter (in)	Thickness (Gauge)	Inside Diameter (in)	Thickness (Gauge)
	Bury Depth: 8'-16'		Bury Depth: 8'- 16'	
48	45.25	14	43.00	12
54	51.25	14	49.00	12
60	57.25	14	55.00	11
66	63.25	12	61.00	10
72	69.25	12	67.00	8
78	75.25	12	73.00	8
84	81.25	12	79.00	5
90	87.25	12	85.00	3
96	93.25	10	91.00	3
102	99.25	10	97.00	3/8"
108	105.25	10	103.00	3/8"
114	111.25	8	109.00	
120	117.25	8	115.00	
126	123.25	7	121.00	
132	129.25	5	127.00	
138	135.25	5	133.00	
144	141.25	3	139.00	

* The information in the above table is based on the following assumptions: AASHTO Section 16: "Steel Tunnel Liner Plates", H20 loading, soil friction angle of zero (0) and a bury depth range of 8 feet to 16 feet.

5.8 THRUST RESTRAINT

5.8.1 General Requirements

All pressurized water and wastewater mains shall be restrained against unbalanced thrust forces due to change in pipeline diameter or alignment in order to prevent joint separation or movement.

5.8.2 Thrust Restraint System

Any or a combination of the following thrust restraint systems are acceptable for DWU mains:

- Horizontal Thrust Block
- Vertical Thrust Block/ Anchor Block
- Joint Restraint System

5.8.3 Horizontal Thrust Block

5.8.3.1 Applicability:

Horizontal thrust block shall be designed to transfer horizontal thrust force to larger bearing area, as needed.

5.8.3.2 Design Consideration:

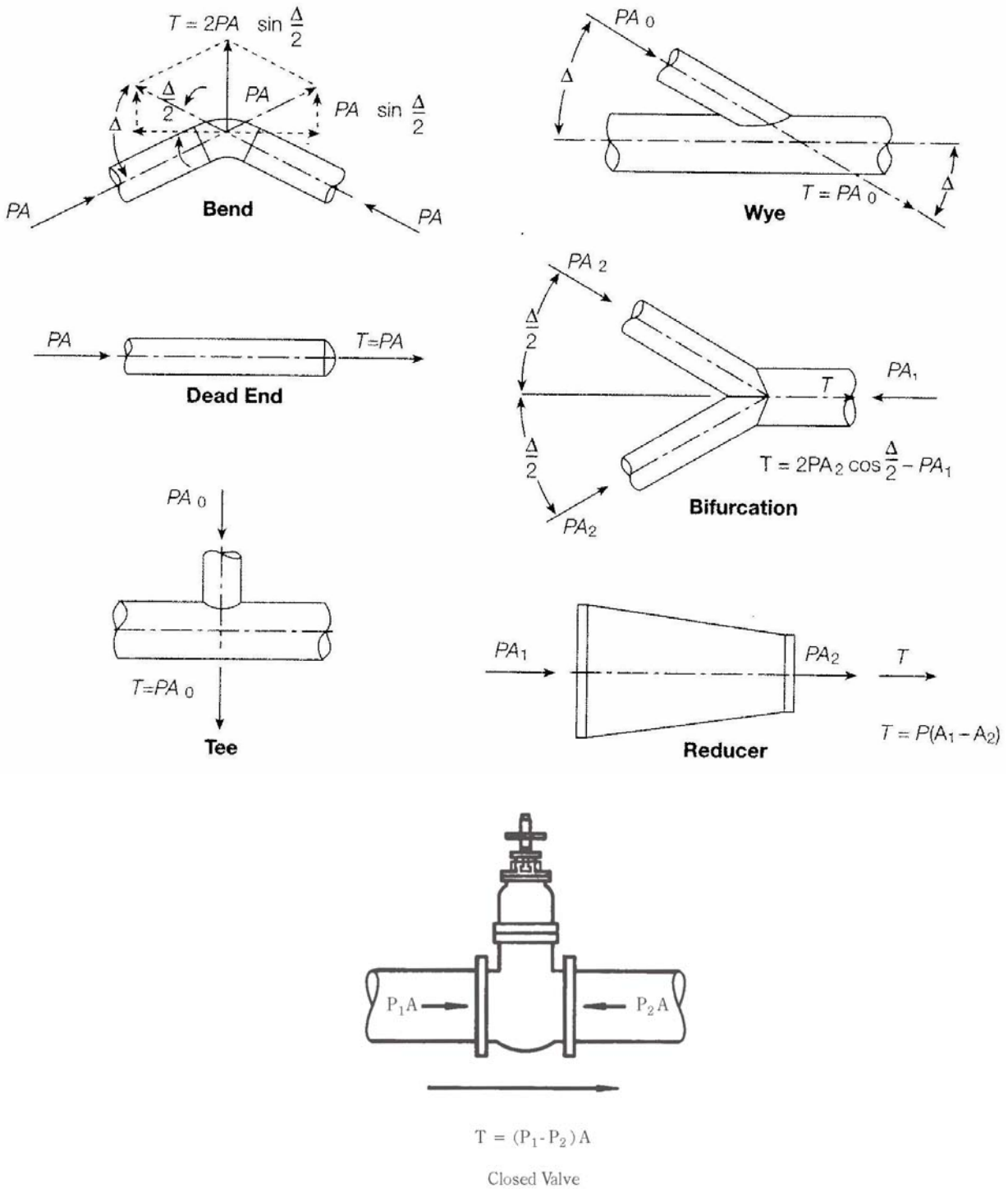
5.8.3.2.1 Design Pressure (P):

The design pressure for horizontal thrust restraint system shall be the maximum anticipated water pressure. Hydrostatic test pressure can be used as the thrust restrained design pressure for most applications.

5.8.3.2.2 Thrust Force (T):

Unbalanced thrust force occurs at the following configurations shall be restraint as needed (**Figure 5.8.3.2.2**):

- Bend
- Wye
- Deadend
- Bifurcation
- Tee
- Reducer
- Closed Valve



Where, T = Hydrostatic Thrust (lb)
A= Cross-Sectional Area of Pipe (in²)

P= Internal Pressure (psi)
Δ= Deflection Angle (degree)

Figure 5.8.3.2.2: Unbalanced Thrust Force at Various Configurations

Source: Thrust Restraint Design for Ductile Iron Pipe, by DIPRA, 2002

5.8.3.2.3 Bearing Area (A_b):

Thrust bearing area can be calculated as follows:

$$A_b = S_f T / S_b$$

Where,

A_b = Bearing Area

S_f = Factor of Safety, Typically 1.5

S_b = Horizontal Bearing Strength

T = Hydrostatic Thrust

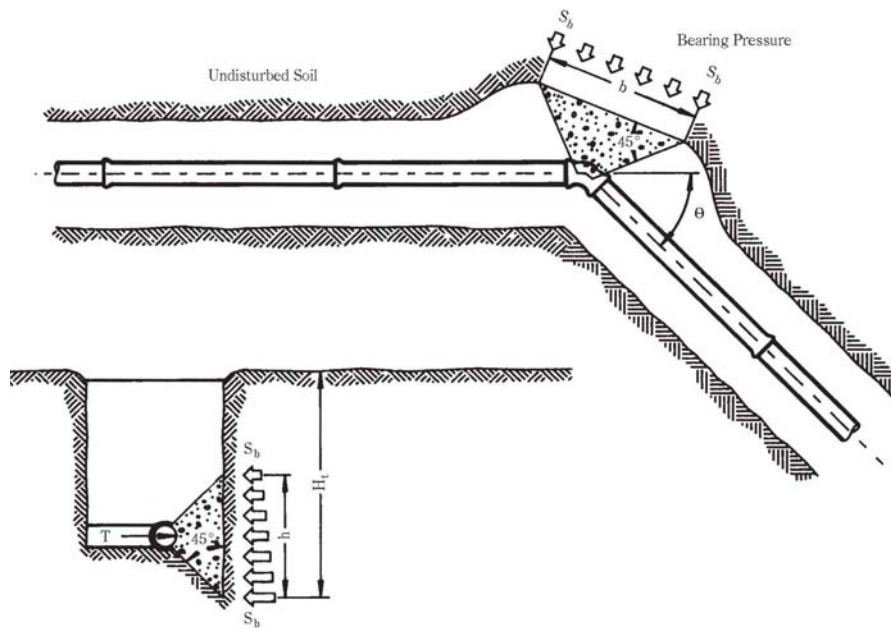


Figure 5.8.3.2.3: Horizontal Thrust Bearing Area

Source: *Thrust Restraint Design for Ductile Iron Pipe*, by DIPRA,, 2002

In absence of actual Horizontal Bearing Strength, **Table 5.8.3.2.3** can be used to estimate bearing strength:

Table 5.8.3.2.3

Soil	Bearing Strength (lb/ft ²)
Muck	0
Soft Clay	1,000
Silt	1,500
Sandy Silt	3,000
Sand	4,000
Sandy Clay	6,000
Hard Clay	9,000

Source: *Thrust Restraint Design for Ductile Iron Pipe*, by DIPRA,, 2000

5.8.3.2.4 Block Dimension:

- Block dimension shall be determined based on the required bearing area with following criteria:

$$b = A_b / h$$

Where,

A_b = Bearing Area

b = Block Width

h = Block Height

- Block height (h) shall be equal to or less than one-half the total depth to the bottom of the block, (H_t), but not less than the pipe diameter (D).
 - $h \leq 0.5 H_t$
 - $h > D$
- Block height (h) should be chosen such that the calculated block width (b) varies between one and two times the height.
 - $h = b \sim 2b$

5.8.3.3 Installation:

- Bearing surface shall be placed against undisturbed soil extending beyond joints. If not, the fill between the bearing surface and undisturbed soil must be compacted to at least 90% Standard Proctor density.
- Thrust block shall not be used in swamps or marshes
- Horizontal thrust block may not be practical for large water main due to size restriction

5.8.3.4 Reference Schematics:

For general application see DWU Standard Drawing Nos. 229- 232

5.8.3 Vertical Thrust Block/Anchor Block

5.8.4.1 Applicability:

Vertical thrust block shall be designed to counter vertical thrust force by weight and to transfer horizontal thrust force to larger bearing area, as needed.

5.8.4.2 Design Consideration:

5.8.4.2.1 Design Pressure (P):

The design pressure for horizontal thrust restraint system shall be the maximum anticipated water pressure. Hydrostatic test pressure can be used as the thrust restrained design pressure for most application.

5.8.4.2.2 Thrust Force (T)

Unbalanced thrust force occurs at the configuration shown in **Figure 5.8.4.2.2**:

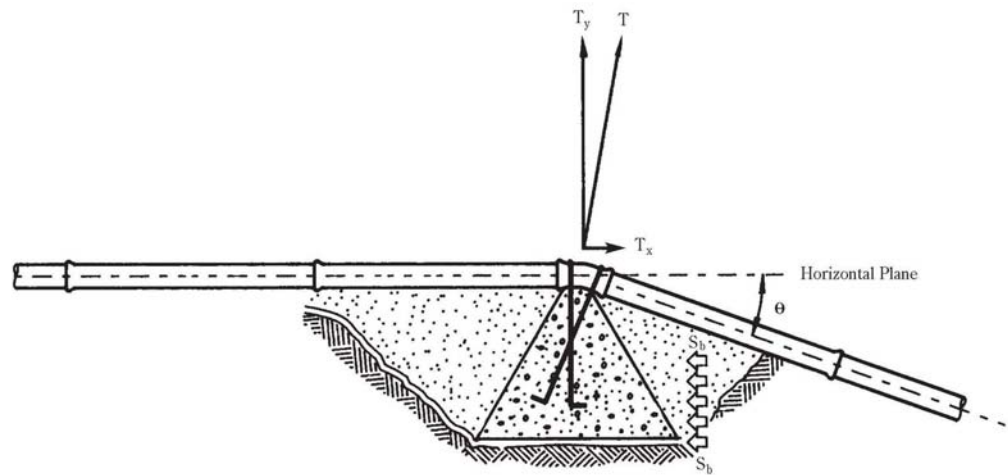


Figure 5.8.4.2.2 Vertical Thrust Block

Horizontal Hydrostatic Thrust, $T_y = PA \sin \Delta$

Horizontal Hydrostatic Thrust, $T_x = PA \sin \Delta$

Where,

P = Internal Pressure (psi)

A = Bearing Area

Δ = Deflection Angle (degree)

5.8.4.2.3 Volume of Vertical Thrust Block (V):

Vertical thrust block shall be designed to provide equilibrium by the weight of the block.

