City of Houston
Houston Public Works

Infrastructure Design Manual

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March 2026

CITY OF HOUSTON
Houston Public Works

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The 2026 edition of the City of Houston Infrastructure Design Manual will be effective March 2, 2026. The manual has been updated and revised to reflect changes to the City of Houston's general requirements; graphic requirements; utility location requirements; storm water design and water quality requirements; and pedestrian, bicycle, and transit design requirements. The 2026 edition will supersede the 2023 edition of the City's Infrastructure Design Manual.

Please keep in mind that the purpose of this manual is to establish the basic criteria from which engineers can design infrastructure in a manner acceptable to the Department and is not intended to address all design conditions or specialized situations.

For more detailed information concerning the updates to the Infrastructure Design Manual, Standard Drawings and the Standard Construction Specifications see the attached Executive Summary.

Respectfully,

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Director, Houston Public Works

Oluwole A. McFoy, P.E.
City Engineer, Houston Public Works

Attachment: Executive Summary

cc: Christon K. Butler, MCD, Chief Operating Officer
Andrew Molly, P.E., Chief Water Officer
Kevin Berry, Chief Technology Officer
Brian Mason, Executive Director
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EXECUTIVE SUMMARY

2023-2026 Review Cycle

The following executive summary highlights the implementation and some of the major updates to the City of Houston's (City) Infrastructure Design Manual (IDM), General Requirements, Standard Construction Specifications, and Standard Drawings from the 2023-2026 review cycle.

GENERAL CHANGES

The 2026 Infrastructure Design Manual, General Requirements, and Standard Construction Specifications show change bars on the left side of the page to indicate a major revision has taken place. For specific details on what changes took place, redlines will be posted on the Design and Construction Standards website for reference.

Numerous formatting changes and references to standards have been updated throughout the IDM, standard specifications and standard details.

INFRASTRUCTURE DESIGN MANUAL (IDM)

Chapter 1 General Requirements

This chapter was not officially part of the 2023-2026 review cycle. The criteria for expiration of projects was revised to prevent unintended consequences of the current procedure. Previously some submittals that lacked technical improvements were submitted solely to secure project activation near the expiration date which allowed applicants to avoid review fees and avoid compliance with the latest IDM requirements. The revised procedure is implemented to ensure review fees are captured and ensure compliance with the latest IDM requirements which are updated annually.

Chapter 3 Graphic Requirements

This chapter was not officially part of the 2023-2026 review cycle. A new article was added to the General Sheet Content section to list the major utilities and overall scope of work on the cover sheet of drawings to increase the speed of routing projects to the responsible departments. Also, the web link for the electronic plan review process was updated.

Chapter 6 Utility Locations

This chapter was not officially part of the 2023-2026 review cycle. Subsurface Utility Exploration (SUE) updates that were approved through a supplement effective June 21, 2024 were added to the IDM. Also, Private Utility Lines section was updated to include an article to avoid frequent damage to wastewater utilities in side lot and back lot easements from other underground structures (e.g. foundations, footings, piers, posts, poles, etc.).

Chapter 9 Stormwater Design Requirements

The chapter was restructured to improve readability and to emphasize areas of greater priority. The definitions and references sections were updated. Numerous figures were added or updated for clarity. Updates related to detention criteria that were approved through IDM supplement IDMS-2025-01

Chapter 9 Stormwater Design Requirements (Cont.)

effective May 16, 2025 were added to the IDM along with updates to provide clarifications to these criteria. Various updates and improvements have been made to this chapter, they are as follows:

1. Sheet Flow exception for single family residential projects that meet certain criteria was included.
2. Several parts of the stormwater design requirements section were modified to improve clarity.
3. Clarified that the receiving jurisdiction's design criteria governs for detention facilities and outfalls for projects located within the City limits that directly discharge into other jurisdictions.
4. Expanded the allowable software used for design of drainage facilities.
5. Tailwater elevation selection for HGL analysis was clarified to avoid misinterpretations.
6. Plan and profile submittal requirements were removed for outfalls for single family residential developments that are less than 15,000 SF.
7. Improved thermoplastic pipe design requirements.
    a. Minimum cover requirements were added.
    b. Corrugated polypropylene pipes for storm application will be allowed under all roadway classifications and no longer be restricted to local streets.
    c. Thermoplastic pipes can be stored in direct sunlight as long as allowed by manufacturer.
    d. A standard backfill detail for thermoplastic pipes in dry stable trench was created providing cement stabilized sand as standard backfill. In construction specifications flowable fill is no longer required as backfill for this material, cement stabilized sand will be required as backfill.
    e. Structural engineering calculations will only be required to be submitted upon request.
8. Summary tables of acceptable storm conduit materials and sizes of storm sewer conduits were added.
9. A paragraph was added to consider options to address maintenance issues in short roadside ditches.
10. Long Run Culvert was defined and a maximum run length was specified.
11. A grated inlet, junction box or manhole will be required at certain distances along the length of the long run culvert to avoid maintenance issues.
12. Expanded acceptable construction measures at ends of culverts (e.g. headwall, sloped paving, etc.).

Chapter 9 Stormwater Design Requirements (Cont.)

13. Revised detention design criteria:
    a. Expanded exceptions to detention criteria for: certain maintenance activities; developments increasing impervious area within the right-of-way; developments within the Lake Houston watershed; and underground utilities which do not create surface impervious area.
    b. It was clarified that detention requirements will be determined for projects dealing with natural disasters on a case-by-case basis.
    c. A paragraph was added to address issued memos by the City that provided a detention exemption for projects within approved locations within Central Business District, Medical Center and Lower Buffalo Bayou. Map figures were added to identify the area of these detention exemptions.
    d. Added an article for considering safety in detention basin designs.
    e. Site, hydraulic, structural, and maintenance requirements for underground detention systems were provided.
    f. Clarified and updated private detention facility requirements related to pump volumes for HCFCD projects, 48-hour drainage of detention facilities, and detention basin setbacks.
14. Clarified that all storm sewers within a Type 2 Permanent Access Easement must follow chapter 9 requirements.
15. Stormwater Water Quality (SWQ) design section was revised to facilitate use of Low Impact Development (LID) techniques. Various updates and improvements have been made, they are as follows:
    a. Defined the term Water Quality Volume and clarified the Best Management Practices (BMPs) design goals to ensure consistency in design.
    b. Added criteria for individual SWQ BMP's related to bacteria removal.
    c. Table for minimum design criteria for conventional SWQ techniques was added.
    d. LID techniques were cross referenced to the associated design requirements within the chapter and listed in a table for quick reference.
    e. A reference to the City's newly published green infrastructure guide "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" was added.
    f. LID incentives section was created to promote use of LID techniques. Incentives include a credit for reduction of detention rate and reference City's policy on tax abatement.
    g. Submittals section was reorganized to provide better communication of submittal requirements and were updated to provide more context for SWQ submittals for private and public projects.

Chapter 17 Pedestrian, Bicycle, and Transit Design Requirements

This chapter was not officially part of the 2023-2026 review cycle. A reference to table 15.7 was added to the safety buffer section for the cases where the safety buffer should not be paved.

IDM Supplements

The City creates supplements for the IDM when there is a need to revise a current IDM chapter that is outside of its normal review cycle period. At the time when a new IDM is released, any active supplements are incorporated into the new IDM and those supplements subsequentially deactivated.

Prior to the completion of the 2023-2026 review cycle, there were three active IDM supplements. Supplement to IDM Chapter 9 (effective May 30, 2024) which was updated and implemented as a part of the Chapter 9. Supplement to IDM Chapter 6 (effective June 21, 2024) which was added to Chapter 6 without further updates. Supplement to IDM Chapter 9 (IDMS-2025-01 effective May 16, 2025) which was added to Chapter 9 with additional updates and clarifications due to proposals received during this review cycle.

Infrastructure Design Manual Implementation

- The 2026 Infrastructure Design Manual is effective March 2nd, 2026.

- *Capital Improvement Projects*
  A 90-day design grace period will be given for Houston Public Works Capital Improvement Projects. Phase II final designs that have not been submitted for a required review (60% submittal) prior to June 1st, 2026, will be required to completely comply with the new Infrastructure Design Manual.

- *Private Sector*
  A 90-day design grace period will be given for projects in the public/private sector. Substantially complete plans submitted for initial review after June 1st, 2026, will be required to comply with the new Infrastructure Design Manual.

CONSTRUCTION SPECIFICATIONS

Revised Specifications

Various specifications, that are associated with the IDM chapters reviewed during the 2023-2026 review cycle, were reviewed and updated. A total of twenty-five (25) specifications included technical changes, no new specifications were created, and none of the specifications were retired. Specifications related to this review cycle were restructured to conform with CSI formatting. A list of all specifications that contained technical changes is provided at the end of this executive summary.

Specification Implementation

- *Capital Improvement Projects*
  The 2026 construction specifications are effective March 2nd, 2026. Per Document 00700 General Condition, section 1.2.4:

  "Reference to standard specifications, manuals, or codes of a technical society, organization, or association, or to laws or regulations of a governmental authority, whether specific or implied, mean the latest edition in effect as of date of receipts of bids, except as may be otherwise specifically stated in the Contract."

- *Private Sector*
  All projects in the public/private sector submitted on or after March 2nd, 2026, shall comply with the latest version of the City's Construction Specifications.

STANDARD DETAIL REVISIONS

Revised Standard Details

Various standard details associated with IDM Chapters were up for review during the 2023-2026 review cycle. A total of twenty-two (22) standard details included technical changes, thirteen (13) new standard details were created, and nine (9) standard details were retired. Title blocks were updated for all drawings associated with this year's review cycle and multiple details that were previously provided on one 22" x 34" sheet were separated onto individual sheets. Numerous drawings were renumbered and/or retitled to follow their associated standard specification. The AutoCAD format of drawings were standardized and will be available for public use. A list of all standard details that contained technical changes, details added, or retired is provided at the end of this executive summary.

Revised Standard Detail Implementation

- The 2026 standard details are effective March 2nd, 2026.

- For Houston Public Works capital improvement projects, Phase II final designs that have already been submitted for a required review prior to March 2nd, 2026, it is recommended that all designers make an effort to incorporate the new changes into their current design to the extent that it does not increase cost or delay a project.

END OF EXECUTIVE SUMMARY

(See Next Page for List of New Revisions)

EXECUTIVE SUMMARY

2023-2026 Review Cycle

NEW IN THE 2026 REVISION

Infrastructure Design Manual (IDM), Standard Construction Specifications and Standard Details for Houston Public Works Design & Construction — 2026 Revision

Infrastructure Design Manual (IDM) Chapters Updated*:

- Ch. 1 – General Requirements
- Ch. 3 – Graphic Requirements
- Ch. 6 – Utility Locations
- Ch. 9 – Stormwater Design Requirements
- Ch. 17 – Pedestrian, Bicycle, and Transit Design Requirements

New Standard Specifications:

- None

Standard Specifications Updated*:

- 01570 – Storm Water Pollution Prevention Control
- 01740 – Site Restoration
- 02081 – Cast-in-place Concrete Manholes
- 02082 – Precast Concrete Manholes
- 02091 – Non Metallic Frames, Grates, Rings, and Covers
- 02221 – Removing Existing Pavements, Structures, Wood, and Demolition Debris
- 02317 – Excavation and Backfill for Utilities
- 02321 – Cement Stabilized Sand
- 02322 – Flowable Fill
- 02400 – Tunnel Shafts
- 02445 – Jack and Bore/ Jack and Mine/ Pilot Tube Guided Boring Tunnels
- 02501 – Ductile Iron Pipe and Fittings
- 02504 – Fiberglass Reinforced Pipe
- 02505 – High Density Polyethylene (HDPE) Solid and Profile Wall Pipe
- 02506 – Polyvinyl Chloride Pipe
- 02507 – Prestressed Concrete Cylinder Pipe
- 02508 – Extra Strength Clay Pipe
- 02509 – Fiberglass Reinforced Pipe for Pressure Mains
- 02510 – Polypropylene (PP) Corrugated Wall Pipe
- 02533 – Acceptance Testing for Sanitary Sewers
- 02611 – Reinforced Concrete Pipe
- 02612 – Precast Reinforced Concrete Box Sewers
- 02631 – Storm Sewers
- 02633 – Precast Concrete Inlets, Headwalls, and Wingwalls
- 03315 – Concrete for Utility Construction

Standard Specifications Retired/Deleted:

- None

New Standard Details:

- 02082-14 – Precast Concrete Top Slab Lid
- 02090-03 – 32” Storm Sewer Manhole Frame and Grate
- 02090-11 - 48” Storm Sewer Manhole Frame and Cover
- 02090-13 – 30” Storm Sewer Manhole Frame and Hinged Cover
- 02090-14 - Storm Sewer Frame and Grate for Type “B-B” Inlet Double Assembly with Camlock
- 02091-02 - Storm Sewer Non-Metallic Manhole Frame and Cover
- 02317-10G – Storm Sewer Bedding and Backfill for Thermoplastic Pipe in Dry Stable Trench
- 02633-01 - Precast Concrete Storm Sewer Inlet Type “A”
- 02633-02 - Precast Concrete Storm Sewer Inlet Type “B-B”, “B-B(1)” and “B-B(2)”
- 02633-03 - Precast Concrete Storm Sewer Inlet Type “C”, “C-1” And “C-2”
- 02633-04 - Precast Concrete Storm Sewer Inlet Type “D”
- 02771-03 - Curb and Gutter Transition For Precast Inlet Type “B-B”, “B-B(1)” and “B-B(2)”
- 02771-04 - Curb and Gutter Transition For Precast Inlet Type “C”, “C-1”, and “C-2”

Standard Details Updated*:

- 01570-01 (prev. 01571-01) - Stormwater Pollution Prevention Plan Details
- 02082-13 - Storm Sewer Precast Box Inlet/Manhole

Standard Details Updated* (cont'd):

- 02082-15 (prev. 02081-04) - Storm Sewer Manhole Type 'C' For Proposed Concrete Box Sewer
- 02082-16 (prev. 02081-08) - Proposed Manhole on Existing Box Storm Sewer
- 02082-17 (prev. 02081-05) – Storm Sewer Manhole for Existing Monolithic Reinforced Concrete 48" Dia and Greater
- 02090-02 (prev. 02084-02) - Storm Sewer Manhole Frame and Cover
- 02090-04 (prev. 02084-04) - Storm Sewer Type "B-B" Inlet Double Assembly
- 02090-05 (prev. 02084-05) - Storm Sewer Frame and Grate for Type "B-B" Inlet Double Assembly
- 02090-06 (prev. 02084-06) - Storm Sewer Type "D" Inlet Grate and Frame
- 02090-07 (prev. 02084-08) - Storm Sewer Type "A" Inlet Grate and Frame
- 02090-08 (prev. 02084-09) - Storm Sewer Type "C", "C-1" and "C-2" Inlet Frame and Cover
- 02090-09 (prev. 02084-10) - 32" Inverted Manhole Frame
- 02090-10 (prev. 02084-11) Storm Sewer Ring Grate for Open End of 18" to 72" RCP Stubs to Ditch
- 02317-02 - Sanitary or Storm Sewer Crushed Stone Foundation for Wet Stable Trench
- 02317-03 – Sanitary or Storm Sewer Bedding and Backfill for Dry Stable Trench
- 02317-05 – Precast Concrete Box Storm Sewer Bedding and Backfill for Dry Stable Trench
- 02317-06 - Precast Concrete Box Storm Sewer Bedding and Backfill for Wet Stable Trench
- 02317-07 - Precast Concrete Box Storm Sewer Bedding and Backfill with Seal Slab
- 02632-04 – Storm Sewer Type "B-B" Inlet for Maintenance Only
- 02632-09 - Storm Sewer Type "E" Inlet
- 02632-10 - Storm Sewer Type "E" Inlet on Exist Monolithic Conc Sewers of 48" Dia & Greater
- 02631-GD01 (prev. 02632-11) - Side Street Ditch Reception
- 02754-02 – Driveways With Culverts on Open Ditch Type Streets

Standard Details Retired/Deleted:

- 02081-07 - Lateral Connection to Existing Monolithic Reinforced Concrete Storm Sewer
- 02084-03 - Storm Sewer Type "B" Inlet Assembly
- 02084-07 - Storm Sewer Type "D-1" Inlet Grate and Frame
- 02632-01 - Storm Sewer Type "A" Grate Inlet
- 02632-03 - Storm Sewer Type "B" Inlet Relocation
- 02632-05 - Storm Sewer Type "B" Inlet Relocation
- 02632-06 - Storm Sewer Type "C-1", "C-2" and "C-2A" Inlet
- 02632-07 - Storm Sewer Type "D" Inlet
- 02632-08 - Storm Sewer Type "D-1" Inlet

*Only IDM chapters, specifications and standard details with technical changes have been included in the list.

PREFACE

PURPOSE

As stated in the City of Houston's Code of Ordinances Article V, Section 40-128, the Director of Houston Public Works can "promulgate rules and regulations… that are consistent with applicable federal and state laws, city ordinances, and sound engineering practices." The purpose of the Infrastructure Design Manual (IDM), as stated by Ordinance 2018 -11 section 37, is to set "forth the standards for infrastructure design and construction as approved by the jurisdiction's Office of the City Engineer." One of the primary purposes of the IDM is to provide the basic requirements, best practices, and direction for the design of infrastructure within the City of Houston and City's extra territorial jurisdiction (as required) and to promote uniformity of design practice in the area.

SCOPE

This document represents the general requirements of the Houston Public Works for designing public infrastructure in the City of Houston and in the City's extra territorial jurisdiction (as required). The standards in this document are not a substitute for sound engineering judgment, but are the basic criteria permitted by the City of Houston to be used in infrastructure design. In achieving the goals of Resilient Houston and the Climate Action Plan, exceeding these basic criteria is facilitated through this document.

REVISION CYCLE

This document is intended to be a dynamic manual (living document), that is developed and maintained in accordance with all City, State, and Federal policies. Each chapter will be reviewed and amended a minimum of every five years. To accomplish this, several chapters will be amended annually and an updated IDM will be released each year. For more information visit: https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards#agency-links-1466. Public comments and recommendations are crucial in maintaining this manual. Supplements will periodically be released to accommodate new technologies, methodologies, and to clarify the application of code provisions relevant to special circumstances.

END OF PREFACE

City of Houston
Houston Public Works

INFRASTRUCTURE DESIGN MANUAL

MARCH 2026

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***Bold chapters have been revised 03-02-2026.**

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***Bold tables have been revised 03-02-2026**

City of Houston

Design Manual

Chapter 1

GENERAL REQUIREMENTS

Chapter 1
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General Requirements

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Chapter 1

GENERAL REQUIREMENTS

SECTION 1 - GENERAL REQUIREMENTS OVERVIEW

1.1.01 CHAPTER INCLUDES

1.1.01.A Research and submittal requirements for projects inside the city limits of Houston or within Houston's Extraterritorial Jurisdiction (ETJ).

1.1.01.B Tree protection requirements.

1.1.02 REFERENCES

The following references should be reviewed in conjunction with this manual:

1.1.02.A Latest revision of the following City of Houston Code of Ordinances:

1. Chapter 33 - Planning and Development, Article IV - City Surveys.
2. Chapter 33 – Planning and Development, Article V – Trees, Shrubs, and Screening Fences.
3. Chapter 33 – Planning and Development, Article VI – Protection of Certain Trees.
4. Chapter 40 – Streets and Sidewalks, Article V - Excavation in Public Way
5. Chapter 42 - Subdivisions, Developments and Platting.
6. Chapter 47 – Water and Sewers, Article V - Industrial Wastewater.

1.1.02.B Texas Accessibility Standards (TAS) of the Architectural Barriers Act, Article 9102, Texas Civil Statutes.

1.1.02.C City of Houston Standard Specifications and Standard Details, latest revision.

1.1.02.D Rules and Regulations published by Texas Commission on Environmental Quality (TCEQ).

1. Texas Administrative Code Title 30, Part 1, Chapter 290 Public Water Drinking, latest revision.
2. Texas Administrative Code Title 30, Part 1, Chapter 217 Design Criteria for Domestic Wastewater Systems, latest revision.

1.1.02.E Texas Board of Professional Engineers and Land Surveyors (TBPELS) Practice Acts and Rules Concerning Practice and Licensure.

1. Texas Statute, Occupations Code, Title 6, Subtitle A, Chapter 1001 Texas Board of Professional Engineers and Land Surveyors.

2. Texas Statute, Occupations Code, Title 6, Subtitle C, Chapter 1071 Land Surveyors.

3. Texas Administrative Code, Title 22, Part 6 Texas Board of Professional Engineers and Land Surveyors.

1.1.02.F Texas Local Government Code, Title 2, Subtitle C, Chapter 42 Extraterritorial Jurisdiction of Municipalities.

1.1.02.G Storm Water Management Handbook for Construction Activities, Latest Edition as Prepared by Harris County, Harris County Flood Control District (HCFCD), and City of Houston.

1.1.02.H Harris County Public Infrastructure Department's Rules and Regulations.

1.1.02.I City of Houston IDM Chapter 13, Geospatial Data Deliverables.

1.1.02.J American Standard for Nursery Stock (ANSI Z60.1).

1.1.03 DEFINITIONS

1.1.03.A As-Built Drawings - Final revised Drawings at completion of the project, submitted by the contractor to the Engineer of Record and City, that captures all changes in work during the construction process shown as revisions on the as-bid Drawings.

1.1.03.B City Engineer - The authorized representative of the City, or the City's designee, having approval authority for Publicly-Funded Projects, Privately-Funded Projects, or having authority for administration of design and construction contracts for the City.

1.1.03.C Conflict Verification - For capital improvement projects requiring the acquisition of fee or easement interest in real property, verification that all existing easements that lie across, along, under, over, through and within the parcel to be acquired will not prevent the construction of the utility or infrastructure or the intended use of the easement.

1.1.03.D Drawings - Plan, profile, details, and other graphic sheets to be used in a construction contract which define character and scope of the project.

1.1.03.E Drip Line - Imaginary circle drawn around a Tree, extending to the Tree's branching limit.

1.1.03.F Engineer of Record - A Professional Engineer who seals Drawings, reports or documents for a project.

1.1.03.G Extraterritorial Jurisdiction (ETJ) - The unincorporated territory extending beyond the corporate boundaries of the City established pursuant to Chapter 42 of the Texas Local Government Code, as may be amended from time to time.

1.1.03.H Parkway - Area lying between the street curb or edge of roadway paving and the adjacent property line.

1.1.03.I Privately-Funded Projects - Projects that are funded by an individual or private entity and do not have a design contract with the City.

1.1.03.J Publicly-Funded Projects - Projects that are funded by a public entity, but do not have a design contract with the City.

1.1.03.K Professional Engineer - An engineer currently licensed and in good standing with the Texas Board of Professional Engineers and Land Surveyors (TBPELS).

1.1.03.L Project Manager - An authorized representative of the City of Houston who manages the project or the Engineer of Record for private development.

1.1.03.M Protected Tree - Corridor Tree, designated Tree, green corridor Tree or Parkway Tree as defined by Chapter 33 of the City of Houston Code of Ordinances.

1.1.03.N Record Drawings - Final revised Drawings prepared by the Engineer of Record on the original as-bid Drawings documenting significant changes in work based solely upon the marked-up As-Built Drawings, addenda, revisions, change orders and other data furnished by the contractor.

1.1.03.O Registered Professional Land Surveyor (RPLS) - A surveyor currently registered and in good standing with State of Texas Board of Professional Engineers and Land Surveyors (TBPELS).

1.1.03.P Review Authorities - The authorized representatives of City departments, divisions, branches or sections responsible for reviewing and approving calculations and Drawings for Publicly-Funded Projects, Privately-Funded Projects and for design and construction contracts with the City.

1.1.03.Q Specifications - City of Houston Standard Specifications plus project-specific narrative descriptions of procedures, requirements, and materials for a particular project.

1.1.03.R Tree - Any evergreen or deciduous Tree which at the time of planting has a caliper equal to or greater than 1 1/2 inches as measured six inches above the root collar, which is not less than six feet in height as measured from the root collar, and which meets the Standard for Nursery Stock Specifications.

1.1.04 PLAT AND CONSTRUCTION DRAWING REVIEW PROCESS

1.1.04.A Review of plat and construction Drawings by Houston Public Works is a required part of the overall platting process under purview of the City Planning Commission and the Planning and Development Department of the City of Houston.[1]

1.1.04.B The process to be followed in submitting documents for review and approval of water, wastewater, storm drainage, and street paving is described by the flowchart depicted in Figure 4.1, Class III Preliminary Plat.

1.1.04.C For projects requiring a subdivision plat, construction of utilities and paving is not permitted until the plat has been recorded.

1.1.04.D For projects not requiring a subdivision plat, construction of utilities and paving is not permitted until final design Drawings are approved and signed by the Director of Houston Public Works, or the Director's designee.

1.1.04.E Signature of the Director of Houston Public Works, or the Director's designee, on final design Drawings for utilities which are intended to remain private, does not indicate acceptance of the City for ownership or maintenance or operation of facilities indicated on the Drawings.

[1] Refer to weblink for City requirements: http://www.houstontx.gov/planning/Commissions/commiss_plan.html

SECTION 2 - GENERAL DESIGN REQUIREMENTS

1.2.01 DESIGN REQUIREMENTS

1.2.01.A Preliminary Design.

1. Publicly/Privately-Funded Projects:

    a. Prior to preliminary design submittal, City reviewers are available to discuss alternate solutions for project elements where alternate designs may be considered.

    b. Provide the Office of City Engineer with Drawings in sufficient detail to describe the proposed improvements. Include proposed materials, if different from materials approved by the City. Identify any problems or conflicts associated with the project. Information furnished must be in sufficient detail for the City Engineer to assess whether the design meets current City design standards.

    c. Provide rights-of-way and easement requirements for the project.

2. Design Contracts with the City:

    a. Participate in preliminary conferences with the City's Project Manager outlining the scope of work and extent of the preliminary report.

    b. Prepare preliminary engineering studies and designs based upon the scope of work and as outlined in the professional engineering services contract with the City.

    c. Prepare the contractually specified number of copies of preliminary layouts, sketches, reports, and calculations supporting the preliminary layouts. Prepare alternate solutions, where applicable to the project, and include the engineer's specific recommendations.

    d. Prepare preliminary cost estimates for primary and alternate solutions of the proposed construction.

    e. Participate in conferences with the City to determine final design.

    f. When required by the professional services contract, provide detailed soils and geotechnical investigations and environmental investigations to support proposed construction of utilities and paving.

1.2.01.A.2 continued

g. Provide required real estate, rights-of-way, and easement requirements for the project.

1.2.01.B Final Design.

1. Publicly/Privately-Funded Projects:

a. Revise design to reflect comments of the City Engineer and Review Authorities. Include design calculations to support proposed improvements.

b. Provide electronic Drawings to the City Engineer and Review Authorities for verification and compliance with prior review comments.

c. Obtain required signatures from governmental agencies (other than the City of Houston) and private utility companies prior to requesting signature by the City.

d. Include the following note on construction Drawings - "Contractor shall notify the City of Houston, Houston Public Works (832-394-9098), 48 hours before starting work on this project."

2. Design Contracts with the City:

a. Furnish the City, where applicable, engineering data necessary for applications for routine permits required by local, state, and federal authorities.

b. Prepare detailed final design Drawings and Specifications in compliance with comments received from the City subsequent to the review of the preliminary design.

c. Prepare detailed cost estimates and proposal forms for the authorized project.

d. Provide estimated construction duration. Include all back up calculations and assumptions. Provide assumed number of holidays, weekends, severe weather and other non-working days as applicable.