Required Volume, V

$$V = S_f T_y / W_m$$

$$= S_f P A \sin \Delta / W_m$$

Where,

S_f = Factor of Safety,
Typically 1.5

T_y = Vertical Component of Thrust

S_b = Horizontal Bearing Strength

W_m = Density of Block Material

5.8.4.3 Reference Schematics:

For general application see DWU Standard Drawing No. 233

5.8.4 Restraint Pipe Joint

5.8.5.1 Applicability:

Restraint Pipe Joint shall be designed to transfer horizontal and vertical thrust force, as needed.

5.8.5.2 Design Consideration:

The design pressure for horizontal thrust restraint system shall be the maximum anticipated water pressure. Hydrostatic test pressure can be used as the thrust restrained design pressure for most application.

5.8.4.3 Reference:

The following technical references shall be used for calculating thrust restraint system, as required

- AWWA M9: Concrete Pressure Pipe by AWWA, Latest Edition
- AWWA M11: Steel Pipe- A Guide for Design and Installation, Latest Edition
- Thrust Restraint Design for Ductile Iron Pipe, 2002, or Latest Edition.

5.9 TRENCHLESS TECHNOLOGY

5.9.1 General Requirements

The deterioration of DWU underground water and wastewater infrastructure systems and a growing demand for new utility services within the congested urban areas have increased the necessity for trenchless technology. These technologies shall be considered in order to minimize the disturbance of the environment, traffic, congested living or working areas while utilizing more efficient methods of installation, inspection, repair, rehabilitation, and replacement of underground utilities.

5.9.2 Technical References

The following references, as applicable, may be reviewed in conjunction with this manual:

- Trenchless Technology Pipeline and Utility Design, Construction, and Renewal by Mohammad Najafi, 2004.

5.9.3 Selection Criteria

The following items, but limited to, shall be considered prior to selecting any specific trenchless technology:

- Pipe size, shape, depth and alignment
- Potential environmental, social and traffic impact
- Existing flow and bypass pumping, if necessary
- Bore pit locations, if necessary

5.9.4 Acceptable Trenchless Technologies

Most commonly acceptable Trenchless Technologies utilized by DWU are summarized in **Figure 4.9.4**. These technologies are primarily divided into two major categories as Trenchless Construction Methods (TCM) and Trenchless Rehabilitation Methods (TRM). TCM can be used for new utility installation where TRM is used for renewing, rehabilitating, and/or renovating an existing utility main. Other technologies may be used on case-by-case basis upon approval by DWU:

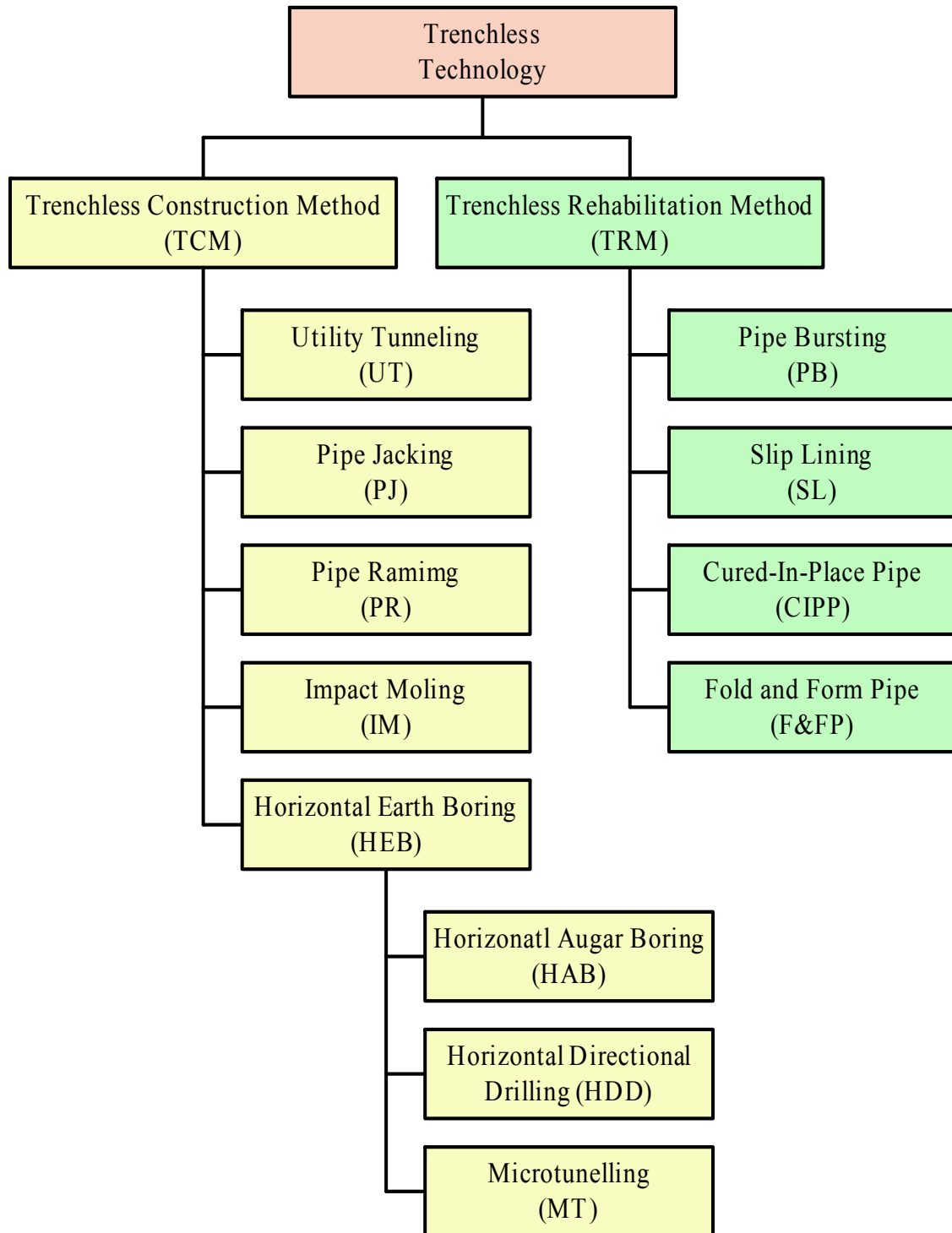


Figure 5.9.4:
DWU Acceptable Trenchless Technologies

5.9.5 Utility Tunneling (UT)

5.9.5.1 General Description:

The Utility Tunneling (UT) involves manual excavation or use of self-propelled tunnel-boring machine (TBM) to install a pipe supported by a segmental liner from a drive shaft to a reception shaft. Manual access to the tunnel face is generally necessary.

5.9.5.2 Applicability:

**Table 5.9.5.2:
Utility Tunneling (UT) Criteria**

Items	Acceptable Parameter
Typical Application	Water Main Wastewater Main- Gravity & Pressure
Encasement Size	42" or Larger
Encasement Material	Steel Pipe , Liner Plate, Rib & Lagging*
Carrier Pipe Size	30" or Larger
Carrier Pipe Material	RCP, Steel, RTRP
Maximum Installation	1500 LF
Special Consideration	- Suitable for almost all types of soil - Requires worker entry

**Rib & lagging to be used for wastewater main with prior approval*

5.9.6 Pipe Jacking (PJ)

5.9.6.1 General Description:

The pipe jacking involves the use of a jacking system to install a prefabricated pipe through the ground from a drive shaft to a reception shaft. This process involves workers to be inside the pipe during the jacking operation.

9.6.2 Applicability:

**Table 5.9.6.2:
Pipe Jacking (PJ) Criteria**

Items	Acceptable Parameter
Typical Application	Water Main Wastewater Main- Gravity & Pressure
Encasement Size	Not Used
Encasement Material	N/A
Carrier Pipe Size	42" or Larger
Carrier Pipe Material	RCP, Steel, RTRP
Maximum Installation	1500 LF
Special Considerations	- Suitable for almost all types of soil - Requires worker entry - Directional changes only possible at the shafts.

5.9.7 Pipe Ramming (PR)

5.9.7.1 General Description:

Pipe ramming utilizes pneumatic tool to hammer a pipe or casing into the ground while the excess soil from the borehole is removed to the surface. The method is most valuable for installing larger pipes over shorter distances and for installations at shallower depths. Pipe ramming can be combined with directional drilling and used to free the product pipe during pullback.

5.9.7.2 Applicability:

**Table 5.9.7.2:
Pipe Ramming (PR) Criteria**

Items	Acceptable Parameter
Typical Application	Water Main Wastewater Main- Pressure
Encasement Size	N/A
Encasement Material	N/A
Carrier Pipe Size	4- 60"
Carrier Pipe Material	Concrete, Steel, DI
Maximum Installation	200' - 400'
Special Considerations	- Not suitable for gravity application or pipeline with grade - High Noise level, ground vibration, surface disruptions

5.9.8 Impact Moling (IM)

5.9.8.1 General Description:

Impact Moling (IM), also known in the field as Missiling, utilizes percussion or hammering action of a pneumatic piercing tool to create bore hole by compacting and displacing soil rather than removing it. Non-steerable moles are the more commonly used. Typically, non-steerable moles are intended for straight bores and steerable moles are intended for inclined or curved bores. This method is most valuable for installing smaller water main or water service over shorter distances and for installations at shallower depths.

5.9.8.2 Applicability:

**Table 5.9.7.2:
Pipe Ramming (PR) Criteria**

Items	Acceptable Parameter
Typical Application	Small Water Main Water Service Lateral
Encasement Size	N/A
Encasement Material	N/A
Carrier Pipe Size	3/8"- 6"
Carrier Pipe Material	PVC, Steel, Copper
Maximum Installation	Non-Steerable Mole: 35 LF Steerable Mole: 200 LF
Special Considerations	- May cause surface damage for too shallow installation - Most conservative depth for installation of a pipe is 4 feet or 10 times diameter of the pipe - High Noise level, ground vibration, surface disruptions

5.9.9 Horizontal Earth Boring (HEB)

Horizontal Earth Boring (HEB) involves borehole excavation for pipe installation by utilizing mechanical means without workers being inside the borehole. The DWU acceptable HEB methods include Horizontal Auger Boring (HAB), Microtunneling (MT) and Horizontal Direction Drilling (HDD).

5.9.9 .1 Horizontal Auger Boring (HAB):

5.9.9.1.1 General Description:

The Horizontal Auger Boring (HAB) method involves simultaneous pushing of a steel casing from a drive pit through the earth while removing the spoil inside the casing by rotating flight auger.

5.9.9.1.2 Applicability:

**Table: 5.9.9.1.2:
Horizontal Auger Boring (HAB) Criteria**

Items	Acceptable Parameter
Typical Application	Water Main Wastewater Main- Gravity & Pressure
Encasement Size	4"- 60"
Encasement Material	Steel
Carrier Pipe Size	2"- 48"
Carrier Pipe Material	PVC, RCP, Steel, RTRP, RPMP, HDPE
Maximum Installation	600 LF
Special Considerations	- Does not require worker entry - May require dewatering under water table

5.9.9.2 Horizontal Direction Drilling (HDD):

5.9.9.2.1 Genera Description:

Horizontal Directional Drilling (HDD) is a steerable method for the installation of pressure pipe in a shallow arc with a surface-launched drilling rig. This method involves simultaneously drilling a fluid-lubricated pilot hole and enlarging the pilot hole with back reamers to accommodate and pull a utility main.