1.2.02 SUBMITTALS

1.2.02.A Submittal Procedures.

1. For Publicly/Privately-Funded Projects:

1.2.02.A.1 continued

a. To obtain review of final design Drawings for both Publicly-Funded and Privately-Funded Projects, first submit Drawings to the Houston Public Works, Office of the City Engineer for assignment of a project number before review will commence. The project number will remain in effect for one year.

b. Once a project number is assigned, reference the number in all correspondence relating to that project.

c. Obtain and complete electronic plan review assigned tasks for each phase of the review process. The same project number will be used for all review phases of each project unless review of a subsequent phase is delayed by over one year.

d. Office of the City Engineer personnel will process reviews through appropriate review teams in Houston Public Works.

e. Once a project has begun the review process, it will become expired and the project number inactivated if the project meets all the following:

(1) Gone over the one-year initial project number lifetime since the first plan review submittal.

(2) Has no activity within 30 days of the previous review.

(3) Has no exceptions granted by the Office of City Engineer for items required of City or other government agencies.

f. The City has a weekly one-day walk-through procedure for the signature of revisions and updates of plans approved through the hard copy review. Instruction sheets for this procedure may be obtained from the Office of the City Engineer.

g. Projects involving construction of privately owned facilities require review and approval of any connection to a public water line, sanitary sewer, or storm sewer or to a public street, using the process defined in this manual.

2. For Design Contracts with the City:

a. Submit documents in accordance with requirements of the professional engineering services contract.

1.2.02.B Preliminary Design.

1.2.02.B continued

1. Publicly-Funded and Privately-Funded Projects: Submit set of the design Drawings and supporting documents through the electronic plan review system. Provide supporting evidence as described in Article 1.2.01 and Article 1.2.04. All Drawings submitted through the electronic plan review system to the Office of the City Engineer are considered to be in the final design stage and ready for signature.

2. Design contracts with the City: Submit documents in accordance with requirements of the professional engineering services contract.

1.2.02.C Final Design.

1. Publicly/Privately-Funded Projects:

   a. Plans submitted through the electronic plan review system to the Office of the City Engineer must comply with Article 1.2.02.B.1.

2. Design Contracts with the City:

   a. Submit documents in accordance with requirements of the professional engineering services contract.

   b. Submit a copy of the City review comments on the preliminary Drawings.

1.2.02.D Signature Stage.

1. Publicly/ Privately-Funded Projects:

   a. This stage is only applicable for submittals that comply with Article 1.2.02.A1.f. Submit previously approved Drawings for signatures.

   b. Plans submitted through the electronic plan review system to the Office of the City Engineer must comply with Article 1.2.02.B.1.

2. Design Contracts with the City:

   a. Submit original tracings with prints containing previous review comments.

   b. Specification submittals: Submit final design Specifications for review.

   c. Submit final computer-generated drawing files in acceptable electronic media including vicinity maps, right-of-way Drawings, construction Drawings, or other information pertinent to the project.

1.2.02.D.2 continued

d. Submit surveyor's field book and electronic data in accordance with Chapter 2, Survey Requirements.

1.2.02.E Construction.

1. For design contracts with the City, refer to construction submittal requirements in the professional engineering services contract.

2. Record Drawings:

a. Provide Record Drawings in the format requested by the City.

b. For design contracts with the City, submit Record Drawings in accordance with requirements of the professional engineering services contract.

c. For Publicly-Funded and Privately-Funded Projects, submit Record Drawings to the Office of the City Engineer no later than two weeks following final acceptance of the project.

d. For projects involving waterlines, refer to Chapter 7 for specific requirements.

3. Geospatial Data Deliverables: Provide GIS datasets in accordance with Chapter 13 – Geospatial Data Deliverables for projects that are proposing or modifying assets identified in Chapter 13 that are or will be operated and/or maintained by the City. In addition, provide GIS datasets in accordance with Chapter 13 – Geospatial Data Deliverables for projects that are proposing or modifying the privately owned and operated telecommunications assets described in Chapter 13.

1.2.02.F Provide additional submittals as required in applicable chapters of the City of Houston Infrastructure Design Manual (IDM).

1.2.03 QUALITY ASSURANCE

1.2.03.A Have surveying and platting accomplished under direction of a RPLS.

1.2.03.B Have recording documents sealed, signed, and dated by a RPLS.

1.2.03.C Have calculations prepared by or under the direct supervision of a Professional Engineer trained and licensed in disciplines required by the project scope.

1.2.03.D Have final design Drawings sealed, signed, and dated by the Professional Engineer responsible for development of the Drawings.

1.2.04 RESEARCH REQUIREMENTS

1.2.04.A Research existing utility and right-of-way information with the City departments listed below. Present and discuss the concept of the project with these same departments.

1. Houston Airport System
2. Houston Public Works
    a. Capital Projects
    b. Customer Account Services
    c. Financial Management Services
    d. Houston Permitting Center
    e. Houston Water
    f. Transportation & Drainage Operations
3. Planning and Development Department
4. Parks and Recreation Department
5. Finance Department, Franchise Administration

1.2.04.B Research existing utilities and rights-of-way or easements for conflicts with the following public and private organizations:

1. Texas Department of Transportation
2. Harris County Public Infrastructure Department
3. Harris County Toll Road Authority
4. Metropolitan Transit Authority of Harris County
5. Harris County Flood Control District
6. Other City and County Governments
7. Franchise Holders:
    a. CenterPoint Energy - Gas
    b. AT & T Company

1.2.04.B.7 continued

c. CenterPoint Energy - Electric

8. Cable television and data communications companies

9. Other utility companies:

a. Utility districts

b. Private utilities/franchises

c. Railroad companies

d. Pipeline companies

1.2.04.C Verify that no restrictions or conflicts exist that will prevent approval and permitting of the project.

1. For capital improvement projects requiring the acquisition of real property, a Conflict Verification is required.

1.2.05 APPROVED DRAWINGS

1.2.05.A Approved Drawings for projects within the city limits and within the ETJ will be assigned a City drawing number and will be filed by the City prior to release back to the Engineer of Record. Record files for facilities within public rights-of-way will be available to the public. Record files associated with plants, buildings and other facilities outside public rights-of-way will be restricted pended security constraints.

SECTION 3 - TREE PROTECTION

1.3.01 TREE PROTECTION

1.3.01.A Tree Protection Requirements

1. Tree protection requirements are designed to protect Trees during any construction activity within the Drip Line circle area of any Protected Tree that is not to be removed. Construction includes, but is not limited to, the following:

    a. Construction or repair of buildings or other structures;

    b. Installation or repair of utilities;

    c. Installation or repair of streets or sidewalks.

2. Tree protection must comply with the following requirements as applicable:

    a. City of Houston Code of Ordinances, Chapter 33, Article V “Trees, Shrubs, and Screening Fences.” and Article VI “Protection of Certain Trees.”

    b. Trees to be preserved must be clearly tagged in the field with ribbon.

    c. Protection barrier shall be composed of wood, wire, snow fence and braces of similar non injurious material.

    d. Tree wells shall be made of a durable material and set a minimum of four feet from any Tree they are designed to protect.

    e. Retaining walls of a durable material, i.e., stone, or treated lumber, are to be constructed around each Tree immediately after the grade is lowered. A retaining wall must be at least four feet from the Tree it is designed to preserve.

    f. Any under story clearing within six feet of existing Tree trunks shall be done by hand.

    g. No building materials are to be stacked or stockpiled within the Drip Line or within six feet of any Tree to be preserved, whichever is greater.

    h. Topsoil shall not be stockpiled within the Drip Line or within six feet of any Tree to be preserved, whichever is greater.

1.3.01.A.2 continued

i. Selective thinning of dead or dying vegetation, Tree stumps and other undesired growth is required in buffer areas. Supplemental vegetation shall comply with the landscape buffer requirements.

j. Tree boarding shall be used if work is required within construction fencing.

k. Where possible, utility lines shall be tunneled beneath Tree roots in order to protect feeder roots, rather than trenched or open cut.

3. Tree Root Barriers

a. Tree root barriers will be used for planting of new Trees, to prevent the uncontrollable spread of Tree roots, following root pruning, to protect land and hardscapes from root damage.

b. Tree root barriers can be designed and configured to surround the Tree or for linear application.

c. Tree root barrier configuration depends on the hardscape to be protected, distance from surrounding Trees, aggressiveness of the Tree, and rooting depth of the Tree(s).

4. Holes for the Tree shall be excavated two feet greater in width than the diameter of the soil ball.

5. The size of root barriers shall be three times the diameter of the root ball.

END OF CHAPTER

City of Houston

Design Manual

Chapter 2

SURVEY REQUIREMENTS

Chapter 2
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Survey Requirements

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Chapter 2

SURVEY REQUIREMENTS

SECTION 1 - SURVEY OVERVIEW

2.1.01 CHAPTER INCLUDES

2.1.01.A Guidelines for use by surveyors and engineers in development of construction drawings and Right-of-Way maps inside the Houston city limits and outside the Houston city limits within the Extraterritorial Jurisdiction (ETJ). These guidelines are required for capital improvement projects designed under professional services contracts with the City of Houston, projects involving underground work greater than or equal to three (3) feet in depth and any other project in which the City requests a survey. Driveway projects do not require a survey.

2.1.02 REFERENCES

2.1.02.A Latest revision of the following City of Houston Code of Ordinances:

1. Article IV, Chapter 33, City Surveys
2. Article I, Chapter 42, Subdivisions, Developments & Platting

2.1.02.B Texas Board of Professional Engineers and Land Surveyors (TBPELS) Practice Acts and Rules Concerning Practice and Licensure

1. Texas Statute, Occupations Code, Title 6, Subtitle A, Chapter 1001 Texas Board of Professional Engineers and Land Surveyor
2. Texas Statute, Occupations Code, Title 6, Subtitle C, Chapter 1071 Land Surveyors
3. Texas Administrative Code, Title 22, Part 6, Texas Board of Professional Engineers and Land Surveyors

2.1.02.C Texas Society of Professional Surveyors (TSPS) Manual of Practice for Land Surveying in Texas, latest edition

2.1.02.D Texas Local Government Code, Title 2, Subtitle C, Chapter 42 Extraterritorial Jurisdiction of Municipalities

2.1.02.E Houston Public Works website

2.1.03 DEFINITIONS

2.1.03.A Central Business District (CBD) – The area of downtown Houston as defined in the City of Houston Code of Ordinances, Chapter 42 - Subdivisions, Developments & Platting, Article I, Sec. 42-1.

2.1.03.B Chief Surveyor - An authorized representative of the City having approval authority for privately-funded projects or having authority for administration of contracts for the City.

2.1.03.C Closure - A mathematical application whereby a determination is made as to the exactness that a geometrical form is generated or attained within its confined elements of connecting lines and points. It is a computation method used by a land surveyor to test the quality of field survey measurements and to apply corrections in balancing or adjusting the survey to meet precision specifications.

2.1.03.D Computer Aided Design (CAD) - Preparation of drawings, plans, prints, and other related documents through the use of computer equipment and software programs.

2.1.03.E Control Point - A point used as a reference for surveying in which horizontal and vertical location/position is known.

2.1.03.F Extraterritorial Jurisdiction (ETJ) - Extraterritorial Jurisdiction shall mean the unincorporated territory extending beyond the corporate boundaries of the City established pursuant to Chapter 42 of the Texas Local Government Code, as may be amended from time to time.

2.1.03.G Engineer of Record - A professional engineer who seals drawings, reports or documents for a project.

2.1.03.H Global Navigation Satellite System (GNSS) - A satellite based positioning system. When it is used with proper observation procedures and equipment, it can provide survey quality locations in terrestrial space.

2.1.03.I GPS - A U.S. owned utility that provides users with positioning, navigation, and timing (PNT) services.

2.1.03.J Official Coordinate System - As defined in Chapter 33, Code of Ordinances for the City of Houston.

2.1.03.K Raw Data File – Computer files generated by all types of field equipment in their original, unprocessed state.

2.1.03.L Registered Professional Land Surveyor (RPLS) - A surveyor currently registered and in good standing with State of Texas Board of Professional Engineers and Land Surveyors (TBPELS).

2.1.03.M Right-of-Way - In this chapter, Right-of-Way refers to any real estate that the City currently has an interest in or will be acquiring an interest in.

2.1.03.N Site Control Monuments - Horizontal and vertical monuments needed to augment existing City monuments, conforming to standards established by the Chief Surveyor.

2.1.03.O Street Reference Monuments - Historic monuments used to re-establish existing City street Right-of-Ways.

2.1.03.P Survey Field Books - Bound standard engineer's field books for transit and level, 7-1/4 inch by 4-3/4 inch.

2.1.03.Q Temporary Benchmark (TBM) - A semi permanent man-made object, bearing a marked point, whose elevation above or below an adopted datum is known.

SECTION 2 - SURVEY DESIGN REQUIREMENTS

2.2.01 DESIGN REQUIREMENTS

2.2.01.A Adhere to these guidelines for capital improvement projects designed under professional services contracts with the City of Houston, projects involving underground work greater than or equal to three (3) feet in depth and any other project in which the City requests a survey. Driveway projects do not require a survey.

2.2.01.B When establishing horizontal control, surveyors shall transcribe onto the pages of a standard Survey Field Book, as described in Article 2.1.03.P, all angles and distances, at the time of measurement, with an accompanying recovery sketch. When establishing vertical control, the surveyor shall use differential leveling, and transcribe the vertical data onto the pages of a standard Survey Field Book, with an accompanying recovery sketch. When establishing control using GNSS/GPS methods, record the date, time, and length of each observation. TBMs should be set where they are not likely to be destroyed during construction.

2.2.01.C For projects in which the horizontal control exceeds a distance of 2,000 feet from a found City of Houston monument, a Site Control Monument shall be set. Additional Site Control Monuments shall be set should the horizontal control exceed a radial distance of 2,000 feet from an existing City of Houston monument or newly set Site Control Monument. Obtain City monument designation numbers from the City Survey Office. If an existing Site Control Monument is used to reference the project, said Site Control Monument must be re-observed and re-submitted with the resultant horizontal and vertical coordinates. All recovery ties must be re-observed and present on the new recovery sheets.

2.2.01.D Field Work.

1. For engineering contracts with the City, field work shall be recorded in field books or electronic field books. Obtain a Survey Field Book number from the Survey Section and record this identification in the title block on drawing sheets.

2. The traverse line and design baseline must be monumented at its beginning, end, street intersections and at angle points with markers of a permanent nature, such as iron rods, spikes, or other lasting identification. Make reference drawings for each control monument showing ties to planimetric features to allow easy recovery. Set markers at a maximum of 1000 feet on long lines. (Wherever practical, all horizontal and vertical control monuments must be marked in such a way as to identify the surveyor in responsible charge.)

2.2.01.D continued

3. Locate any found monuments and/or property corners and reference them to the design baseline according to the existing City of Houston survey system, as required by Article IV, Chapter 33, City Surveys, of the Code of Ordinances.

4. Use the City datum (Code of Ordinances, Article IV, Chapter 33) as a basis for all elevations. Set TBMs within 200 feet of the beginning and end of each project baseline and at intervals not to exceed 1000 feet throughout the project.

5. Show the stations of all side street construction centerlines with angular relationships or bearings of said centerlines of side streets with the main roadway centerline station.

6. Record topographic information and improvements within the existing public Right-of-Way, proposed Right-of-Way, any contiguous easements to the Right-of-Way, and any area within the construction project.

7. Always collect topographic information and improvements a distance of 20 feet beyond the existing Right-of-Way and 25 feet beyond the proposed Right-of-Way, where accessible.

8. Record topographic information and improvements on intersecting streets for a distance of 100 feet beyond proposed pavement. Identify all visible underground structures, such as inlets, manholes, and junction boxes, with size, depth, and type. See Figure 2.1 Perimeter of Standard Topographical Survey.

9. Cross sections shall be taken at intervals of 100 feet for projects outside of the CBD. For projects within the CBD, take cross sections at 25 or 50 foot intervals. For levels recorded in field books, record rod readings or elevations as + or - and distance right or left of the design baseline or roadway centerline. Data collector of a total station can be used to acquire necessary elevations at required intervals. Record elevation of driveways at intersection of driveway centerline with existing or proposed Right-of-Way line. Cross sections shall include a reading at the following points: street centerline and/or crown of the street, flow-line of ditch or gutter, curb or pavement edge, sidewalk, the existing or proposed Right-of-Way line, 20 feet beyond the Right-of-Way line if possible. See Figure 2.1 Perimeter of Standard Topographical Survey.

10. For acquisition of new or additional Right-of-Ways:

    a. Tie all points of beginnings (POB) for each parcel and points of commencing (POC) to the Official Coordinate System as defined in Chapter 33, Code of Ordinances for the City of Houston.

2.2.01.D.10 continued

b. Set iron rods or permanent markers at the intersections of the proposed Right-of-Way and property lines of parcels to be acquired.

c. Identify monuments, corners, angle points, points of curve (PCs), points of intersection (PIs), points of tangency (PTs), and other points as either "found" or "set." Describe each monument in such a way as to clearly define size, type of material and the nature of the monument, i.e., 3/4-inch iron pipe, 5/8-inch iron rod, cotton spindle, mag nail, etc.

d. Locate visible improvements, buildings, fences, permanent signs, utilities and other structures within 25 feet of the proposed Right-of-Way line.

2.2.01.E Calculations.

1. Calculate coordinates of proposed Right-of-Way parcels, Control Points, found or set monuments, curve data, lengths, stations and offsets to monuments, and proposed improvement features.

2. Electronic ASCII files of the coordinate calculations shall be submitted to the City with Survey Field Books and Raw Data Files.

2.2.01.F Construction Drawings.

1. All found monuments (property corners, Street Reference Monuments, benchmarks etc.) must be plainly shown on the drawings and located by station and distance, right or left from the traverse line, or design baseline. Monuments used to establish the design line or traverse must be identified as Control Points, and their relationship to the design baseline and to the proposed Right-of-Way lines must be shown. If the project is dimensioned from a traverse line, which is different than the design baseline, it must be established and monumented in accordance with the requirements of Article 2.2.01.D. Coordinates for traverse Control Points and all points of curve, points of tangency, and points of intersection along the design baseline shall be shown.

2. Show location and identification of existing Site Control Monuments and found Street Reference Monuments, by station and distance and whether right or left of traverse line or design baseline. Show swing ties for all Control Points and Street Reference Monuments using the City of Houston recovery sheet format.

3. Show and identify location of the City datum monuments and TBMs used for elevation control. List the TBM located closest to that particular sheet in a station/offset, description and elevation format.

2.2.01.F continued

4. Show centerline angles of intersection of side streets with main roadway centerline. Where bearings are used, identify source of bearings and show bearings on both control line and project centerline when they are not the same line.

5. For bridges, overpasses and underpasses show top of pavement elevations at gutter line and centerline for the following locations:

   a. Construction joints

   b. Armor or expansion joints

   c. Intervals between bents that correspond to the increments used for dead load deflection calculations.

6. For bridges and grade separations, drawings must incorporate layout sheets which identify proposed centerline and curve information plus:

   a. Surface coordinates for Control Points so that an inverse between coordinates reflects a surface distance. Identify origin of coordinate system used.

   b. Show coordinates of design baseline at PIs.

   c. Show coordinates of curb lines at their intersection with the centerline of bents and abutments for irregular structures.

7. For all horizontal and vertical control monuments, show coordinates on the Official Coordinate System as defined in Chapter 33, Code of Ordinances for the City of Houston. Proper metadata for GPS - derived points should include the vertical adjustment, the Geoid used, and the current published coordinates of the base stations at the time of calculation.

2.2.02 SUBMITTALS

2.2.02.A Computer Aided Design (CAD) file format shall be submitted in accordance with Chapter 3 requirements.

2.2.02.B Examples, templates and checklists can be found on the survey section website located here, https://www.publicworks.houstontx.gov/survey-section.

2.2.02.C For work performed through a professional service contract with the City, deliver:

1. Original Survey Field Books, signed & sealed by a Registered Professional Land Surveyor (RPLS). Electronic submittals of Survey

2.2.02.C.1 continued

Field Books are acceptable if they are legible, in color, and comply with 22 Tex. Admin. Code §138.35 (2021) and any amendments or recodifications to that statute thereafter.

2. An electronic text file in standard ASCII format (Point Number, Northing, Easting, Elevation, Description) containing all points collected, calculated and set for the project.

3. The CAD file submitted by the project surveyor to the Chief Surveyor shall be the same file that is provided to the Engineer of Record.

4. All Raw Data Files (conventional and GPS/GNSS) as defined in this chapter.

2.2.02.D For projects identifying or describing acquisition of new or additional Right-of-Ways, additional documents to be submitted are:

1. Drawings:

   a. Overall index map identifying all Right-of-Way parcels for the project.

   b. Individual survey drawings of each parcel,

   c. All maps and drawings shall be signed and sealed by an RPLS. Electronic submittals of maps and drawings are acceptable if they are legible, and comply with 22 Tex. Admin. Code §138.35 (2021) and any amendments or recodifications to that statute thereafter.

2. Metes & bounds descriptions (signed and sealed) and Closure report printouts for each parcel.

3. Abstract information, all recorded plats and copies of instruments used (i.e., deeds) in preparation of the Right-of-Way drawings.

4. The CAD file generated for parcels shall utilize the parcel title block template found on the Survey Section website.

2.2.02.E For projects requiring new Site Control Monuments, the surveyor responsible for setting the monuments shall submit sealed City of Houston monument sheets, with necessary supporting data, to the City Survey Section.

2.2.02.F All submittals will be retained in the City's permanent files.

2.2.03 QUALITY ASSURANCE

2.2.03.A Field surveying used in the development of construction drawings, calculations and preparation of metes & bounds descriptions and Right-of-Way maps, shall be performed by or under the direct supervision of an RPLS.

2.2.03.B Survey Field Books, metes & bounds descriptions and Right-of-Way maps shall have the imprinted or embossed seal of the responsible RPLS and shall be dated and signed by the RPLS.

2.2.04 RIGHT-OF-WAY MAPS

2.2.04.A Show "x," "y" values on monuments based on the City survey control and the scale factor used to convert grid coordinates to "surface" coordinates. All distances shall be shown as "surface" distances and plainly marked as such. All bearings shall be based on the Official Coordinate System.

2.2.04.B Distances on proposed Right-of-Way lines shall be continuous from beginning to end of the job. Show either straight line or arc distance across intersecting streets.

2.2.04.C Where a parcel is taken from a larger tract, show dimensions, distances, and area of the remainder of the tract based on recorded information.

2.2.04.D Identify the evidence used to decide the final placement or establishment of the proposed Right-of-Way line, such as angle points, or corner monuments, as either "set" or "found." The description of each point used shall be shown on the drawing as identified in the field survey.

2.2.04.E Curve data must include the following: delta, radius, arc length, chord length, and chord bearing.

2.2.04.F Grid coordinate values of "x," "y" must be given on the POB of each parcel. Show coordinates on map and metes and bounds with the scale factor.

2.2.04.G Other information to be shown on Right-of-Way maps:

1. All visible improvements such as buildings, fences, permanent signs, utilities, and other structures located on the property or within 25 feet outside the proposed Right-of-Way line, if accessible.