5.9.9.2.2 Applicability:

**Table 5.9.9.2.2:
Horizontal Direction Drilling (HDD) Criteria**

Items	Acceptable Parameter
Typical Application	Water Wastewater Main- Pressure
Encasement Size	Not Used
Encasement Material	N/A
Carrier Pipe Size	2"- 48"
Carrier Pipe Material	PVC- Fusible/Certa-Lok, HDPE, Steel, DI
Maximum Installation	600- 6000 LF
Special Considerations	- May cause significant ground movement especially for shallow ground cover. - Disposal of drilling fluid may be required - May cause community problem due to surfacing of drilling fluid known as "Frack Outs"

5.9.9.3 Microtunneling (MT):

5.9.9.3.1 Genera Description:

Microtunneling (MT) is a precise remotely controlled method of jacking pipe behind a Microtunnel Boring Machine (MTBM), where the earth is continuously supported at the face.

5.9.9.3.2 Applicability:

**Table 5.9.9.3.2:
Microtunneling Criteria**

Items	Acceptable Parameter
Typical Application	Wastewater Main- Gravity
Encasement Size	10- 136"
Encasement Material	N/A
Carrier Pipe Size	4"- 108"
Carrier Pipe Material	RCP, Steel, DI, RTRP, RPMP
Maximum Installation	600 LF
Special Considerations:	- Does not require worker entry

5.9.10 Pipe Bursting (PB)

5.9.10.1 General Descriptions:

Pipe bursting is a method by which the existing pipe is forced outward and opened by a bursting tool. During the pipe bursting process, the rehabilitated pipe segment must be taken out of service by rerouting flows around it. After the pipe bursting is completed, laterals are to be re-connected with robotic cutting devices or other approved methods, as needed.

5.9.10.2 Applicability:

**Table 5.9.10.2:
Pipe Bursting (PB) Criteria**

Items	Acceptable Parameter
Typical Application	Wastewater Main- Gravity/Pressure
Host Pipe Size	4"- 48"
Host Pipe Material	PVC, Clay, DI, RTRP*, RPMP**
New Pipe Size	4"-48"
New Material	HDPE
Maximum Installation	750 LF
Special Considerations	- Upsize allowable up to 1.5 times of the diameter of the host pipe - Bypass or diversion of flow required - Insertion pit required - Percussive action can cause significant ground movement - Point repair may be required

* RTRP denotes Reinforced Thermosetting Resin Pipe

** RPMP denotes Reinforced Polymer Motar Pipe

5.9.11 Slip Lining (SL)

5.9.11.1 General Description:

The Slip Lining (SL) process involves insertion of a new liner of smaller diameter inside the existing pipe and grouting the annular space to provide structural integrity. After the slip lining is completed, laterals to be re-connected by excavation or by a remote-cutter, as possible. SL by the segment method can be accomplished without rerouting the existing flow.

5.9.11.2 Applicability:

**Table 5.9.11.2:
Slip Lining (SL) Criteria**

Items	Acceptable Parameter
Typical Application	Water Wastewater Main- Pressure/Gravity
Host Pipe Size	4"- 144"
Host Pipe Material	PVC, Clay, DI, RCP, CI
Liner Pipe Size- Segmental	24"-144"
Liner Pipe Size- Continuous	4"- 60"
Liner Material*	Water: Fusible PVC Wastewater: HDPE, RTRP, RPMP
Maximum Installation	1500 LF
Special Considerations	- Reduce pipe size - Insertion pit required - Not well suited for small diameter pipes - Point repair may be required

*Reference: ASTM F585: Practice for Insertion of Flexible Polyethylene pipe into Existing Sewers

5.9.12 Cured-In-Place Pipe (CIPP)

5.9.12.1 General Description:

Cured-In-Place Pipe (CIPP) process involves the insertion of a thermosetting resin coated flexible fabric liner into the existing pipeline and cured by hot water, steam or UV light to form a new liner. The liner is typically inserted into the existing pipe through an existing manhole.

5.9.12.2 Applicability:

**Table 5.9.12.2:
Cured-In-Place Pipe (CIPP) Criteria**

Items	Acceptable Parameter
Typical Application	Wastewater Main- Pressure/Gravity
Host Pipe Size	8"- 120"
Host Pipe Material	PVC, Clay, DI
Liner Pipe Size- Inverted	8"-108"
Liner Pipe Size- Winched	8"- 100"
Liner Material *ASTM D5813, Specify Class I,II or III	Thermoset Resin/ Fiber Composite
Max. Installation- Inverted	3000 LF
Max. Installation- Winched	1500 LF
Special Considerations	- Bypass or diversion of flow required - Curing can be difficult for long pipe segments - Must allow adequate curing time - Resin may clump together on bottom of pipe - Reduces pipe diameter - Point repair may be required

**References:*

ASTM F1216: Practice for Rehabilitation of Existing Pipeline s and Conduits by the Inversion and Curing of a Resin Impregnated Tube

ASTM F1743: Practice for Rehabilitation of Existing Pipeline s and Conduits by Pulled-in-Place Installation of Cured-in-Place Thermosetting Resin Pipe (CIPP)

ASTM F2019: Practice for Rehabilitation of Existing Pipeline s and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GPR) Cured-in-Place Thermosetting Resin Pipe (CIPP)

5.9.13 Fold & Form Pipe (F&FP)

5.9.13.1 General Description:

The Fold & Form Pipe process involve insertion of a folded liner into the existing pipe and expanding it through pressure, heat or mechanical means to restore its original circular shape. The annular space between the old pipe and the liner may require grouting, unless the old pipe and the new pipe fit closely together.

5.9.13.2 Applicability:

**Table 5.9.13.2:
Fold & Form (F&FP) Criteria**

Items	Acceptable Parameter
Typical Application	Wastewater Main- Pressure/Gravity
Host Pipe Size	8' - 15"
Host Pipe Material	PVC, Clay, DI
Liner Pipe Size	<15"
Liner Material*	PVC, HDPE
Max. Installation	350- 600 LF
Special Considerations	It was not used on line segments which had broken or collapsed

*References:

ASTM F1867: Practice for Installation of Folded/Formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation

ASTM F1871: Specification for Folded/formed Poly (Vinyl Chloride) (PVC) Pipe Type A for Existing Sewer and Conduit Rehabilitation

ASTM F1947: Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP)

APPENDIX A

SUBSURFACE UTILITY ENGINEERING (SUE) QUALITY LEVEL B REQUIREMENTS DALLAS WATER UTILITIES

**SUBSURFACE UTILITY ENGINEERING (SUE)
QUALITY LEVEL B REQUIREMENTS
DALLAS WATER UTILITIES**

1.0 GENERAL REQUIREMENTS

- All firms selected to provide Subsurface Utility Engineering (SUE) services to the Dallas Water Utilities (DWU) shall have a minimum of three (3) years of verifiable experience involving work of similar nature.
- SUE provider must have in-house crew, equipment and other resources in order to perform appropriate function in the field.
- All personnel involved in SUE project must have completed 40 hour OSHA safety training and have the proper equipment including, but not limited to blower, gas tester, tripod and other equipment as necessary.
- SUE provider must have a safety plan and submit a copy for each project.

2.0 REFERENCES

2.1 General

Following references shall be applicable in conjunction with SUE services:

- Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, CI/ASCE 38-02 BY American Society of Civil Engineers, Latest Edition.

2.2 Standard Terminology

- Quality Level D:
Information derived from existing records or oral recollections.
- Quality Level C:
Information obtained by surveying and plotting visible above-ground utility features and by using professional judgment in correlating this information to Quality Level D.
- Quality Level B:
Information obtained through the application of appropriate surface geophysical methods to determine the existence and approximate horizontal position of subsurface utilities.

- Quality Level A:

Precise horizontal and vertical location of utilities obtained by the actual exposure and subsequent measurement of subsurface utilities, usually at a specific point.

3.0 SCOPE OF SERVICES

3.1 Utility Coordination

The SUE provider at a minimum shall conduct the following utility coordination to locate existing utilities prior to initiating any field works:

- DIG-TESS Center (800-344-8377 or 214-670-5111)
- DWU Water Distribution/Wastewater Collection Division Hotline (311)
- Coordinate with non DWU utilities as needed
- Coordinate with outside property owners as needed (Right of Entry)
- Comply with applicable City, State, and Local standards for utility coordination

3.2 Tasks

- Perform or verify tasks described for Quality Levels “C” and “D” (**Section 2.0**). In most instances, DWU Engineer has already performed level “C” and “D” and will provide that information to SUE provider prior to commencement of work.
- Select an appropriate suite of surface geophysical methods to search for utilities within project limits.
- Apply appropriate surface geophysics to search for utilities within project limits
- Interpret the surface geophysics. Depending on the methods this may be performed in the field or in the office.
- Mark the indications of utilities on the ground for subsequent survey.
 - Local utility owners, agencies, and/or one-call statues may dictate or recommend the markings color, sizes, or labeling.
 - Care shall be taken to differentiate markings placed on ground for design purposes from those placed on ground for damage prevention
 - A non-water base paint, must be used on all surface markings of underground utilities.

- Survey all markings that indicate the presence of a subsurface utility.
- Depict all designated utilities using MicroStation
- Correlate the designated utilities' depictions with utility record as necessary
- Resolve differences between designated utilities and utility records and surveyed appurtenances as necessary.
- Recommend additional measures to resolve differences if they still exists.

4.0 DELIVERABLES

All final deliverables shall be sealed and signed by a Texas Professional Engineer. Electronic and hard copy deliverables shall include, but not be limited to the following:

4.1 SUE Location Map

A preliminary drawing showing all designated utilities at 1:1 scale in MicroStation format shall be submitted with the following criteria:

- All utility information must clearly designated in plan-view for quality levels B, C, and D.
- A Line Code, shall be used to differentiate between the quality levels
- Color is used to indicate a utility pipe
- Layers or Levels are used to isolate utilities by owner and or quality level
- Approximate utility depth(s) and size(s) at critical locations along pipeline alignment shall be shown as available.

APPENDIX B

SUBSURFACE UTILITY ENGINEERING (SUE) QUALITY LEVEL A REQUIREMENTS DALLAS WATER UTILITIES

**SUBSURFACE UTILITY ENGINEERING (SUE)
QUALITY LEVEL A REQUIREMENTS
DALLAS WATER UTILITIES**

1.0 GENERAL REQUIREMENTS

- All firms selected to provide Subsurface Utility Engineering (SUE) services to the Dallas Water Utilities (DWU) shall have a minimum of three (3) years of verifiable experience involving work of similar nature.
- SUE provider must have in-house crew, equipment and resources in order to perform appropriate function in the field.
- SUE provider must have air lance capability along with other state-of-the-art non-destructive locating equipment and software systems, as necessary.
- All personnel involved in SUE project must have completed 40 hour OSHA safety training and have the proper equipment including, but not limited to blower, gas tester, tripod and other equipment as necessary.
- SUE provider must have a safety plan and submit a copy for each project.

2.0 REFERENCES

2.1 General

Following references shall be applicable in conjunction with SUE services:

- Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, CI/ASCE 38-02 BY American Society of Civil Engineers, Latest Edition.

2.2 Standard Terminology

- Quality Level D:
Information derived from existing records or oral recollections.
- Quality Level C:
Information obtained by surveying and plotting visible above-ground utility features and by using professional judgment in correlating this information to Quality Level D.

- Quality Level B:

Information obtained through the application of appropriate surface geophysical methods to determine the existence and approximate horizontal position of subsurface utilities.

- Quality Level A:

Precise horizontal and vertical location of utilities obtained by the actual exposure and subsequent measurement of subsurface utilities, usually at a specific point.