2.2.04.G continued

2. Abstract information used in preparation of the Right-of-Way map.

3. Survey Field Book numbers obtained from the Chief Surveyor.

4. Right-of-Way parcel numbers obtained from Real Estate Services.

END OF CHAPTER

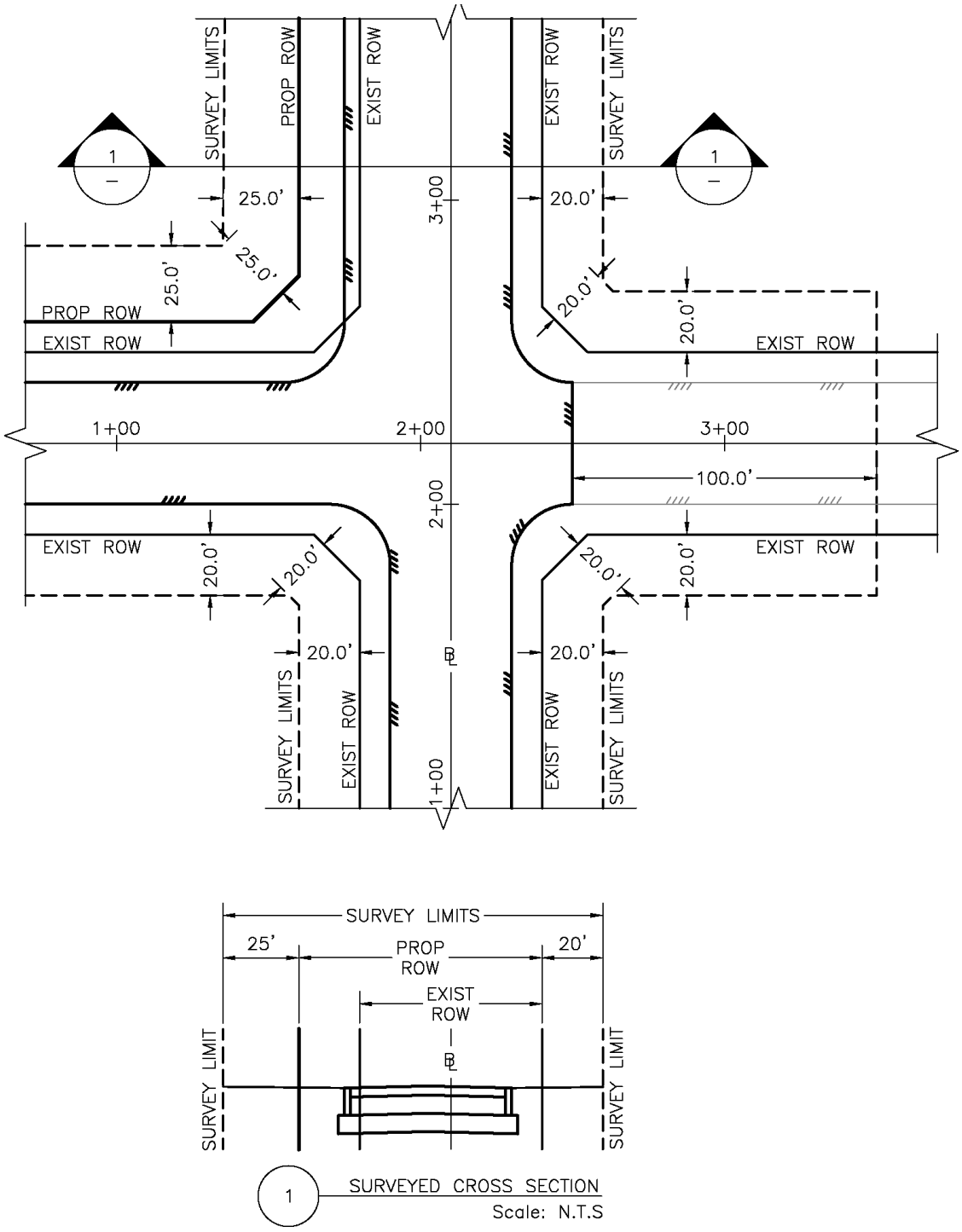


Figure 2.1 – PERIMETER OF STANDARD TOPOGRAPHICAL SURVEY

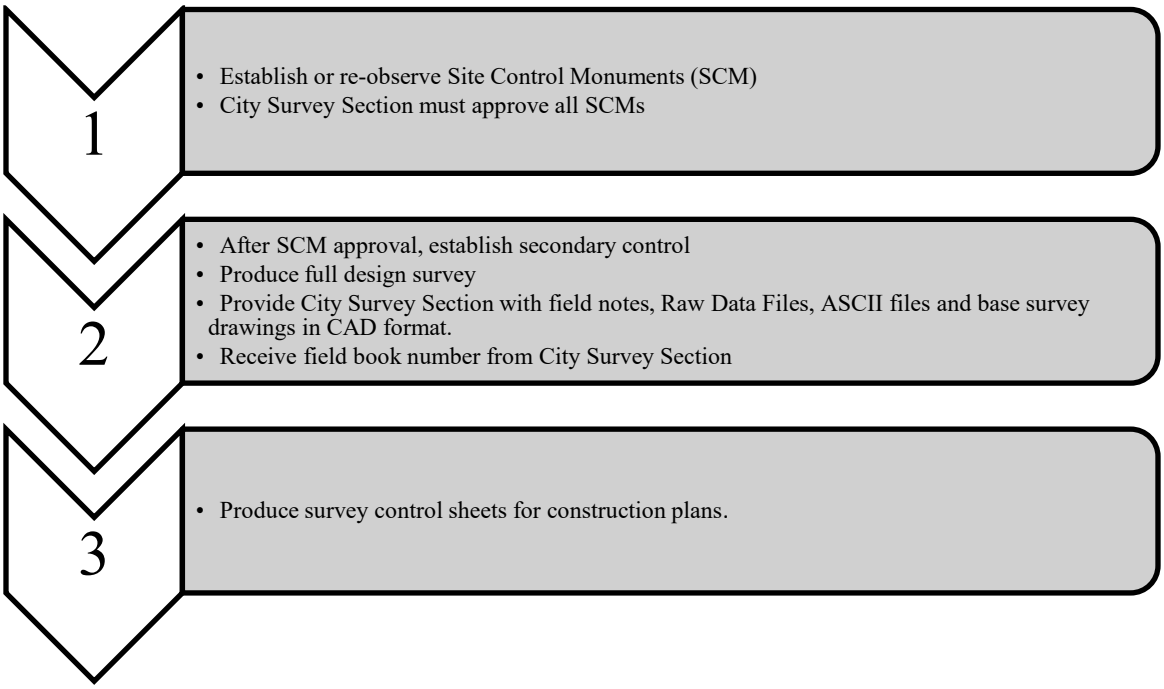


Figure 2.2 – GENERAL PROCESS FOR DESIGN CONTRACTS

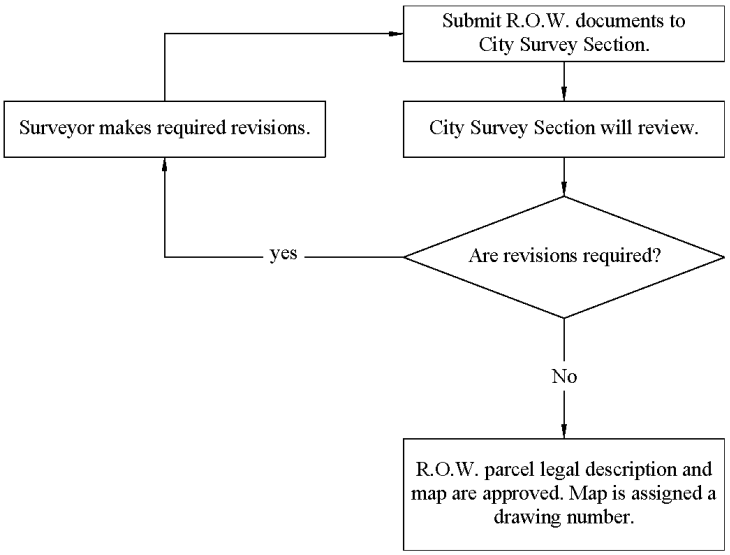


Figure 2.3 – GENERAL PROCESS FOR R.O.W. PARCEL REVIEWS

END OF CHAPTER

APPENDIX A - DESIGN FIGURES

1.01 SITE CONTROL MONUMENT INSTALLATION REQUIREMENTS FOR VARIOUS CONDITIONS (CITY OF HOUSTON)

Site Control Monuments are intended to serve as the primary control for capital improvement projects. They should be established in a location and manner to ensure stability and longevity.

The two options presented in Appendix A are the minimum requirements for installation of Site Control Monuments and will be appropriate for most conditions. Any deviation from these minimum requirements must be approved by the Chief Surveyor.

THE REQUIREMENTS IN THIS APPENDIX ARE HEREBY APPROVED AS MINIMUM REQUIREMENTS FOR SURVEY SITE CONTROL MONUMENTS.

JULY 2022

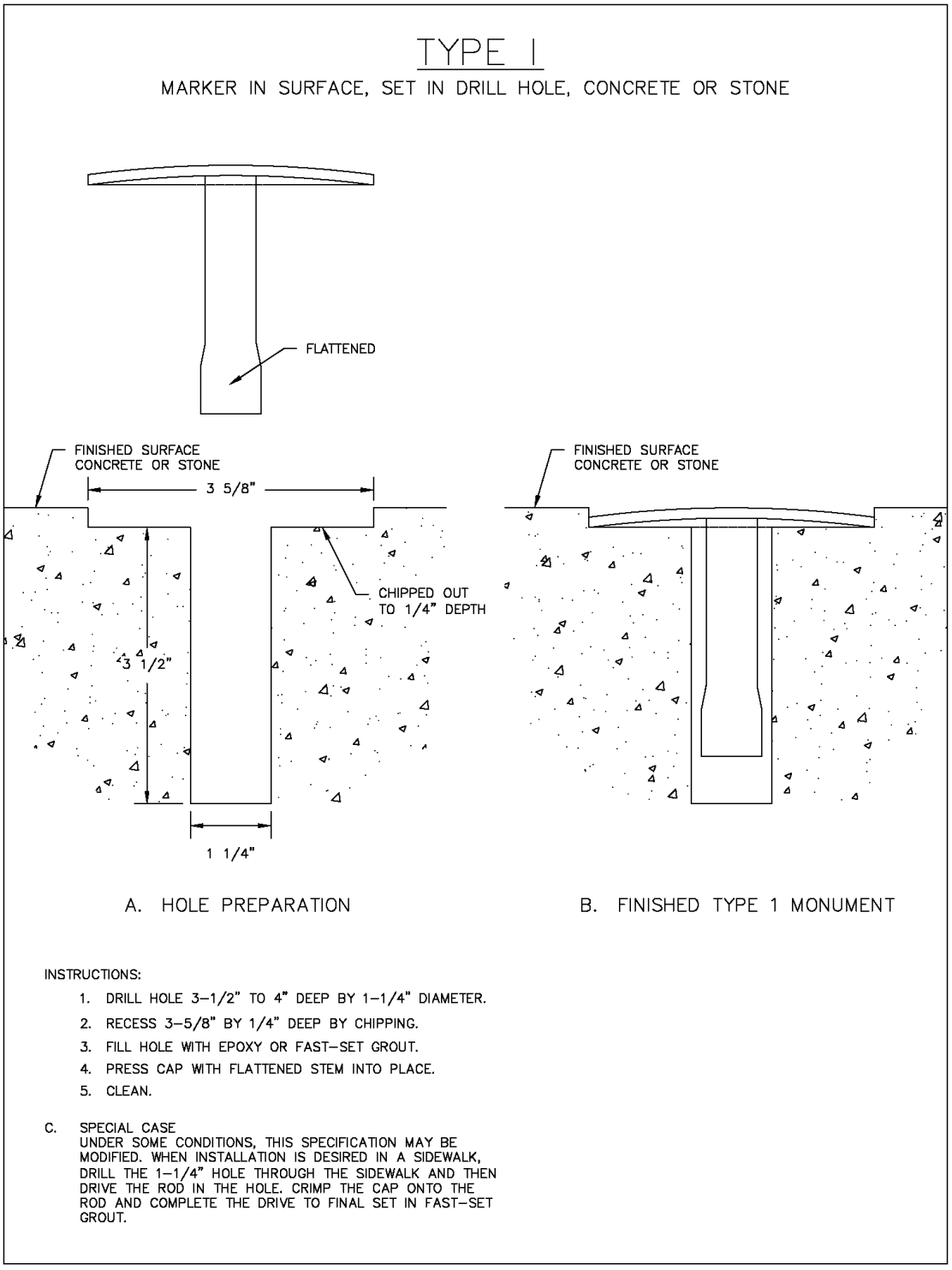


Figure A. 1 – TYPE I, MARKER IN SURFACE, SET IN DRILL HOLE CONCRETE OR STONE

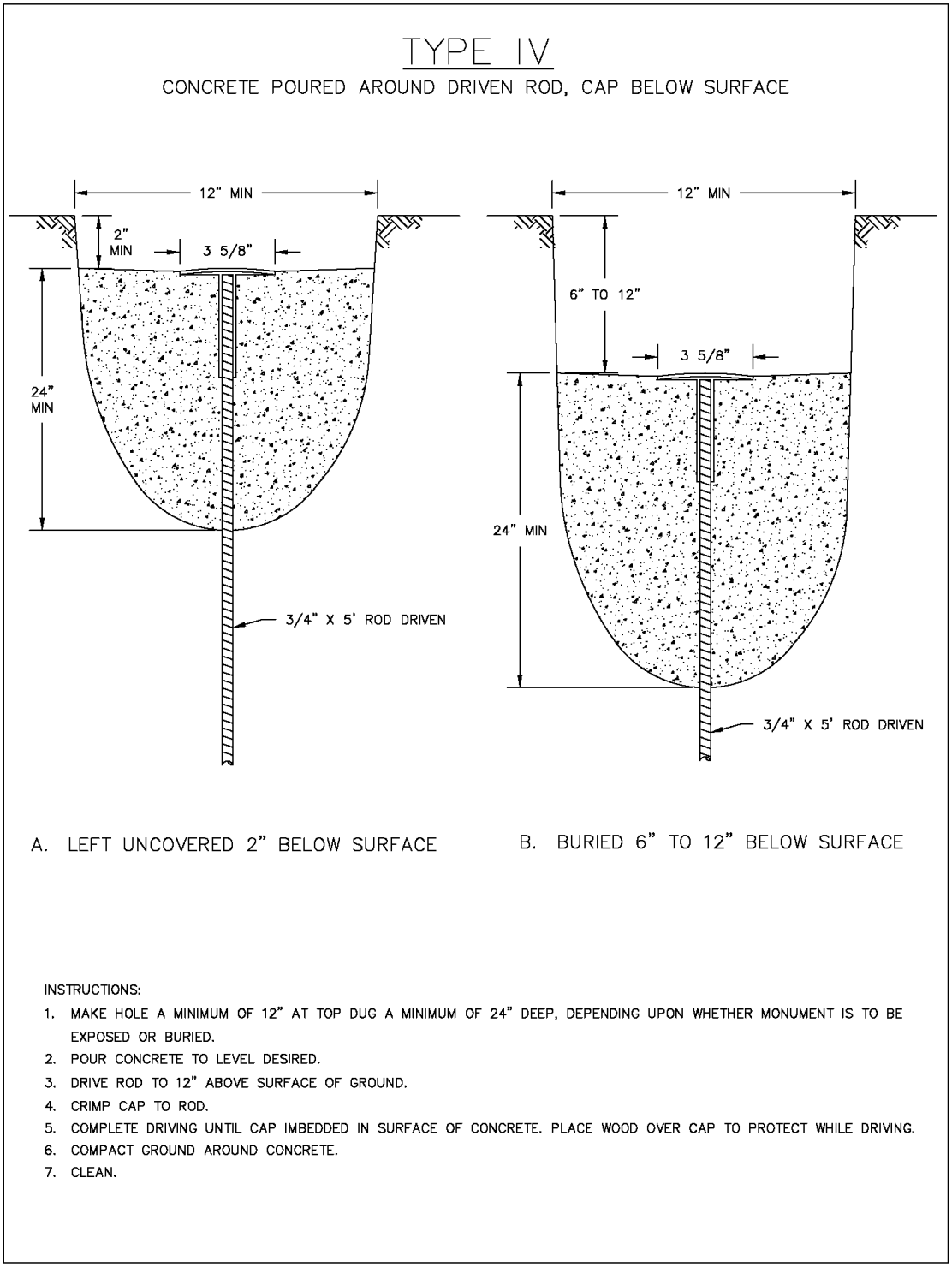


Figure A. 2 – TYPE IV, CONCRETE POURED AROUND DRIVEN ROD, CAP BELOW SURFACE

END OF APPENDIX A

City of Houston

Design Manual

Chapter 3

GRAPHIC REQUIREMENTS

Chapter 3
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Chapter 3

GRAPHIC REQUIREMENTS

SECTION 1 - OVERVIEW

3.1.01 CHAPTER INCLUDES

3.1.01.A Graphic requirements are provided for a consistent uniform appearance for engineering drawings. It is not the intent of this manual to be a training guide for AutoCAD, ArcGIS or other software products.

3.1.01.B This chapter is to be used for all new projects. For projects already underway, coordinate with the City Project Manager to assess the appropriateness of implementation. It is not the intent of this update to cause existing projects to incur additional time or cost, and measure should be taken to avoid such.

3.1.02 REFERENCES

3.1.02.A City of Houston, Code of Ordinances, Chapter 33, Article IV - City Surveys.

3.1.02.B City of Houston, Standard Details, current edition.

3.1.02.C City of Houston, Standard Specifications, current edition.

3.1.02.D National Institute of Building Sciences, U.S. National CAD Standard (NCS).

3.1.02.E Texas Board of Professional Engineers and Land Surveyors (TBPELS), Practice Acts and Rules Concerning Practice and Licensure.

3.1.03 DEFINITIONS

3.1.03.A AutoCAD - CAD software platform for two and three-dimensional design and drafting. The file format of AutoCAD is DWG. AutoCAD has included file format support for DXF and DWF.

3.1.03.B ArcGIS – Provides an infrastructure for making maps and geographic information.

3.1.03.C City Project Manager - An authorized representative of the City of Houston who manages the project.

3.1.03.D Computer Aided Design (CAD) - Preparation of Drawings, plans, prints, and other related documents through the use of computer equipment and software programs.

3.1.03.E Control Point – A point used as a reference for surveying in which horizontal and vertical location/position is known.

3.1.03.F Drawings - Plan, profile, detail, and other graphic sheets to be used in a construction contract which define character and scope of the project.

3.1.03.G Engineer of Record - A Professional Engineer who seals Drawings, reports, and documents for a project.

3.1.03.H Geographic Information System (GIS) – A system designed to capture, store, manipulate, analyze, manage, and present geographic data.

3.1.03.I Layout Space - Commonly known as "Paper Space", is the area designated for producing printed deliverables.

3.1.03.J Model Space – A limitless 3-D drawing area that is the default in AutoCAD software used for the beginning of a design.

3.1.03.K Professional Engineer - An engineer currently licensed and in good standing with the Texas Board of Professional Engineers and Land Surveyors (TBPELS).

3.1.03.L Registered Professional Land Surveyor (RPLS) - A surveyor currently registered and in good standing with the Texas Board of Professional Engineers and Land Surveyors (TBPELS).

3.1.03.M Right-of-Way - Any real estate that the City currently has an interest in or will be acquiring an interest in.

3.1.03.N Special Structures – Structures not covered by approved standard details, such as stream or gully crossings, special manholes, and junction boxes.

3.1.03.O Temporary Benchmark - A semi-permanent man-made object, bearing a marked point, whose elevation above or below an adopted datum is known.

3.1.03.P U.S. National CAD Standard (NCS) – Standards created to encourage a more rational construction regulatory environment. The U.S. National CAD Standard is published by the National Institute of Building Sciences. https://www.nationalcadstandard.org/ncs6/

3.1.04 SOFTWARE AND DATA FORMAT

3.1.04.A All CAD files, both references and sheet file deliverables, shall be provided in .DWG file extension format compatible with the most recent version of AutoCAD. However, the use of other software with the ability to convert files into the proper .DWG format, will also be acceptable.

3.1.04.B Electronic .PDF drawings submitted to the City of Houston are to be devoid of AutoCAD SHX comments or .PDF comments automatically generated during the .PDF conversion process, and shall have a minimum of 400 dpi resolution. Annotations and form fields are to be flattened prior to submittal.

3.1.05 IMPORTING STANDARD DETAILS

3.1.05.A Standard details shall be imported onto the sheet files when applicable. City standard details shall not be cropped and must be included in the Drawings as the City provides them. The standard detail's entire border and title block must remain visible. For visibility each sheet shall only have up to:

1. Six 8 ½" x 11" standard details oriented portrait.
2. Four 8 ½" x 11" standard details oriented landscape.
3. Two 11"x17" standard details oriented landscape.
4. One 22"x34" standard detail oriented landscape.

3.1.05.B The current standard details can be found here: https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.1.06 MODIFICATIONS TO STANDARD DETAILS

3.1.06.A Modifications to standard details are allowed. Any modifications to a City standard detail during the project's design phase, however minor, must follow the requirements in 3.1.06.B.

3.1.06.B Modification Process:

1. CAD files to be used for creating modified standard details are posted online. These CAD files have been modified to remove the City Engineer and Houston Public Works Director's signature. City signatures will not be allowed on modified standard details.
2. All changes in each sheet that are pertinent to each modification shall be enclosed in revision "clouds".
3. The letter of the modification, beginning with "A", shall be placed inside of a triangle, commonly known as a "delta". The letter is meant to indicate the engineer who modified the standard detail. If multiple engineers modify details on the same sheet, they shall use different revision letters. Letters shall only be used for modifications to standard details during the design phase. For modifications during the construction phase follow SECTION 5 of this chapter.
4. Each modification delta shall be placed adjacent to the corresponding modification cloud(s) and next to the corresponding engineer's seal. Modification deltas and clouds shall not be removed from the sheet at any time.

3.1.06.B continued

5. It is acceptable to have multiple clouds with the same modification delta on a sheet if all changes are approved by the same Engineer of Record.

6. The designation "MOD" must be appended to the standard detail title, the sheet title (if different than standard detail title) and must be reflected in the sheet index.

7. Each modification must be documented on the title block area of each sheet.

8. All modification information must be filled out, including the letter of the modification, date, a brief description that explains each item changed, and approver.

SECTION 2 - GENERAL SHEET CONTENT

3.2.01 GENERAL SHEET CONTENT

3.2.01.A Plan sets for typical projects shall be produced to scale on 22” x 34”, ANSI D sheet sizes.

3.2.01.B Final Drawings Submittal.

1. Physical Drawings shall be India ink on mylar or produced by CAD on mylar using non-water based ink. Do not use adhesive-backed material on final Drawings.

2. Electronic Drawings must be submitted according to SECTION 4 of this chapter.

3.2.01.C The seal, date, and original signature of the Professional Engineer responsible for the Drawings is required on each sheet developed by the design engineer. The design engineer may use stamped seal or embossed imprint; however, the embossed imprint must be shaded so that it will reproduce on prints. Use of an electronic seal for plan submittal needs to be in accordance with the Texas Board of Professional Engineers and Land Surveyors (TBPELS) Practice Act and Rules Concerning Practice and Licensure. Survey control sheets require seal and signature of Registered Professional Land Surveyor (RPLS).

3.2.01.D Applicable City standards shall be included in the engineering plan set.

3.2.01.E Develop Drawings to accurate scale showing proposed pavement, typical cross sections, details, lines and grades, existing topography within street Right-of-Way, and any easement contiguous with the Right-of-Way. At the intersection, the cross-street details shall be shown at sufficient distance (20-foot minimum distance outside the existing roadway Right-of-Way or 25-foot minimum distance outside the proposed roadway Right-of-Way, of which the wider Right-of-Way shall govern) in each direction along cross street for designing adequate street crossings.

3.2.01.F If a roadway exists where Drawings are being prepared to improve or construct new pavement or a utility, label the existing roadway width, surfacing type, and thickness.

3.2.01.G Show all street and road alignments on Drawings refer to Chapter 2, Section 2.2.01.F, Construction Drawings.

3.2.01.H Existing utilities shall be plotted in color according to Article 3.3.03 - LINE WEIGHTS.

3.2.01.I On the cover sheet, the major utilities and overall scope of work proposed in the plan and profile drawings shall be listed as part of the project title.

3.2.02 DRAWING FILE ASSEMBLY

3.2.02.A To ensure consistency, the same drawing file assembly convention must be followed. This section describes the use of reference files, sheet files, Model and Layout Space.

1. Reference Files.

    a. Contain the subset of design elements and geometric components, with all content drawn and placed in Model Space. All reference files are to be drawn full scale 1’ = 1’ with pertinent annotation, text, and dimensions.

2. Sheet Files.

    a. Reference file attachments shall be included in Model Space except for the title block. The title block shall be attached in Layout Space.

3. Model Space.

    a. Annotation, text, and dimensions that are directly related to the elements in the reference files shall be placed in Model Space. Reference files are to be attached in Model Space.

4. Layout Space.

    a. Typical sheet items include north arrow, bar scales, match lines, benchmarks, revision clouds and deltas, sheet and project text, title block information, specific notes, profile street names, profile stationing, and any other annotation unique to each sheet.

3.2.03 DRAWING SCALE

3.2.03.A Draw key overall layouts to a minimum scale of 1" = 200'.

3.2.03.B Standard scales for plan and profile sheets are required on construction Drawings are as follows:

1. Major thoroughfares, streets with esplanades over 400 feet in length, or special intersections/situations.

    a. 1" = 20' Horizontal, 1" = 2' Vertical

2. Minimum standard scales for minor or residential single-family streets.

    a. 1" = 20' Horizontal, 1" = 2' Vertical

    b. 1" = 40' Horizontal, 1" = 4' Vertical

3.2.03.B.2 continued

c. 1" = 50' Horizontal, 1" = 5' Vertical

3. Larger scales may be used to show details of construction.

4. Single-banked plan and profile sheets are acceptable; double-banked plan and profile sheets are allowed such as off-site utility lines in undeveloped areas.

5. Details of Special Structures shall be drawn with vertical and horizontal scales equal to each other.

3.2.04 TITLE BLOCK

3.2.04.A Use latest edition of the title block issued by Capital Projects for private and City projects.

3.2.05 NORTH ARROW

3.2.05.A The approved City north arrow is on the symbols sheet found here: https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.2.05.B A north arrow is required on all sheets and should be oriented either toward the top or to the right.

3.2.05.C The requirement in 3.2.05.B is waived under the following conditions:

1. A storm water sewer, sanitary sewer, or large diameter water line with flow from east to west or from north to south.

2. A primary outfall drainage ditch with flow from east to west or from north to south.

3. Stationing is intended to start from the cardinal points of the compass and proceed in the direction of construction.

4. The north arrow can be down or to the left on a loop street.

3.2.06 GENERAL NOTES

3.2.06.A Privately Funded Projects.

1. General notes for privately funded projects can be found in the “CAD Tools and Templates” section located here: https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

2. These notes are not intended to be used on City funded projects.

3.2.06.B City Funded Projects.

1. General notes for City funded projects can be found in the "Capital Projects" section located here: https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

2. These notes shall only include third party notes. Any direction given to a contractor shall be handled through the use of construction specification to be accompanied by a unit price item if appropriate.

3.2.07 STATIONING

3.2.07.A Plan stationing must run from left to right, except for short streets or lines originating from a major intersection, where the full length can be shown on one sheet. Tic symbols shall be used to mark stations.

3.2.07.B Never commence stationing at 0+00. Acceptable start stations are 1+00 or 10+00.

3.2.07.C Every even X+00 station shall be annotated with station text and a tic mark.

3.2.07.D Every X+50 station shall only contain a tic mark.

3.2.08 MATCH LINES

3.2.08.A Match lines shall be located at each end of plan view, perpendicular to the design centerline and shall be labeled as to station, and matching sheet number.

3.2.08.B Match lines between plan and profile sheets shall not be placed or shown within cross street intersections including cross street Right-of-Way.

3.2.09 SURVEY REQUIREMENTS

3.2.09.A Show times on survey control or swing tie Drawings to City monuments, Control Points and Temporary Benchmarks. All construction Drawings shall be prepared in accordance with Chapter 2, Section 2.2.01.F, Construction Drawings.

3.2.09.B Monument ties must comply with the City of Houston Code of Ordinances Chapter 33, Article IV – City Surveys.

3.2.10 PLAN AND PROFILE

3.2.10.A Basic plan and profile sheets shall contain the following information:

3.2.10.A continued

1. Identify and label all existing and proposed lines in plan and profile view regardless of line type, including lot lines, property lines, plat record numbers, easements, Rights-of-Way, and Harris County Flood Control District outfalls.

2. Label each plan sheet as to street/easement widths, pavement widths, pavement thickness where applicable, type of roadway materials, curbs, intersection radii, curve data, stationing, existing utilities (type and location), and any other pertinent feature affecting design.

3. Easement labels must clearly identify the type of easement (i.e., dedicated water, dedicated wastewater, combined storm and wastewater easement, etc.). Label will identify the private utility easement owner if the information is obtainable.

4. Show utility lines 4 inches in diameter or larger within the Right-of-Way or construction easement in profile view. Show utility lines, regardless of size, in the plan view, including communication and fiber optic cables.

5. List on plans the typical aerial utility owners for power, telecommunication and other utility lines. List the name of the owner by location of the line on the pole, with the line closest to the top of the pole as the first listed, followed by the other aerial lines listed from highest to lowest.

6. Graphically show flow line elevations and direction of flow for existing ditches.

7. Label proposed top of curb grades except at railroad crossings. Centerline grades are acceptable only for paving without curb and gutters.

8. Show curb return elevations for turnouts in profile view.

9. Gutter elevations are required for vertical curves, where a railroad track is crossed.

10. For street reconstruction projects, show in profile the centerline elevation at the property line of existing driveways.

11. Show both existing and proposed station esplanade noses or the centerline of esplanade openings, including esplanade width.

12. The design of both roadways is required on paving sections with an esplanade.

13. Show in plan view station points of curvature (PCs), points of tangency (PTs), and radius returns. Show station radius returns and grade change points of inflection (PIs) with their respective elevations in profile view.

3.2.10.A continued

14. All existing and proposed utilities and pavement shall be on the same plan and profile sheet for a given section.

15. Plan view and profile view shall be on the same sheet as long as the entire proposed design within the scope of the project can be shown clearly and legibly (i.e., depth of all utilities can be graphically viewed).

16. Each plan and profile sheet shall have a benchmark elevation and description defined. Refer to Chapter 2 for further specification.

17. Show natural ground profiles as follows:

    a. For privately funded projects, centerline profiles are satisfactory except where a difference of 0.50 feet or more exists from one Right-of-Way or easement line to the other, in which case, dual profiles are required.

    b. For City funded projects, provide natural ground profiles for each Right-of-Way line. For projects with existing (and/or proposed) roadside ditches, provide ditch flowline in profile view. Also show and label all driveway culverts.

3.2.11 TELECOMMUNICATION REQUIREMENTS

3.2.11.A To ensure identification of utility conflicts, all utilities within the public Right-of-Way shall be shown on the Drawings when any on-ground or underground telecommunication facilities are proposed. For exceptions see article 3.2.11.B.