3.0 SCOPE OF SERVICES

3.1 Utility Coordination:

The SUE provider at a minimum shall conduct the following utility coordination to locate existing utilities prior to initiating any field works:

- DIG-TESS Center (800-344-8377 or 214-670-5111)
- DWU Water Distribution/Wastewater Collection Division Hotline (311)
- Coordinate with non DWU utilities for marking existing utilities as needed
- Coordinate with outside property owners as needed (Right of Entry)
- Comply with applicable City, State, and Local standards for utility coordination

3.2.1 Task

- Perform or verify tasks designated for Quality Levels “B”, “C” and “D” (**Section 2.0**). In most instances, DWU Engineer has already performed level “C” and “D” and will provide that information to SUE provider prior to commencement of work.
- Select an appropriate method of gathering data that will achieve the accuracies and precision required by the project.
- Excavate test holes in such a manner that protects the integrity of the utilities to be measured:
 - Neatly cut and remove existing pavement material, such that the cut does not exceed 0.10 square meters (1.076 square feet) unless unusual circumstances exist.
 - Coordinate cut with City of Dallas Cut Permit Process, if in public ROW.

- Expose the utility using a minimally intrusive excavation (i.e. vacuum excavation). To eliminate the possibility of damaging the utility or its protective coating, air lance should be the first choice of nondestructive excavation. Comply with applicable damage prevention laws, permits and specifications, and coordinate with utilities and inspectors, as required.
- Determine the following items:
 - Horizontal and vertical location of the top and/or bottom of the utility referenced to the project survey datum.
 - The elevation of the existing grade over the utility at a test hole referenced to the project survey datum.
 - The outside diameter of the utility and configuration of non-encased, multiconduit systems
 - The utility structure material composition, when reasonably ascertainable
 - the benchmarks and/or project survey datum used to determine elevations
 - The paving thickness and type, where applicable
 - The general soil type and site conditions from visual or physical observation
 - Groundwater elevation, if applicable
 - Observed condition of outside utilities
 - Other pertinent information as is reasonably ascertainable from each test hole site.
- Resolve any differences between depicted Quality Level A data and other quality levels. This may take the form of additional surface geophysical searches or depiction of adjacent or nearby data points at a lower quality level.

4.0 DELIVERABLES:

All final deliverables shall be sealed and signed by a Texas Professional Engineer. Electronic and hard copy SUE deliverables shall include, but not be limited to the followings:

4.1 Test Hole Data Sheet:

Submit Test Hole data sheet(s) for each test hole containing following information:

- Date of Work
- Digital sketch of Test Hole with northing and easting in State Plane Coordinates (in grid)
- Digital Sketch Cross Section of pipe as it relates to the existing ground
- Photograph of Test Hole

4.2 SUE Location Map:

A preliminary drawing showing all Test Holes at 1:1 scale in MicroStation format shall be submitted. All utility information must clearly designated in plan-view for quality levels A, B, C, and D

- A Line Code, shall be used to differentiate between the quality levels
- Color is used to indicate a utility pipe
- Layers or Levels are used to isolate utilities by owner and or quality level
- Quality level “A” must be depicted in a profile or separate data sheet

APPENDIX C

TOPOGRAPHIC SURVEY REQUIREMENTS FOR WATER/WASTEWATER MAIN PROJECTS DALLAS WATER UTILITIES

TOPOGRAPHIC SURVEY REQUIREMENTS FOR WATER/WASTEWATER MAIN PROJECTS DALLAS WATER UTILITIES

1.0 GENERAL REQUIREMENTS

- All firms selected to provide surveying services to the Dallas Water Utilities (DWU) shall have a Registered Professional Land Surveyor (RPLS) as a full time employee to act as the Surveyor of Record. The Surveyor of Record will hold a current RPLS license issued by the State of Texas.
- All surveying must be performed under the direct supervision of the designated Surveyor of Record. Should the Surveyor of Record become unable to perform the required duties, work on the project will cease immediately and the DWU Project Manager shall be notified. Any work performed on the project when the Surveyor of Record is unavailable to perform the required duties will be deemed unacceptable and be rejected.

2.0 REFERENCES

Following references shall be applicable in conjunction with surveying services:

- Texas Professional Land Surveying Practices Act by Texas Board of Professional Land Surveying (TBPLS), latest edition as available at:
http://www.txls.state.tx.us/04_act_rules/2009_act.pdf
- General Rules of Procedures and Practices by TBPLS, latest edition as available at:
http://www.txls.state.tx.us/04_act_rules/rules2010.pdf
- Paving Design Manual by the City of Dallas Public Works and Transportation (PW&T), latest edition as available at:
<http://www.dallascityhall.com/pwt/pdf/PavingDesignManual-searchable.pdf>
- Water & Wastewater Pipeline Design Manual by DWU, latest edition as available at:
<http://www.dallascityhall.com/dwu/pdf/WaterWastewaterPipelineDesignManual.pdf>
- Drafting Standards for Water/Wastewater Pipeline Projects by DWU, latest edition as available at:
http://www.dallascityhall.com/dwu/pdf/PipelineDrafting_standards_oct2010.pdf

3.0 SCOPE OF SERVICES

3.1 Purpose:

The purpose of the topographic survey is to locate and document all information that is pertinent to the design and construction of water/wastewater main projects.

3.2 Record Search:

The Surveyor of Record shall research all boundaries, subdivision plats, right-of-ways, easements and other available survey elements, which may affect the physical boundaries of the project. All the easements with volume and page numbers shall be identified and labeled on the survey submittal. Research shall include all public record resources, including but not limited to, the followings:

- City of Dallas Survey Records Vault
- Dallas, Denton and Collin County Records as applicable
- Texas Department of Transportation (TXDOT) Right-of-Way Records
- Private Utility Providers Records for gas, telephone, electric, cable, fiber optics and other utilities
- Ownership or Easement Records as available

3.3 Utility Coordination:

The Surveyor of Record at a minimum shall conduct following, but not limited to, utility coordination to locate existing utilities prior to initiating any field works:

- DIG-TESS Center (800-344-8377 or 214-670-5111)
- DWU Water Distribution/Wastewater Collection Division Hotline (311)

3.4 Width of Topographic Survey:

3.4.1 Non-Street/Alley Survey:

The typical survey along a non-street or alley area shall encompass 10 ft beyond the minimum required water/wastewater easement along the proposed alignment as specified in §1.8.3 of Water & Wastewater Pipeline Design Manual by DWU, latest Edition. Unless otherwise specified, the width of a typical survey along a typical non-street/alley shall be as per **Table 1**:

Table 1: Width of Typical Topographic Non-Street/Alley Survey

Size of Main (inch)	Min. Easement Width (ft)	Min. Survey Width (ft)
8" through 12"	25	45
16" through 24"	35	55
30" through 66"	50	70
72" and Larger	70	90

3.4.2 Street Survey:

Unless otherwise specified, the typical survey shall encompass 10 ft beyond the right-of-way as shown in **Figure 1**:

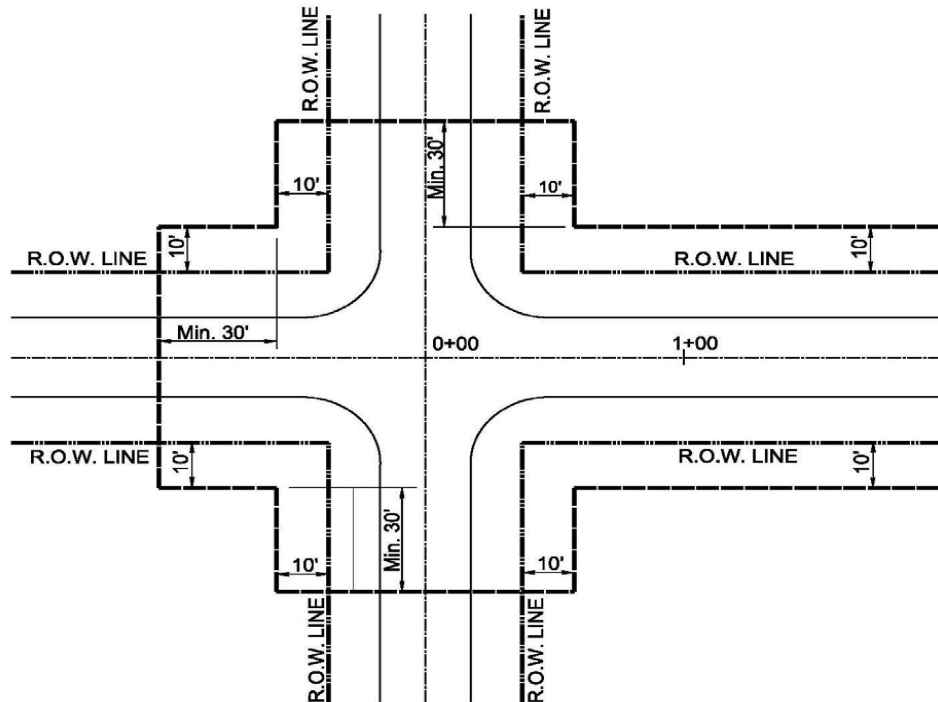


Figure 1: Width of Typical Topographic Street Survey

4.0 SURVEY CONTROLS

4.1 Horizontal Control

- Horizontal control datum for City of Dallas shall be the North American Datum of 1983 (NAD83) as defined by National Geodetic Survey (NGS).
- The applicable State Plane Coordinate (SPC) zone for City of Dallas is Texas North Central Zone (Code 4202).

If requested, a survey baseline or street/right-of-way centerline shall be established and monumented with following criteria:

- Monumentation shall be set at 100-foot stations at the beginning and end of the project along with all points of curvature (PC), points of tangency (PT), and points of intersection (PI).

- Monumentation shall be “PK” or “MAG” nails set through stainless steel washers imprinted with the registration number of the designated Surveyor of Record and the wording: “Survey Baseline/Centerline”.
- Monumentation shall be located sufficiently away from the possible construction areas so as not to be disturbed by the contractors or utilities.

4.3 Vertical Control

- Vertical control datum for City of Dallas shall be based on National Geodetic Vertical Datum of 1929 (NGVD29), as defined by National Geodetic Survey (NGS).
- Vertical control for DWU project shall be determined from the network of DWU established benchmarks (BM).
- Benchmarks (BMs) or Control Points (CPs) are to be established at each end of the project, with intermediate locations spaced about every 500 feet and at a sufficient distance outside the limits of construction so as not to be disturbed. A minimum of two BMs or CPs are to be provided on each project with the northing, easting, elevation and description.
- A closed loop consisting of at least two (2) DWU BMs shall be required to verify existing benchmark datum. Loops are to be established using level/ level rod and must have with an accuracy of plus or minus 0.05 foot times the square root of the distance in miles looped.
- When running the benchmark loop, additional BMs used on other projects in the immediate area should be turned through to provide a check. However, BMs from different projects should not be assumed to on the same datum.
- Turning points should be sufficiently stable to maintain desired accuracy. Backsights and foresights should be balanced in distance and shots should not exceed 300 feet. Care should be taken to ensure level rod is properly extended and "waved or rocked" to ensure lowest reading.
- BMs shall be referred to as found or set. Set BMs (also known as CPs) shall include the date set in the description. Found BMs shall include record elevation and refer to source of benchmark, such as DWU BM Book number, or plan number such as 411Q1321, sh. 21 etc.
- Set BMs or CPs points established shall be reasonably permanent and substantial (avoid using R/R spikes, 60-D nails, crosses on top of fire hydrants, etc). They shall be easily identified and afforded reasonable protection against damage or destruction. A description of the BMs or CPs shall be written in a clear and concise manner so that it can be easily recovered (specify distance to nearest cross street when applicable).

4.4 Special Considerations for GPS Survey

When instruments employing Global Positioning System (GPS) survey technology are used, following procedures will be required:

- A notation to the fact that GPS survey procedures were used in the performance of the surveys shall be placed in all field notes and final drawings.
- When a State Plane projection is employed, the NOAA monument used for control shall be listed in all field notes and final drawings. Submittals of data and drawings produced shall be in State Plane Coordinate Datum shall state whether the coordinate datum is Grid values or has been adjusted to a local projection.
- Control monuments established or used in a GPS survey shall have the World Geodetic System (WGS) Latitude and Longitude values derived from the raw observation data listed along with the monument type, location and other coordinate data.
- GPS survey instrument technology will not be approved for use in surveys for any design or construction purposes where vertical accuracy greater than 0.07 feet is required.
- GPS survey instrument technology and procedures will not be approved for use in establishing vertical control for project benchmarks.

5.0 FIELD DATA COLLECTION

Field data collection shall include, but not be limited to, the followings:

5.1 Right-of-Way and Property:

- Locate and tie all existing rights-of-way, property lines and easements including type, size, bearing, volume and page, as necessary.
- Show lot, block, abstract number and dimensions with adjacent street names.
- Identify corporation lines with involved cities listed.

5.2 Topographic Features:

5.2.1 Roadways and Railways:

- Identify roadways, driveways, alleys and sidewalks with pavement type.
- Show centerlines and angles of intersection of the side street(s) with main roadway centerline, as necessary.
- Show all mail boxes, road signs and signal posts.

- Identify all existing or abandoned railways with company names, if available.

5.2.2 Trees, Shrubs and Landscaping:

- Locate all trees, vegetation lines and special landscaping.
- Locate and describe any trees, bushes, shrubs or other landscaping plants.
- Provide tree caliper (at 1 foot above ground), type of tree, and drip line location for all trees over 2 inches in diameter.
- Provide locations of other landscaping materials such as grass lawns, rock structures, sculptures, etc.
- Provide the type, locations and elevations of sprinkler heads, sprinkler control boxes, and other sprinkler devices that may become a design consideration

5.2.3 Fence and Retaining Wall

- Provide the location and type of fence (wooden, wrought iron, barbed wire etc.) within limits of the survey.
- Show retaining walls with detailed description.

5.2.4 Creek and Drainage Features:

- Show high and low banks of creeks.
- Locate toe and top of slopes within a drainage features.

5.2.5 Bridges

- Locate and fully describe all bridges.
- Show elevations along the centerline and of edge the structure.
- Show elevations and locations of sides and bottom of any channel, creek or drainage structure the structure bridge passes over.
- Show the bottom elevation of any beams or other physical restrictions.
- Show edges of bridge abutments, columns and wing wall if available.

5.3 Utilities:

Locate and confirm all existing utilities and appurtenances along with type, size and materials, as possible:

5.3.1 Water Mains and Appurtenances:

- Size and material type of water main
- Size and type of manhole, meter and fire hydrant (specify color)
- Size and type of valve with operating nut elevation

5.3.2 Wastewater Mains and Appurtenances:

- Size and material type of wastewater main with flow direction
- Size and type of manhole (brick, concrete, fiberglass, drop manhole etc.)
 - Rim elevations
 - Flowline elevations of all lines entering and exiting manhole
- Wastewater Access Device, Cleanout and other appurtenances

5.3.3 Stormdrains, Open Channels, and Culverts

- Size and material type of storm drains with flow direction
- Size and type of appurtenances including inlet, manhole, junction box etc.
- Indicate all open channels and culverts with material and elevations
- Provide the width and height of all box culverts as well as the entry and exit elevations
- Provide elevations, widths and locations of any headwalls, retaining walls, aprons or other objects within the limits of the survey.

5.3.4 Gas Mains :

- Size and material type of gas main, if available
- Indicate owner's name and pressure rating of the gas main if available
- Size and type of appurtenances including meter, manhole, valve etc.

5.3.5 Underground Telephone

- Size and material type, if known
- Indicate owner's name, if available
- Size and type appurtenances (manhole, telephone pole, guy wire etc.)

- 5.3.6 Underground Electric (Size, Material, Appurtenances- Manhole etc)
- Size and material type, if known
 - Indicate owner's name, and contact information, voltage, if available
 - Size and type appurtenances (manhole, vault, power pole, guy wire etc.)
- 5.3.7 Underground Cable (Size, Material, Appurtenances- Manhole etc.)
- Size and material type, if known
 - Indicate owner's name, and contact information, if available
 - Size and type appurtenances (manhole, vault etc.)
- 5.3.8 Underground Fiber Optic (Size, Appurtenances- Manhole etc.)
- Size and material type, if known
 - Indicate owner's name, and contact information, if available
 - Size and type appurtenances (manhole, vault etc.)

6.0 DATA IMPORT AND DIGITAL TERRAIN MODEL:

The latest version of InRoads or equivalent software(s) as approved by DWU, shall be used to perform survey data import, surface modeling, horizontal and vertical alignment, and related tasks as necessary. In addition, all drawings produced by a CADD system with electronic file format must be compatible with MicroStation V8 XM or the latest edition.

7.0 DELIVERABLES

All survey data shall be furnished in Read Only compact disc (CD-R) labeled as "Survey Data" along with PID, Location/Limit and Consultant Name. Survey deliverables shall include, but not be limited to, the following data:

7.1 List of Horizontal/Vertical Controls:

A list of horizontal and vertical controls along with pertinent calculations shall be furnished in both electronic and hard copy. Hard copy shall be sealed and dated by Surveyor of Record containing a statement as "All field data is based on the horizontal and vertical controls as shown in this document(s)".

7.2 Point File:

A list showing point numbers, northings/eastings, elevations, and description shall be furnished.

7.3 Field Sketch:

Field sketches and notes depicting any special field information shall be furnished, if available.

7.4 Preliminary Base Map:

A preliminary base map at 1:1 scale containing all pertinent survey data shall be prepared as per the latest edition of “Drafting Standards for Water/Wastewater Pipeline Projects” by DWU to incorporate following criteria:

- File Format: This map shall be based on the latest version of “**DWUSeed3D-xx.dgn**” as available in City of Dallas website. This file shall be re-named as per DWU standard naming convention:

“Basemap3D-xx.dgn”

Where, “xx” refers to project identification number (PID), street or project area name.

Examples:

Basemap3D-PID763_764_789.dgn

Basemap3D-MainSt.dgn

Basemap3D-ParkMainAlley.dgn

- Global Origin: The default Global Origin (GO) for a 3D file in MicroStation is set to the center of the design plane with coordinate values of 0,0,0.
- Working Units: The default working units (1:12:1000) and related parameters as set for DWU3D Seed file shall not be altered in 3D basemap.
- Level Designation: All designated levels in DWU3D Seed file with predefined attributes consisting of specific color, line style, and line weight must be used
- Standard Symbol: All standard symbols as available shall be used
- Digital Terrain Model/Contour Data: Digital terrain model (DTM) and contours shall be included. Contours shall be at 1-ft minor and 5-ft major intervals.

7.5 Profile Drawing:

If requested, a drawing showing centerline alignment and profile shall be furnished

7.6 Supplementary Files:

All computational files necessary for the production of the drawings including geometry files, survey data collector files (in both internal and ASCII formats), digital terrain model files and supplementary files shall be furnished as necessary.

APPENDIX D

BOUNDARY SURVEY REQUIREMENTS FOR EASEMENT OR RIGHT-OF-WAY ACQUISITION DALLAS WATER UTILITIES

**BOUNDARY SURVEY REQUIREMENTS
FOR EASEMENT OR RIGHT-OF-WAY ACQUISITION
DALLAS WATER UTILITIES**

1.0 GENERAL REQUIREMENTS

- All firms selected to provide surveying services to the Dallas Water Utilities (DWU) shall have a Registered Professional Land Surveyor (RPLS) as a full time employee to act as the Surveyor of Record. The Surveyor of Record will hold a current RPLS license issued by the State of Texas.
- All surveying must be performed under the direct supervision of the designated Surveyor of Record. Should the Surveyor of Record become unable to perform the required duties, work on the project will cease immediately and the DWU Project Manager shall be notified. Any work performed on the project when the Surveyor of Record is unavailable to perform the required duties will be deemed unacceptable and be rejected.

2.0 REFERENCES

Following references shall be applicable in conjunction with surveying services:

- Texas Professional Land Surveying Practices Act by Texas Board of Professional Land Surveying (TBPLS), latest edition as available at:
http://www.txls.state.tx.us/04_act_rules/2009_act.pdf
- General Rules of Procedures and Practices by TBPLS, latest edition as available at:
http://www.txls.state.tx.us/04_act_rules/rules2010.pdf
- Paving Design Manual by the City of Dallas Public Works and Transportation (PW&T), latest edition as available at:
<http://www.dallascityhall.com/pwt/pdf/PavingDesignManual-searchable.pdf>

3.0 SCOPE OF SERVICES

3.1 Purpose

The purpose of the boundary survey is to locate and prepare legal description for fee title conveyances, right-of-way, easement, lease agreement, abandonments and licenses for Dallas Water Utilities.

3.2 Title Search

The Surveyor of Record shall assume the responsibility for adequate title research to support the determination of the location of intended boundaries of the land parcel surveyed. The title must be searched back in time sufficiently far enough to uncover all of the pertinent information. In many cases, this will be to the sovereignty of the soil. Research shall include all public record resources, including but not limited to, the followings:

- City of Dallas Survey Records Vault
- Dallas, Denton and Collin County Records
- Texas Department of Transportation (TXDOT) Right-of-Way Records
- Private Utility Providers Records for gas, telephone, electric, cable, fiber optics and other utilities
- Ownership or Easement Records as available

4.0 FIELD WORKS

4.1 Coordinate System

- Horizontal control datum for City of Dallas shall be the North American Datum of 1983 (NAD83) as defined by National Geodetic Survey (NGS).
- The applicable State Plane Coordinate (SPC) zone for City of Dallas is Texas North Central Zone (Code 4202).

4.2 Survey Method

Conventional, Global Positioning System (GPS) or a mixture of both techniques shall be used for boundary survey.

4.3 Special Considerations for GPS Survey

When instruments employing Global Positioning System (GPS) survey technology are used, the following procedures will be required:

- A notation to the fact that GPS survey procedures were used in the performance of the surveys shall be placed in all field notes and final drawings.
- When a State Plane projection is employed, the NOAA monument used for control shall be listed in all field notes and final drawings. Submittals of data and drawings produced shall be in State Plane Coordinate Datum shall state whether the coordinate datum is Grid values or has been adjusted to a local projection.

- Control monuments established or used in a GPS survey shall have the World Geodetic System (WGS) Latitude and Longitude values derived from the raw observation data listed along with the monument type, location and other coordinate data.
- GPS survey instrument technology will not be approved for use in surveys for any design or construction purposes where vertical accuracy greater than 0.07 feet is required.
- GPS survey instrument technology and procedures will not be approved for use in establishing vertical control for project benchmarks.

4.4 Monumentation

- All set monuments shall be at a minimum of 5/8" diameter x 18" iron rods capped with surveyor's name and registration number or survey company's name.
- Consultant Surveyor shall determine whether Letters of Permission granting access to private property for surveying purposes will be required. The City Project Manager shall be informed of the need for this task, and kept informed of its progress.

5.0 FIELD NOTES

Field Notes for boundary survey shall be prepare as per **Exhibit 1** entitled "Field Note Guidelines by Department of Public Works Surveying Services dated January, 2011".

6.0 DELIVERABLES

Final survey deliverables shall include, but limited to, the following data:

- Three (3) copies of Survey Field Notes and drawings affixing surveyor's seal and original signature
- Copy abstract of title or title run sheet
- All pertinent calculations

Field Note Guidelines

Department of Public Works and Transportation Surveying Services

City of Dallas

Revised, January 2011

The following guidelines are to be used and incorporated into the preparation of real property descriptions for fee title conveyances, Rights-of-Way, easements, lease agreements, abandonments, licenses, etc., for the City of Dallas.

Field notes will be subjected to a review process to insure substantial compliance with both the form and content outlined in these guidelines. Your cooperation is needed to assist the City of Dallas in preparing and processing the legal instruments so that these field note descriptions can be relied upon to provide certain relevant information in a reasonably standard format.

Surveys and descriptions must meet all of the requirements of the Texas Board of Professional Land Surveying (Rules), and fully comply with the Professional Land Surveying Practices Act (Act).

For the laws regarding land surveying and the preparation of field note descriptions, please refer to the publications of the Texas Board of Professional Land Surveying.

Field notes for the purposes of these guidelines are defined as a worded metes and bounds description of the results of an on-the-ground survey of real property.