1. On-ground and underground telecommunication facilities include, but are not limited to, underground telecommunication lines, ground supported utility boxes, telecommunication facility support structures (e.g. utility poles, service poles, and cabinets) and foundations.

2. All utility lines located on both sides of the roadway must be shown regardless of the location of the proposed telecommunication line relative to the roadway.

3.2.11.B For projects where aerial telecommunication facilities are proposed exclusively on existing poles and are supported off-ground (e.g. utility boxes on existing poles, network nodes on existing poles):

1. It is not required to show existing underground utilities and their above grade features (e.g. fire hydrants, cabinets, etc.) on the plan view.

2. Profile view is not required.

3.2.11.C Aerial telecommunication lines, along with other aerial lines must be listed on Drawings according to 3.2.10.A. 5.

3.2.11.D Drawings must conform to additional labeling requirements as defined in other chapters of this manual. This includes, but is not limited to, Chapter 6 and Chapter 7 requirements.

3.2.12 BORE HOLE REQUIREMENTS

3.2.12.A See Chapter 11 for project types that require geotechnical bore hole information in the Drawings, boring spacing and depth requirements. A bore hole layout along with the corresponding bore hole logs is to be included as part of the Drawings.

3.2.12.B The bore hole layout sheets shall contain the following information:

1. Project bore holes at the correct location and providing: bore hole number, station, offset, northing and easting. Station and offset provided should be determined from the project's design base line.

2. Bore hole number or identifier matching the geotechnical report.

3. Topographic survey and surveyed benchmark.

4. Design baseline.

3.2.12.C The bore hole log sheets shall contain the following information:

1. Project bore logs, arranged on sheet from left to right, in order of ascending stationing with 6 bore hole logs per sheet. Bore logs should match the project geotechnical report.

SECTION 3 - LEADERS AND DIMENSIONS

3.3.01 LEADERS AND DIMENSIONS

3.3.01.A Leaders shall use straight leader lines and closed, filled arrows.

3.3.01.B The leader style shall attach the leader landing to the top of the multi-line text.

3.3.01.C Leader lines shall be placed as close as possible to the object being identified.

3.3.01.D Leader lines in the same area shall be parallel whenever possible.

3.3.01.E Leader lines shall be avoided that are: horizontal or vertical. At the same angle as cross-hatching, at very small angles to the terminating surface, parallel to extension or dimension lines, curved, or crossed.

Table 3.1 - DIMENSION SETTINGS[1]

Dimension Setting	Value for Proposed	Value for Existing
Associative Dimensions	2”	2”
Extension line beyond dimension line	0.05”	0.05”
Extension line offset from object	0.05”	0.05”
Arrow Size	0.10”	0.08”
Dimension Text Style	RomanS	RomanS
Dimension Text Height	0.10”	0.08”
Dimension Primary Units	2 (Decimal)	2 (Decimal)
Dimension Precision	0.00	0.00

Note:
1. Dimension settings can be used as a general guide.

3.3.02 LETTERING

3.3.02.A Standard text height is 0.10” for most drawing annotations. A minimum height of 0.05” is acceptable when used for special purposes such as for symbols or stacked fractions. The standard text style shall use the upper-case RomanS font. Table 3.2 can be used as a general text property guide.

1. Text shall be in designated Model Space.
2. Text shall be placed readable from the bottom or right side of the page.
3. Text shall be justified top left, top right, or middle center as best applicable for each case.
4. Text strings shall not overlap one another.

3.3.02.A continued

5. Where necessary, place text strings away from the features and use a leader.

Table 3.2 – TEXT PROPERTIES

Existing/Proposed	Text Style	Printed Height	Printed Width
Proposed text and dimensions	RomanS	0.10”	1.0
Existing text and dimensions	RomanS	0.08”	1.0
Major title block text	RomanS	0.30”	1.0
Survey spot elevations	RomanS	0.08”	1.0
Sheet numbers, detail titles, section or detail call outs, match line labels, table and location map sub-titles, and column headings	RomanS	0.20”	1.0
Stacked fractions, symbols, small detail annotation	RomanS	0.05”	1.0
Cover sheet title	COH CIP Cover	0.70”	1.0
Cover sheet sub-titles	COH CIP Cover	0.40”	1.0

3.3.03 LINE WEIGHTS

3.3.03.A The “COH.ctb” plot configuration file included with the City drawings specifies plotted line weights. No modifications are to be made to this file.

1. Colors 1-9 and 20 have been reserved for unscreened elements such as proposed objects, annotations, text and dimensions in the “COH.ctb” file. The basic colors and corresponding weights can be located in Table 3.3.

2. With exception to colors reserved for color plotting for existing utilities, colors 11-248 can be used as needed for the described typical use and each designated weight is represented by various colors within this color rage.

3. Colors 249-254 have been reserved for screening, ranging from 80-30%, in descending value in the “COH.ctb” file

4. Refer to “COH Std Line Weights.pdf” for a visual representation of available colors and corresponding line weights. See SECTION 7 of this chapter for description and weblink to design aids.

5. Table 3.3 is based on the U.S. National CAD Standard (NCS) – V6, 2.0 line width guide and corresponds with colors 1-10 in the “COH.ctb” file.

6. Existing utilities shall be plotted in color according to “COH Std Line Weights.pdf”.

3.3.03.B The line weights shown in Table 3.3 are shown as a general guide. Some objects will need to be shown in a different line weight for clarity.

3.3.03.B continued

Table 3.3 – LINE WEIGHTS

Colors[1]	Thickness	MM	IN.	Typical Use
1	Fine	0.18	0.007	Hatch patterns, sheet trim lines
2, 3, 4	Thin	0.25	0.010	Table and section grid lines, construction details
8	Thin	0.25	0.010	Existing object lines and text
7, 9	Medium	0.35	0.0138	Proposed medium object lines, proposed text, existing Right-of-Way
5	Wide	0.50	0.020	Sheet and title block borders, sheet dividers, major title text, match line text, outlines, location map outlines, section lines, proposed object lines requiring special emphasis, proposed design lines and elements
6	Extra Wide	0.70	0.028	Proposed Right-of-Way
20	XX Wide	1.20	0.048	Drainage areas

Notes:
1. Basic colors are shown. Other pen table colors may be used to satisfy these requirements.

3.3.04 LINE TYPE

3.3.04.A Use Standard line types shown in the "COH Line Type.pdf". See SECTION 7 of this chapter for description and weblink to design aids.

3.3.04.B Standard line type definitions are located in the "COH.lin" file provided by the City and can be downloaded at the following link: https://www.houstonpermittingcenter.org/media/3696/download.

3.3.05 LAYERS

3.3.05.A The layer standard is based on the drawing layer format by the U.S. National CAD Standard (NCS). The NCS format consists of four data fields (Discipline Designator, Major Group, and two Minor Groups), and a status field. Each field is separated by a dash for clarity. The Discipline Designator and Major Group fields are mandatory. The Minor Groups and Status field are optional.

	C	-	A	L	G	N	-	C	N	T	R	-	A	N	N	O	-	1
Discipline Designator (1-2 Letters)			Major Group (4 Letters)					Minor Group (4 Letters)					Minor Group (4 Letters)					Status Field (1 Letter)

Figure 3.1 – LAYER NAMING DIAGRAM

3.3.05.B Table 3.4, Table 3.5, and Table 3.6 are lists of common layer fields. Not all field codes are represented. Refer to the U.S. National CAD Standards (NCS)[1] for layer field codes of disciplines not defined in this section. Layers may be created to provide additional clarity to the data placed in a drawing. The guidelines above shall be observed when creating layers not listed in the NCS. Layer names shall not exceed 18 characters.

Table 3.4 – DISCIPLINE DESIGNATORS

Designator:	Description of Discipline Designator:
G	General
GR	General Record Drawings
V	Survey
VA	Aerial Survey
VF	Construction Field Survey
C	Civil
CD	Civil Demolition
CU	Civil Utilities
CP	Civil Paving
CT	Civil Transportation

Table 3.5 – MAJOR GROUP

Major Field:	Description of Major Layer Field:
ALGN	Alignments
ANNO	Sheet annotation
BLDG	Buildings and primary structures
BLIN	Baseline
BORE	Test borings
BRDG	Bridge
CABL	Cable
COMM	Communications
CTRL	Control Points
DETL	Details
DRIV	Driveways
ESMT	Easements
NGAS	Natural gas
PIPE	Pipes
PROP	Property
PVMT	Pavement
RAIL	Railway
ROAD	Roadways
RWAY	Right-of-Way
SIGL	Traffic signals
SSWR	Sanitary sewer
STRM	Storm sewer
WATR	Water supply
WETL	Wetlands

[1] https://www.nationalcadstandard.org/ncs6/

3.3.05.B
continued

Table 3.6 – MINOR GROUP

Minor Field:	Description of Minor Layer Field:
ANNO	Annotation
ASPH	Pavement: asphalt
CNTR	All: center lines
CONC	Pavement: concrete
DATM	Datum notes
DIMS	Dimensions
EDGE	Channels, major water bodies, ponds, creeks and rivers
FDPL	Flood plain
FIBR	Fiber optic
LABL	Annotation: labels
LEGN	Sheets: legends, symbols keys
NOTE	Sheets: notes
NRTH	Sheets: north arrows
POLE	Utilities: boxes / poles
ROAD	Pavement: roadways
SECT	Sections
TTLB	Sheets: border and title blocks
UTIL	Utilities

Table 3.7 – STATUS GROUP

Status Field:	Description of Status Field:
1	Phase 1
2	Phase 2
3	Phase 3
H	Horizontal (for profile grids)
V	Vertical (for profile grids)
F	Future work

SECTION 4 - ELECTRONIC DRAWINGS

3.4.01 ELECTRONIC PLAN REVIEW

3.4.01.A The process for registering the engineering firm with the iPermits Customer Portal for the Office of the City Engineer Plan Review, and the electronic plan review system is called ProjectDox. The electronic plan review process is broken down into 10 key steps. The process utilizes two systems: iPermits and ProjectDox. The iPermits Customer Portal is used to submit applications and to make payments. ProjectDox is used to upload Drawings, receive comments, and receive approvals. The step-by-step user guide can be found here:

https://bit.ly/4cWK6yT

3.4.02 ELECTRONIC PLAN FILE NAMING

3.4.02.A File names are limited to 70 characters. Documents should be submitted in PDF format per the COH I-Permits and ProjectDox system requirements. File names should contain the sheet number, dash, and corresponding sheet title the following format: "### - XXXXXXX" add "00" to single digit page numbers to avoid the page jumping from 1, 11,12, etc. See Table 3.8 below for some examples of common sheet files and corresponding file name to be used.

Table 3.8 – FILE NAMING

Sheet Title	**Sheet Number**	**File Name**
Cover Sheet	01	001 – Cover Sheet
Sheet Index	02	002 – Sheet Index
Abbreviations	03	003 – Abbreviations
Symbols	04	004 – Symbols
General Notes	05	005 – General Notes
Overall Project Layout(s)	06	006 – Overall Project Layout(s)

SECTION 5 - REVISION PROCESS

3.5.01 REVISION PROCEEDURES

3.5.01.A Revisions required during the construction phase shall follow the revision process in this section. Revisions on plans are to be annotated and documented with the following guidelines:

1. First Revision Procedures.

    a. All changes in each sheet that are pertinent to each revision shall be enclosed in revision “clouds”.

    b. The number of the revision shall be placed inside of a triangle, commonly known as a “delta”.

    c. Each revision delta shall be placed adjacent to the corresponding revision cloud(s).

    d. It is acceptable to have multiple clouds with the same revision delta on a sheet if all changes apply to that revision.

    e. It is acceptable to cloud an entire plan view area with a single revision cloud and delta, when a significant portion within the cloud has been revised or when clouding each revised item becomes impractical.

    f. If an entire sheet is added to a plan set as a part of a revision, the sheet title and sheet number shall be clouded along with a delta.

    g. The sheet index for each plan set shall also reflect revisions with the outlined procedures.

2. Second (and Subsequent) Revisions Procedures.

    a. The revision cloud(s) from any previous revision(s) shall be removed from each sheet.

    b. The revision delta(s) from any previous revisions(s) shall remain in their original location on each sheet.

    c. All of the new changes to each sheet shall follow the revision procedures outlines in the above narrative.

3. Title Block / Cover Sheet Annotation Procedures.

    a. Each revision is to be documented on the title block area of each plan sheet or cover sheet, see Figure 3.2 for examples.

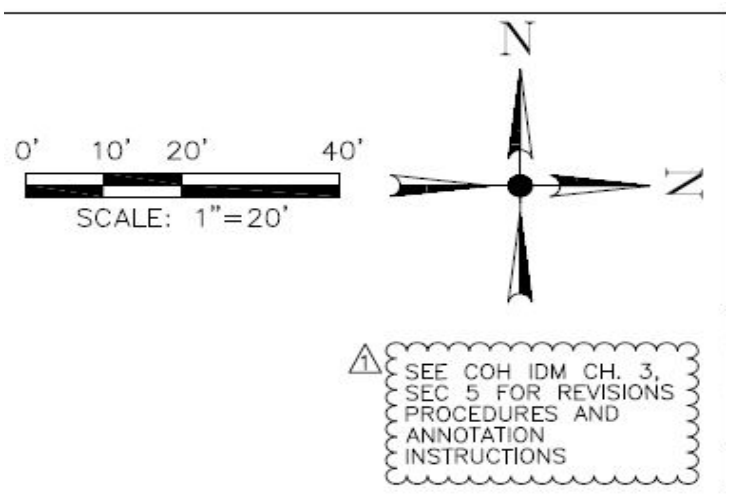
3.5.01.A.3 continued

b. All information is to be filled out, to include a brief description of the revision, starting from bottom to top or right to left.

c. Once the maximum amount of revision lines is completed, the oldest revision annotation will be removed to accommodate the newest current revision information.

d. The oldest revision information will be located at the bottom or right, with the current information located at the top or left.