Field notes shall include sufficient information to identify the location, boundaries, Monumentation, and area of the described tract, as well as its relationship to the parent tract out of which it was surveyed, and all adjacent tracts. Each field note description will be accompanied by a drawing which graphically depicts the worded description.

Field notes submitted to the City of Dallas Survey Section for review shall be typed on a plain **8 1/2" x 11" white bond paper** and shall include at least three (3) sets, bearing the original seal, date and signature of the responsible surveyor.

All originals are to be of high reproductive quality and legibility.

Each of the three sets of field note descriptions shall consist of the following parts:

PART 1 – HEADING

This part shall appear on the top of each page and include the following information:

- The **area** in square feet and acres of the proposed conveyance.
In all cases where area is stated, it shall be expressed in both square feet and acres.
Acreage may be in parenthesis following the square footage.
- The **official city block number** of the affected tract of land.
- The **type of conveyance** for which the tract is being described
i.e. drainage easement, street widening, Right-of-Way dedication, water easement,
wastewater easement, covenant, abandonment, license agreement, ingress-egress, etc.
(A “corner clip” must be further defined to express the actual type of easement
conveyed.)
- For Right-of-Way acquisition, include name of the effected roadway.
- The **owner’s name(s)** whose tract is affected by the conveyance.

PART 2 – GENERAL DESCRIPTION

- The **area** described in the field notes described in square feet, with acres in parenthesis.
- The **Survey and Abstract number**.
- Citing the appropriate **County and City, Subdivision name, Lot and Block designation**
(when applicable). Official City of Dallas Block numbers are sometimes different from
Addition plat Block numbers.
- **Dallas County Recording nomenclature:**
 - Prior to 1903: all records, including maps and addition plats filed in Dallas
County Records were filed as **Deed Records**
 - Plats and Additions recorded in Volume 1, Page 1, beginning January 14, 1903
thru Volume 51, Page 154, ending February 14, 1963 were filed as **Map Records**
 - Deeds, plats and additions recorded from February 1963 thru Volume 2003221,
Page 10186 thru November 4, 2003 are recorded in **Deed Records**
 - Deeds, plats and additions recorded from November 4, 2003, starting with
Volume 2003221, Page 10186 thru to the present are filed in **Official Public
Records**
 - Dallas County records went from a Volume and Page filing system to an
Instrument number filing system in mid 2005.
- **Ownership information** for the effected area: the current record owner’s name and the
type of conveyance instrument (i.e. Warranty Deed, etc.).
**Neither a Deed of Trust nor a Quit Claim Deed convey title, and are therefore not
acceptable.**

- The conveyance instrument recording information shall be included (Deed Record designation, Volume, Page, cause number, execution date, etc.)
- A legible copy of the current deed of ownership must be attached to each field notes submitted.
- All Right-of-Way abandonments must include reference information as to how the Right-of-Way was created, such as by deed with Volume, Page, date, or dedicated by Addition plat, with recording information.

PART 3 –PARTICULAR DESCRIPTION

This part shall contain specific information identifying the boundary of the described tract. As a general rule, **descriptions should be written with the calls proceeding in a clockwise direction from the point of beginning.**

The mathematical figure described must close with a precision of at least 1 : 15,000 $\pm$ 0.10 feet.

The following items should be clearly identified within this part of the description:

- **Point of Beginning:** identifying the type and size of monument found (or set), and its relationship to the parent tract, explaining which corner of the described tract it represents.
Point of Beginning shall be tied to a found monument of record, at a dedicated street intersection, Block corner or Lot corner recorded in the subdivision plat or parent tract containing the tract of land.
All monuments set shall be (at a minimum) 5/8" diameter x 18" iron rods capped with Surveyor's name and registration number or Survey Company's name.
- **Points of reference or Commencement:** (if applicable) identify the type and size of monuments and their relationship to the Point of Beginning.
- **Metes and bounds** calls: stating bearings in degrees, minutes and seconds; distances in feet and hundredth of a foot.
- **Curve Data:**
Defined curve geometry such as Point of Curvature (P.C.), Point of Tangency (P.T.), Point of Reverse Curvature (P.R.C.), and Point of Compound Curvature (P.C.C.) are always tangent to curve.
A call for any of these elements is understood to be a point of tangent alignment.
Point on Tangent (P.O.T.) is defined as lying on a line, and Point on Curve (P.O.C.) is a point lying on a curve.
If the beginning of a curve, or any change in alignment involving a curve is not a tangent point, the field notes must state the fact.
Curves shall be defined by
 - their **direction** being left or right,
 - **tangent or non-tangent,**
 - **delta** or central angle,
 - **radius,**
 - **arc length,**
 - **chord bearing and chord distance.**

- **References to adjoining properties** (calls for adjoiners): which helps to identify or clarify the described boundaries.
Show dimensions for all boundaries of adjoining properties.
 - Right-of-Ways (indicating width)
 - Natural or physical locative features
 - Witness or reference monumentation, etc.
- **Reference discrepancies:** note when recorded measurements and field measurements differ.
- **Volume and Page of any covenants, licenses, or easements** the described tract is subject to.
- **Area** in square feet and acres.
- **The Basis of Bearings** need to be clearly stated at the end of every metes and bounds description on which the description was established.
Per the “Professional Land Surveying Practices Act and General Rules of Procedures and Practices,” under §663.19 (b)
“Courses shall be referenced to an existing physically monumented line for directional control **or** oriented to a valid published reference datum and shall be clearly noted upon any report, survey plat or other written instrument.”

Therefore, if a boundary line is used as Basis of Bearings it must be a line with a minimum of two monuments.
Reference or cite controlling monuments and the recording information of the instrument of which defines the Basis of Bearings.

Reference to a Datum, such as “Texas State Plane Coordinate System, North Central Zone, North American Datum of 1983” is sufficient.
- Each page of multiple pages must be referenced to each other with **page number** and total number of pages included, i.e. Page 1 of 4.

NOTE:

A legible copy of the recorded plat(s) and/or parent tract(s) cited must be supplied with the field notes.

FIELD NOTE DRAWING

Field note descriptions shall be accompanied by a field note drawing produced on a plain 8 ½” x 11” white bond paper bearing the seal, date and signature of the responsible Registered Professional Land Surveyor.

All copies shall be of high reproductive quality and legibility.

In an instance where the field note description represents a part of a larger subdivision plat or tract of land, you will be required to reproduce the appropriate portion of the larger subdivision plat or tract of land.

Field note drawings shall show the following:

- North arrow and graphic scale (or mention of the drawing being not to scale).
- Legend which includes symbols for all monuments found or set and description.
- Title block giving information on
 - the tract to be acquired with Block and Lot numbers (if exists),
 - the purpose of the acquisition,
 - surveyor and drafter information
 - file number to be recorded in the City of Dallas Survey Records Vault
 - folder to be recorded in at the Survey Records Vault
 - date
 - scale
- Survey and Abstract name and number. Approximate Survey line between two surveys labeled on both sides of the line where it is applicable.
- **Do not show topographic information.**
- To easily identify the subject tract, the property to be acquired shall be shown on the drawing with a solid line, with a line-weight significantly heavier than any other. Block boundaries and Right-of-Ways shall also be significantly different from other line segments (see example attached to these Filed Note Guidelines).
- Information to identify adjoining properties or locative features, including subdivision, Lot and Block designations, names of adjoining owners of record, Volume and Page references to instruments defining adjoining boundaries, including roadways (with Right-of-Way width information) or prominent natural features.
- Relationship of the described tract to its parent tract(s), showing any appropriate Lot and Block designation(s), subdivision name(s), and recording information.
Show bearings and distances for all abutting properties.
- Location of the Point of Commencing (if it exists), the Point of Beginning and any reference or witness points.
- Monuments set at each corner of the tract of land to be acquired, whether it is fee title acquisition or easement.

All corners must be monumented, per the “Professional Land Surveying Practices Act and General Rules of Procedures and Practices,” under §663.17 (b):

“When delineating a property or boundary line as an integral portion of a survey (survey being defined in the Professional Land Surveying Practices Act, §1071.002 (6) or (8)), the land surveyor shall set, or leave as found, sufficient, stable, and reasonable permanent

survey markers to represent or reference the property or boundary corners, angle points, and points of curvature or tangency. All survey markers shall be shown and described with sufficient evidence of the location of such markers on the surveyor's plat."

- All bearings and distances referred to in the field note description. Avoid using tables for line and curve information.
- Reference and clearly identify discrepancies, i.e. measured bearings and distances vs. recorded bearings and distances.
- Easements shall be shown and identified by width, use and ownership, and tied to parent tract.
- Area of the described tract in square feet and acres.
- The name(s) of the present owner(s) of record as cited in the deed of the described tract and surrounding properties with recording information.
- Basis of Bearings:

Per the "Professional Land Surveying Practices Act and General Rules of Procedures and Practices," under §663.19 (4)

"Courses shall be referenced to an **existing physically monumented line** for directional control **or** oriented to a **valid published reference datum** and shall be clearly noted upon any report, survey plat or other written instrument."

- Sign and seal of the surveyor conducting the survey of the property.
- Each page of multiple pages must be referenced to each other, with page number plus total number of pages included, i.e. Page 1 of 4.

LOCATOR MAP

Locator Maps are used for Council Agenda items, to identify the general area of the project.

Drawing shall be plotted on a plain 8 ½" x 11" white bond paper.

No company letterheads or logos.

The drawing need not be at a specific scale, it generally indicates the subject parcel boundaries and includes readily recognized streets. The effected parcel shall be cross hatched.

A legend shall denote the purpose of the cross hatched area – i.e. "Area to be acquired for Street Widening"; "Area to be acquired for Drainage Easement"; etc.

As the Locator Map will not be filed for record, it will not be necessary to number this page.

DESCRIBING EASEMENTS

Easements will be prepared by metes and bounds description, unless prior approval is granted to use another method of description.

Descriptions for easements will be subjects to the same guidelines as for fee title or Right-of-Way conveyances.

All easement corners are required to be monumented per the "Professional Land Surveying Practices Act and General Rules of Procedures and Practices," under §663.17 (b):

"When delineating a property or boundary line as an integral portion of a survey (survey being defined in the Professional Land Surveying Practices Act, §1071.002 (6) or (8)), the land surveyor shall set, or leave as found, sufficient, stable, and reasonable permanent survey markers to represent or reference the property or boundary corners, angle points, and points of curvature or tangency. All survey markers shall be shown and described with sufficient evidence of the location of such markers on the surveyor's plat."

§1071.002 (6)

"Professional surveying" means the practice of land, boundary, or property surveying or other similar professional practices. The term includes:

- (A) (iii) preparing and perpetuating maps, record plats, field note records, **easements**, and real property descriptions that represent those surveys.

All metes and bounds descriptions prepared for easements shall be tied to physical monuments of record related to the boundary of the affected tract.

TEMPORARY WORK SPACES

Temporary work spaces will require a metes and bounds description, when a temporary work space is prepared to accompany and adjoin a permanent easement.

The guidelines for easements will be used for temporary work spaces.

The following checklist is provided for your convenience. It is intended as a minimum standard.

FIELD NOTE CHECKLIST

For your help in field note submittal include the following:

☐	Three (3) sets of signed, sealed and dated field notes of the RPLS who prepared the description
☐	Closure sheet – 1 copy
☐	Copy of the recorded instrument of current ownership of the property to be acquired or the easement or Temporary Work Space

PART 1 : HEADING

☐	Size of property to be acquired in square feet and acres
☐	Type of conveyance
☐	City Lot and Block number
☐	Name of affected roadway, creek, project, etc.
☐	Name of the owner of the tract of land

PART 2 : GENERAL DESCRIPTION

☐	Size of property to be acquired in square feet and acres
☐	Survey name and Abstract number
☐	City, County and State where the property is located
☐	Subdivision name, Lot and Block number, County Land Records recording information. Copy of subdivision map must be supplied with recording information Official City of Dallas Block number (sometimes different from Addition plat Block number)
☐	Current record owner's name as cited in the deed, type of conveyance instrument (Deed of Trust or Quit Claim Deed is not acceptable), recording information (Volume, Page, cause (if applicable), execution date, etc.) with Records information

PART 3 : PARTICULAR DESCRIPTION

☐	Point of Commencing (if used)
☐	Point of Beginning
☐	Bearings and distances around the tract of land to be acquired
☐	Curve data: direction of the curvature, tangent or non-tangent, all significant curve elements (radius, delta, length, chord bearing and chord length)
☐	Monuments set for the property to be acquired and monuments found and called out with size, type, with plastic cap stamped with the RPLS number or company name
☐	Property information: Lot or Tract number, Block number, subdivision name(s), current owner's name and recording information
☐	Roadway information (if encountered) with Right-of-Way width specified in parenthesis
☐	Adjoining properties – any adjoining property call must have recording information
☐	Any easements, covenants, licenses, etc., that tract is subject to, included in the description and shown on the field note drawing
☐	Area in square feet and acres for the tract of land to be acquired or easement or temporary work space.
☐	Basis of Bearings statement
☐	Seal, signature and date of RPLS who prepared the description

FIELD NOTE DRAWING CHECKLIST

☐	North arrow
☐	Graphic Scale (if applicable)
☐	Legend with symbols and descriptions of monuments set and found
☐	Survey name and Abstract number, approximate location of Survey line between surveys (if near enough) labeled on both sides of the line
☐	“Area to be acquired” with area in square feet and acres
☐	Point of Commencing (if used), Point of Beginning
☐	All bearings and distances as referred to in the field notes with notation to differences from record and measured distances
☐	- Point of Curvature (P.C.) - Point of Tangency (P.T.) - Point of Reverse Curvature (P.R.C.) - Point of Compound Curvature (P.C.C.) - Point on Tangent (P.O.T.) - Point on Curve (P.O.C.)
☐	All Curve data along curve segments: radius, arc length, delta (central angle), chord bearing and chord length Identify non-tangent curves
☐	Addition name (if it exist, or otherwise note “Unplatted”) and/or Ownership information (name as appears in the recorded instrument and recording information) of all adjoined properties called in field notes Common ownership between platted lots shall be shown
☐	Identify specific purpose areas shown on the plat (detention area, escarpment areas, floodway easement, park and common areas, etc.)
☐	Easement(s) information : show and identify all easements with width, use and ownership information, where applicable
☐	Corporate (City) limits and County lines, where applicable
☐	Basis of Bearings statement
☐	Seal, signature of RPLS preparing the description, and date

LOCATOR MAP CHECKLIST

☐	North Arrow
☐	Wider area with recognizable streets
☐	Effected parcel shaded or hatched
☐	Legend

**Field Notes Describing a 16,276 Square Foot (0.3734 Acre)
Water Pipeline Easement To Be Acquired in City Block 7955
From ONCOR Electric Transmission Company**

Being a 16,276 Square Foot (0.3736 Acre) tract of land out of the Thomas Lagow Survey, Abstract Number 759, Dallas County, Texas, and being a part of that tract of land conveyed to the Dallas Power and Light Company (current ownership is in the ONCOR Electric Transmission Company) by Deed recorded in Volume 5116, Page 37 of the Deed Records of Dallas County, Texas, and being more particularly described as follows:

BEGINNING at a 5/8 inch diameter iron rod with cap marked "DALLAS" (hereinafter referred to as "5/8" I.R. w/COD Cap") set on the Southwest line of said ONCOR property at the most Westerly North corner of a 10.00 foot wide Water Pipeline Easement to the City of Dallas, recorded in Volume 3620, Page 424 of the Deed Records of Dallas County, Texas, from which a 5/8 in dia. Iron rod found on the said DP&L Southwest line at the intersection with the common line between a tract of land conveyed to the Dallas Housing Authority by deed recorded in Volume 3575, Page 275 of the Deed Records of Dallas County, Texas, and a tract conveyed to the City of Dallas by Deed recorded in Volume 5564, Page 585 of the Deed Records of Dallas County, Texas, at the most Northerly corner of said City of Dallas tract, bears South 45°49'02" East a distance of 5.19 feet:

THENCE North 45°39'08" West with the common line between said ONCOR and Dallas Housing Authority tracts, pass at 65.25 feet the common line with a tract of land conveyed to the City of Dallas by Deed recorded in Volume 5656, Page 88 of the Deed Records of Dallas County, Texas, at 186.16 feet pass the South Right-of-Way line of U.S. Highway 175 (C.F. Hawn Freeway) conveyed to the State of Texas by Deed recorded in Volume 91204, Page 2210 of the Deed Records of Dallas County, Texas (from which a 5/8 inch diameter iron rod found, bears South 40°00'31" East a distance of 1.73 feet) and continuing for a total distance of 222.50 feet to a 5/8" I.R. w/COD Cap set on the Southwest line of said ONCOR tract, at the Northwest corner of the herein described tract of land:

THENCE North 89°44'14" East, departing the last said common line between said ONCOR and State of Texas tracts, a distance of 29.53 feet to a 5/8" I.R. w/COD Cap set in the Southwest line of a 15.00 foot wide Sanitary Sewer Easement conveyed to the City of Dallas by Deed recorded in Volume 3533, Page 372 of the Deed Records of Dallas County, Texas, and being also the Northeast corner of the herein described tract of land:

THENCE South 45°39'08" East, parallel with the Southwest line of the above said ONCOR tract and with the Southwest line of said Sanitary Sewer Easement, a distance of 1,309.02 feet to a 5/8" I.R. w/COD Cap set at the most Easterly corner of the herein described tract of land:

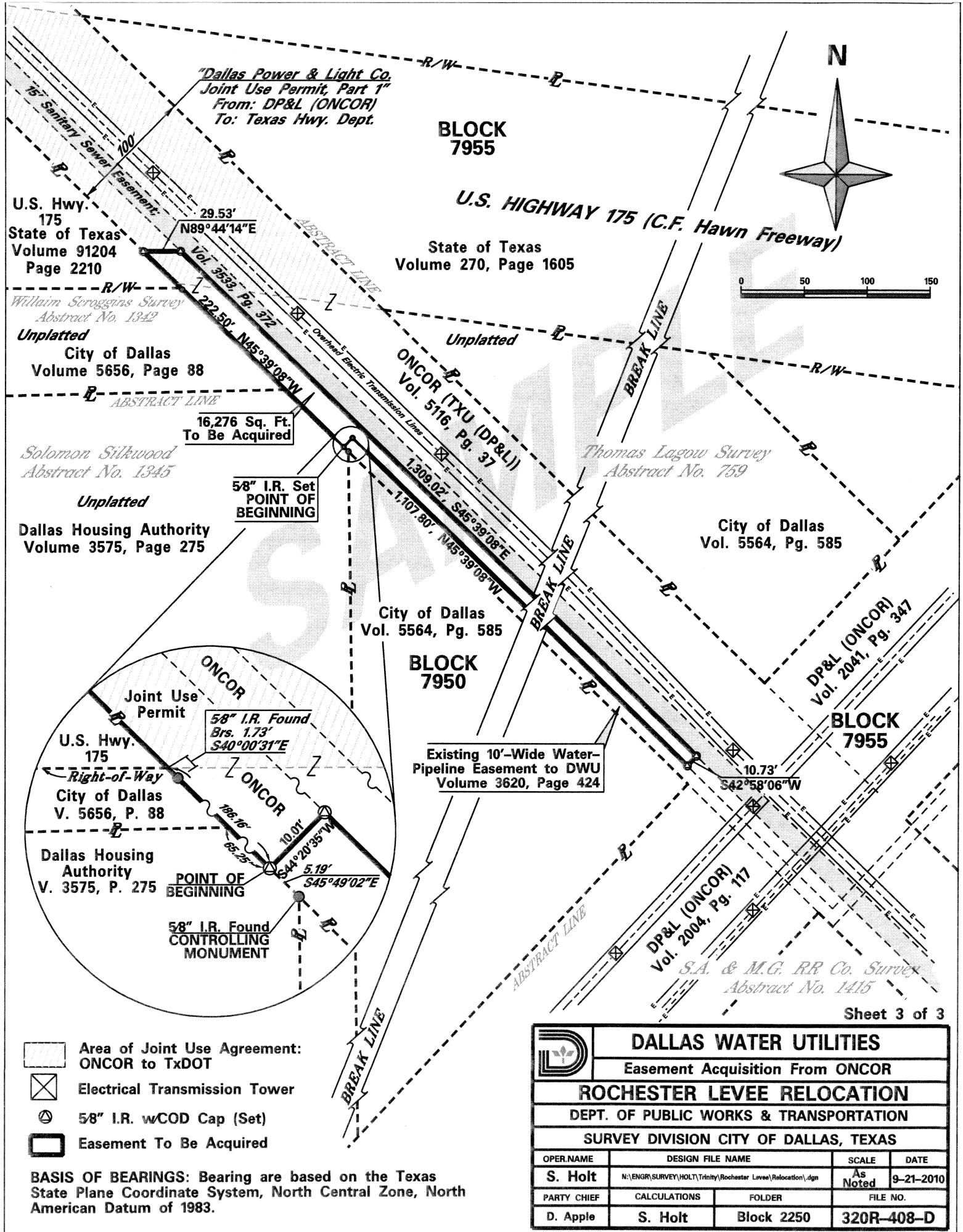
**Field Notes Describing a 16,276 Square Foot (0.3734 Acre)
Water Pipeline Easement To Be Acquired in City Block 7955
From ONCOR Electric Transmission Company**

THENCE South 42°58'06" West, departing the Southwest line of said Sanitary Sewer Easement, a distance of 10.73 feet to a 5/8" I.R. w/COD Cap set at the most Southerly corner of the herein described tract of land, on the Northeast line of the above said 10.00 foot wide Water Pipeline Easement:

THENCE North 45°39'08" West, with the Northeast line of said Water Pipeline Easement a distance of 1,107.80 feet to a 5/8" I.R. w/COD Cap set at the most Northerly corner of said Water Pipeline Easement, at an inside corner of the herein described tract of land:

THENCE South 44°20'35" West with the Northwest line of said Water Pipeline Easement a distance of 10.01 feet to the **POINT OF BEGINNING**, containing 16,276 Square Feet, or 0.3736 Acres of land.

BASIS OF BEARINGS: Bearings are based on the Texas State Plane Coordinate System, North Central Zone, North American Datum of 1983.



APPENDIX E

GENERAL NOTES FOR TYPICAL WATER/WASTEWATER MAIN CAPITAL IMPROVEMENT PROJECT

PROJECT CONTACTS:

DWU PROJECT MANAGER:

GENERAL

1. All work shall be done in accordance with the North Central Texas Council of Governments (NCTCOG) Standard Specifications for Public Works Construction (Applicable Edition) and City of Dallas Addendum (Latest Edition) to these specifications.
2. Reference to standard drawings shall mean those shown in the DWU Standard Drawings for Water & Wastewater Construction (Latest Edition).
3. All items of work required to complete the work as shown or implied by the plans and as specified in the contract documents which are not listed as a pay item in the proposal, shall be considered subsidiary.
4. The location, elevation, and size of existing utilities shown on the plans as obtained from the City of Dallas and utility company records, are considered approximate. The engineer does not certify that all utilities are shown. The Contractor shall verify exact locations, sizes, and depths of existing utilities before beginning construction (including ordering of pre-cast manholes and concrete pipe if applicable). NO SEPARATE PAY ITEM
5. The Contractor shall contact Texas Excavation Safety System (**800-DIG-TESS: 800-344-8377**) and other utility companies 48 hours prior to locating existing utilities and or construction activities. NO SEPARATE PAY ITEM
6. The Contractor shall preserve, protect and support all existing utilities at all times during construction. Any damage to utilities resulting from the contractor's operation shall be restored at his expense. NO SEPARATE PAY ITEM
7. Power poles may have to be braced at the Contractor's expense.
8. No machinery, construction access or storage shall be allowed on park property beyond the limits of the temporary workspace as defined by the City of Dallas Inspector.

TRAFFIC CONTROL

1. The Contractor shall develop a traffic control plan in accordance with the City Of Dallas Traffic Barricade Manual, Latest Edition and the TXDOT Texas Manual on Uniform Traffic Control Devices (TMUTCD), latest version, if necessary. NO SEPARATE PAY ITEM
2. The diversion of pedestrians and vehicles during the progress of the work shall be in a manner satisfactory to the City of Dallas Inspector. NO SEPARATE PAY ITEM
3. The Contractor shall coordinate all traffic variances with City of Dallas Traffic Safety Coordinators at XXX-XXX-XXXX.
4. Two-way traffic shall be maintained at all times and flagmen should be used to maintain two-way traffic as necessary.
5. All barricades, warning signs and traffic control devices shall conform to the City Of Dallas standards. NO SEPARATE PAY ITEM
6. When closing side streets, two working days notification is required for Fire, Police, Streets and Sanitation Departments. Please contact XXX at XXX-XXX-XXXX to notify of traffic restrictions.
7. Contractor shall maintain access to private driveways at all times during construction. NO SEPARATE PAY ITEM
8. Vehicular ingress and egress (entrance and exit) to a business property shall be maintained at all time. If not, specific signs along with business name and direction arrow(s) shall be used for any temporary access locations. Additional signs may be necessary if there is a detour. NO SEPARATE PAY ITEM
8. The Contractor shall replace any pavement markings and signs that are removed or damaged during construction. NO SEPARATE PAY ITEM

PAVEMENT REPLACEMENT

1. Saw cut, remove and replace pavements, sidewalks, curbs and gutters to conform with City of Dallas Public Works, Pavement Cuts and Repair Standards Manual, Latest edition.
2. All disturbed pavement markings including, but not limited to, striping, traffic buttons, crosswalks shall be restored to same or improved condition as per City of Dallas Specifications for Public Works Construction, Standard Construction Details and all Addenda Thereto. NO SEPARATE PAY ITEM

TREES AND LANDSCAPING

1. The Contractor shall not damage or remove any trees or landscaping unless otherwise authorized by the City of Dallas Inspector. Any trees or landscaping that are damaged or removed during the construction shall be replaced by the contractor at his expense.

WATER MAIN AND APPURTENANCES:

1. All 6", 8" and 12" water mains shall be PVC C900 (DR-14) water pipe, with Class "C+" embedment, except as noted.
2. All water mains with no profiles shall have a minimum cover of four (4) feet below street grade in an improved street and six (6) feet of cover in an unimproved street or alley.
3. Compact fittings are not authorized for this project. All ductile iron pipe, fittings and fire hydrant bases shall be encased with polyethylene wrap.
4. All bends, tees, fire hydrants and plugs are to be restrained type fittings and to be blocked with Class "B" Concrete as per DWU Standard Drawing No. 229-234, in addition to restrained joints.
5. If required by the City of Dallas Inspector, the Contractor shall install temporary water lines on both sides of the street until the new water main has been completed, tested, approved, and accepted by DWU. NO SEPARATE PAY ITEM
6. If no temporary mains are required by the City of Dallas Inspector, then the existing water mains are to be in service with the fire hydrants until the new water main has been tested, approved and accepted by DWU. NO SEPARATE PAY ITEM
7. The contractor will ensure that fire hydrants are accessible to fire trucks at all times. NO SEPARATE PAY ITEM
8. The Contractor shall sequence his construction such that no more than one fire hydrant is out of service at any given time.

9. All fire hydrants shall be installed as per DWU Standard Drawing No. 224. Existing fire hydrants on killed water lines are to be removed and delivered to DWU Distribution Division at XXX XX, Dallas, Texas, if required by City of Dallas Inspector; otherwise they become the property of the contractor.
10. Backfill made on break repairs to existing water mains may have been made with crushed rock. This could present a cave-in danger to a new ditch; therefore, precautions should be taken by the contractor. NO SEPARATE PAY ITEM.
11. Abandon all water valves on existing mains being killed as per DWU Standard Drawing No. 219. NO SEPARATE PAY ITEM.
12. The Contractor shall coordinate all water main ties-ins with City of Dallas Inspector.
13. The Contractor shall verify the location and number of all existing active water services and construct new services up to the meter prior to killing existing main.
14. Water services greater than 30 feet shall be minimum of 1 inch in diameter.

WASTEWATER MAIN AND APPURTENANCES:

1. The Contractor shall maintain existing wastewater flow at all times. NO SEPARATE PAY ITEM.
2. Abandon all manholes on abandoned wastewater mains.
3. The Contractor shall verify the location of all the wastewater laterals and construct new laterals from the wastewater main to the property line with cleanouts and reconnect to the existing laterals. Dye testing may be required at no additional cost to the owner.
3. Prior to reconnection of wastewater laterals, the Contractor shall verify whether the existing lateral is active or inactive. The Contractor is required, as a minimum, to include T.V. survey & perform dye testing. All laterals determined to be inactive shall not be reconnected. The City of Dallas Inspector shall approve all laterals targeted for reconnection. NO SEPARATE PAY ITEM
4. The backfill around manholes located in existing or new pavement shall be flowable backfill as per Specifications. NO SEPARATE PAY ITEM
5. The removal of existing manholes, wastewater access devices and cleanouts is considered incidental unless noted otherwise.

APPENDIX F

GENERAL NOTES FOR TYPICAL WATER/WASTEWATER MAIN JOINT CONTRACTS

GENERAL

1. All work shall be done in accordance with Specifications included in the contract documents.
2. All existing utilities are shown at approximate locations and depths are based on the best available records and limited field data. The Engineer does not certify that all utilities are shown. The Contractor shall verify exact locations, sizes, and depths of existing utilities before beginning construction (including ordering of pre-cast manholes and concrete pipe if applicable). NO SEPARATE PAY ITEM.
3. The Contractor shall coordinate all tie-ins with the on-site City of Dallas Inspector.
4. The Contractor shall ensure that existing fire hydrants are accessible to fire trucks at all times.
5. CAUTION!! Existing underground utilities involved. Call DIG TESS at 1-800-344-8377, 48 hours prior to construction for the location of any underground utilities involved in the area. NO SEPARATE PAY ITEM.
6. The Contractor is responsible for the protection of ALL existing utilities and utility structures. Power poles may have to be braced at Contractor's expense. Contractor shall support underground utilities when excavating or constructing under such utilities. NO SEPARATE PAY ITEM.
7. Reference to Standard Drawings shall mean those shown in the Dallas Water Utilities Standard Drawings for Water and Wastewater Construction (latest edition).
8. All items of work required to complete the work as shown or implied by the plans and specified in the Contract Documents which are not listed as a pay item in the proposal shall be considered incidental.

WATER DESIGN

1. The existing water line is to be used as a service line until the proposed main has been tested, approved and placed in service.
2. Abandon all valves on abandoned water mains as per DWU Standard Drawing 219. NO SEPARATE PAY ITEM.
3. The Contractor shall salvage fire hydrants and deliver them to 2901 Municipal Street, Monday thru Friday between 8 a.m. and 4p.m. Contact Lindell Gaskey or Juan Nino at 214-670-8970; 24 hours prior to delivery.
4. All bends, tees, fire hydrants and plugs shall be restrained type fittings. Compact fittings shall not be used. All bends shall be blocked with Class "B" concrete as per DWU Standard Drawing pp.229-234. All fire hydrants shall be installed per DWU Standard Drawing p.224. Polywrap shall be used on all cast iron fittings and fire hydrant bases.

5. All water services are to be replaced from the proposed water main to the meter clearing all existing and proposed utilities and pavement. Relocate and reset all water meter as required and reconnect to existing house services. Install water deadheads to unimproved lots.
6. Fire hydrant leads and barrels shall be set to grade established for the proposed paving. If the hydrant is not accessible because of existing ground conditions, the hydrant shall be raised with extension(s) as directed by the owner.
7. *All R.C.C.P. water mains shall be installed with bonded joints. All D.I. pipe and fittings shall be polywrapped. All flanged connections are to be insulated as per DWU Standard Drawing 223.
8. The Contractor shall sequence his construction such that no more than one fire hydrant is out of service at any given time.
9. Backfill made on break repairs to existing water mains may have been made with crushed rock. This could present a cave-in danger to a new ditch; therefore precautions should be taken by the Contractor. NO SEPARATE PAY ITEM.
10. If required by the City of Dallas Inspector, the Contractor shall install temporary water lines on both sides of the street until the new water main has been completed, tested, approved, and accepted by DWU. NO SEPARATE PAY ITEM.
11. Water services greater than 30 feet shall be a minimum of 1 inch in diameter.

***Special Case**

WASTEWATER DESIGN

1. The Contractor shall verify the location of all wastewater laterals and construct new laterals from the wastewater main to the property line with cleanouts and reconnect to the existing laterals for all existing buildings. Deep cut connections may be required.
2. The contractor shall maintain existing wastewater service and flow at all times. NO SEPARATE PAY ITEM.
3. Prior to reconnection of wastewater laterals, the Contractor shall verify whether the existing lateral is active or inactive. The Contractor is required, as a minimum, to include T.V. survey & perform dye testing. All laterals determined to be inactive shall not be reconnected. The DWU Construction Superintendent shall approve all laterals targeted for reconnection. NO SEPARATE PAY ITEM.
4. The Contractor shall verify the location of all wastewater laterals and reconnect approved, active laterals to the existing lateral.
5. The backfill around manholes located in existing or proposed pavement shall be flowable backfill as per NCTCOG Specification Items 504.6.6 and 504.2.3.4. NO SEPARATE PAY ITEM.

6. Removal of existing MH's, Wastewater Access Devices & Cleanouts is considered incidental unless noted otherwise.

PAVING REPLACEMENT

1. For proposed paving, drainage, and traffic control plans see State of Texas Department of Transportation Plans of Proposed State Highway Improvement, Federal Aid Project, STP-97 (434) MM, CSJ: 0918-45-369, for ELAM ROAD, DALLAS COUNTY, FROM ST. AUGUSTINE ROAD TO ACRES DRIVE.

OR

For proposed paving and drainage plans in Coxville St. from Skyfrost east to Dead-end, see 311D _____ and 421Q _____.

2. Temporary paving shall be used over all street, drive and sidewalk cuts (AND TRENCH) within proposed paving limits. Permanent paving shall be used outside proposed paving limits.
3. For all construction performed outside paving limits, the contractor will be required to make paving repairs in strict accordance with the City of Dallas Pavement Cut and Repair Standards Manual (latest edition).

TRAFFIC CONTROL

1. The Contractor shall provide for the diversion of pedestrians and vehicles during the progress of work in a manner satisfactory to the on-site City of Dallas inspector and in accordance with the City of Dallas Traffic Barricade Manual, latest edition. NO SEPARATE PAY ITEM.
2. The Contractor is responsible for coordinating all new water and wastewater construction with the traffic control plan. Supplemental traffic control needed for the water and wastewater construction shall meet TxDOT traffic control standards.
3. The Contractor shall maintain vehicular traffic ingress and egress to private property at all times.
4. The Contractor shall replace any pavement markings and signs that are removed or damaged during construction. NO SEPARATE PAY ITEM.

EXTRA NOTES

1. Shut down of water mains 20" and larger shall ONLY be done during winter months of October 1st thru April 1st. Actual time shall be determined by the Construction Engineer.
2. Construct wastewater lateral cleanouts and water meter boxes in the proposed sidewalks where applicable.
3. All existing culverts and ditches are to be restored satisfactory to the construction engineer. No separate pay item
4. The Contractor shall provide water services with deadheads and wastewater laterals with cleanouts to all unimproved lots.
5. All proposed water mains shall be PVC C900 (DR-14) Class C+ Embedment, except as noted on the plans.
6. All water mains with no profile shall have a minimum cover as follows: 6", 8", 10", & 12" - 48" below finished street grade or 72" below unimproved grade.
7. Abandon all manholes on abandoned wastewater mains per DWU Standard Drawing p.316.
8. Construction ditches in the traffic lanes are to be backfilled or plated after each construction period.