3	MM/DD/YY	BRIEF DESCRIPTION	XXX
2	MM/DD/YY	BRIEF DESCRIPTION	XXX
1	MM/DD/YY	BRIEF DESCRIPTION	XXX
NO.	DATE	REVISION	APP.



3	MM/DD/YY	BRIEF DESCRIPTION	XXX
2	MM/DD/YY	BRIEF DESCRIPTION	XXX
1	MM/DD/YY	BRIEF DESCRIPTION	XXX
NO.	DATE	REVISION	APP.

Figure 3.2 – REVISION BLOCK EXAMPLES

SECTION 6 - EXAMPLE PLAN SET SHEETS

3.6.01 CAD STANDARDS APPLICABLE TO CITY AND PRIVATELY FUNDED PROJECTS

3.6.01.A Provide a cover sheet for projects involving three or more design Drawings (excluding City of Houston standard detail sheets).

3.6.01.B The example sheets in the following figures are to give the user an overall feel of how specific plans should appear and how they differ from each other. A few basic sample sheets are listed below and shown in this section:

1. Figure 3.3 - ABBREVIATONS
2. Figure 3.4 – LINETYPES, CELLS & STANDARD SYMBOLS
3. Figure 3.5 – COH SHEET INDEX
4. Figure 3.6 – CAPITAL PROJECTS COVER SHEET
5. Figure 3.7 – NON- CAPITAL / PRIVATE PROJECTS COVER SHEET
6. Figure 3.8 – TELECOMMUNICATION COVER SHEET
7. Figure 3.9 – GENERAL NOTES
8. Figure 3.10 – PLAN AND PROFILE
9. Figure 3.11 – BORE HOLE LAYOUT
10. Figure 3.12 – BORE HOLE LOGS

3.6.01.B
continued

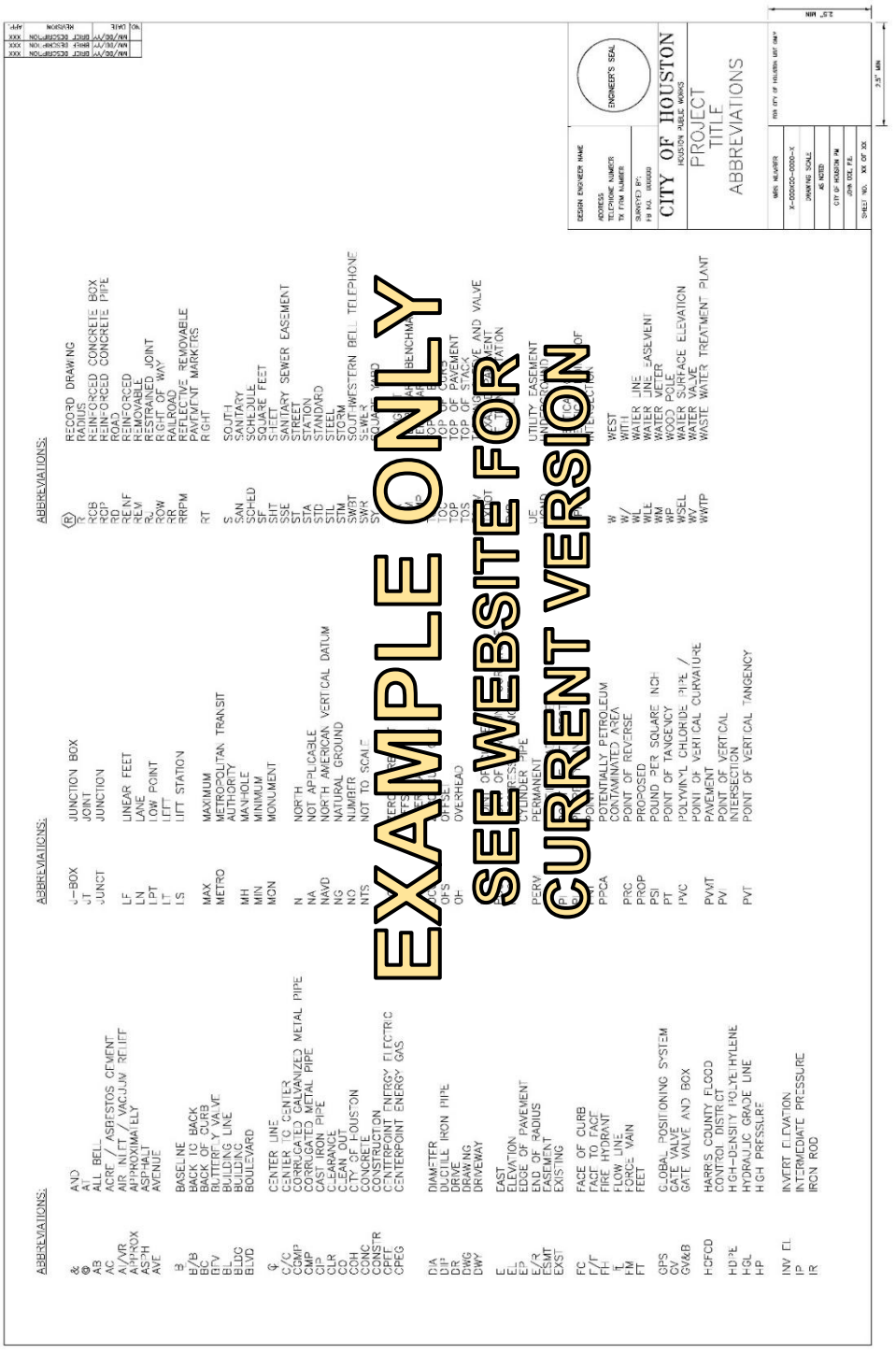


Figure 3.3 - ABBREVIATONS[2]

[2] For the most up to date sheet go to:
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued

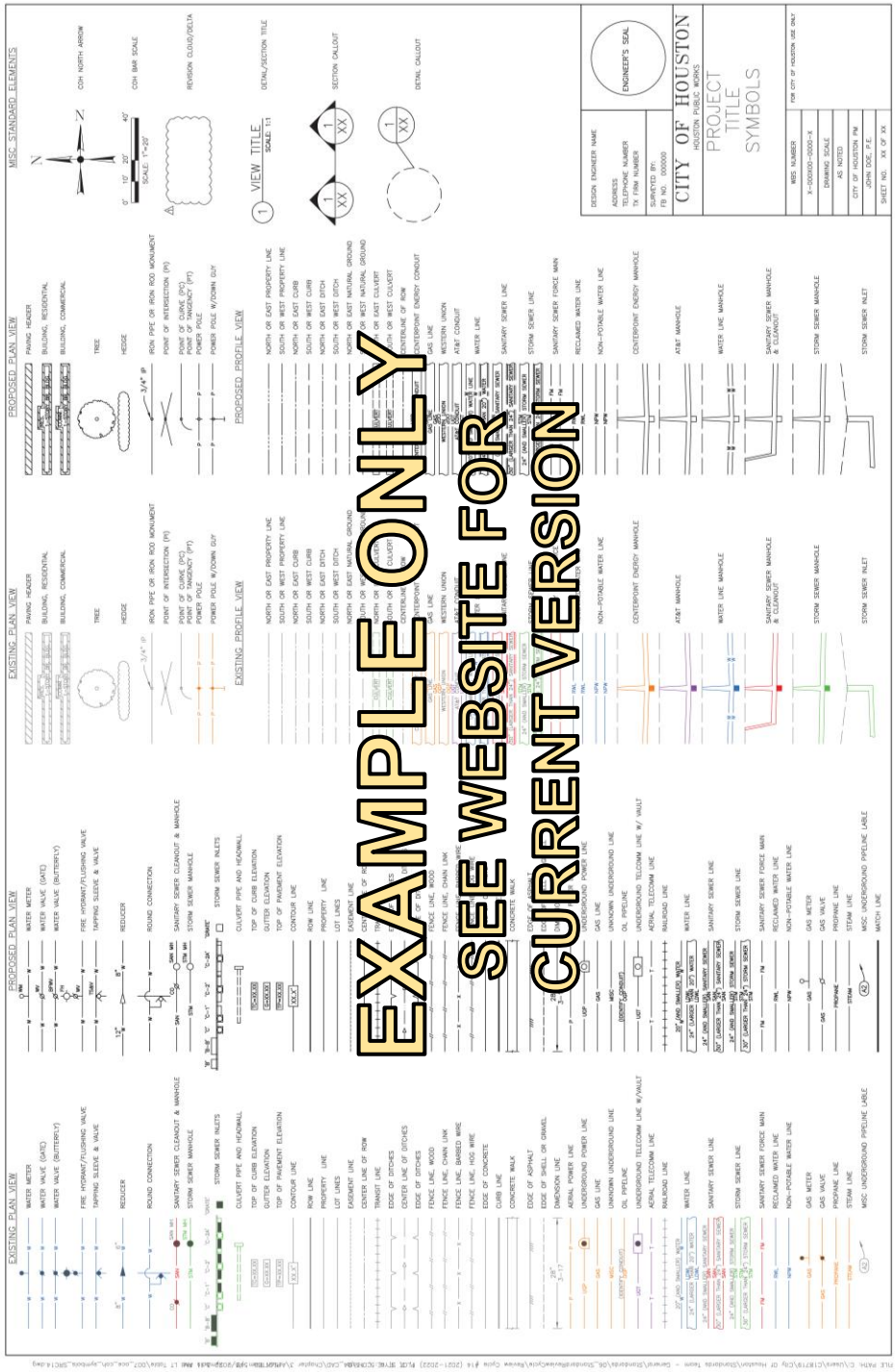


Figure 3.4 – LINETYPES, CELLS & STANDARD SYMBOLS[3]

[3] For the most up to date sheet go to:
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued

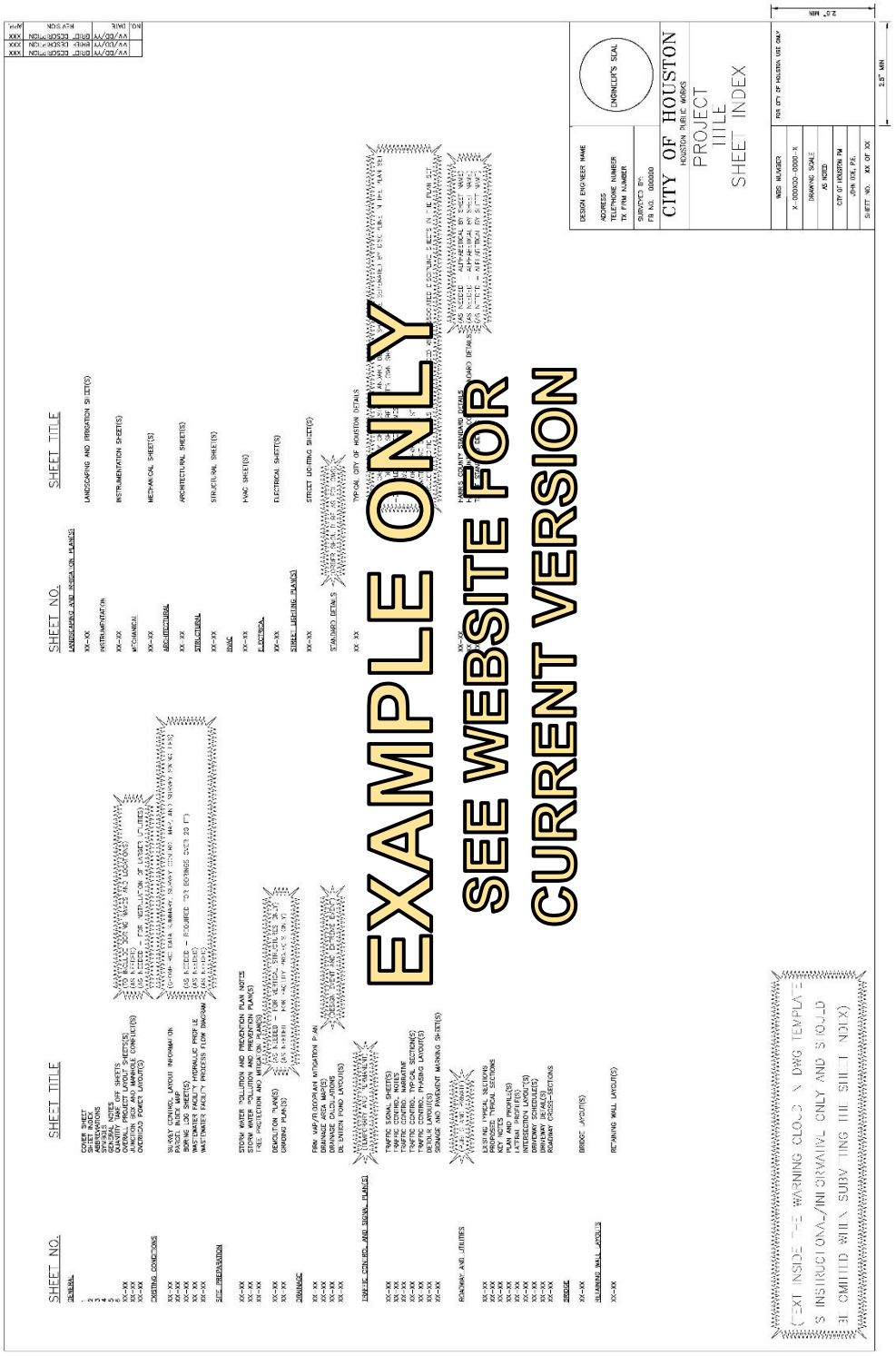


Figure 3.5 – COH SHEET INDEX[4]

[4] For the most up to date sheet go to:
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued

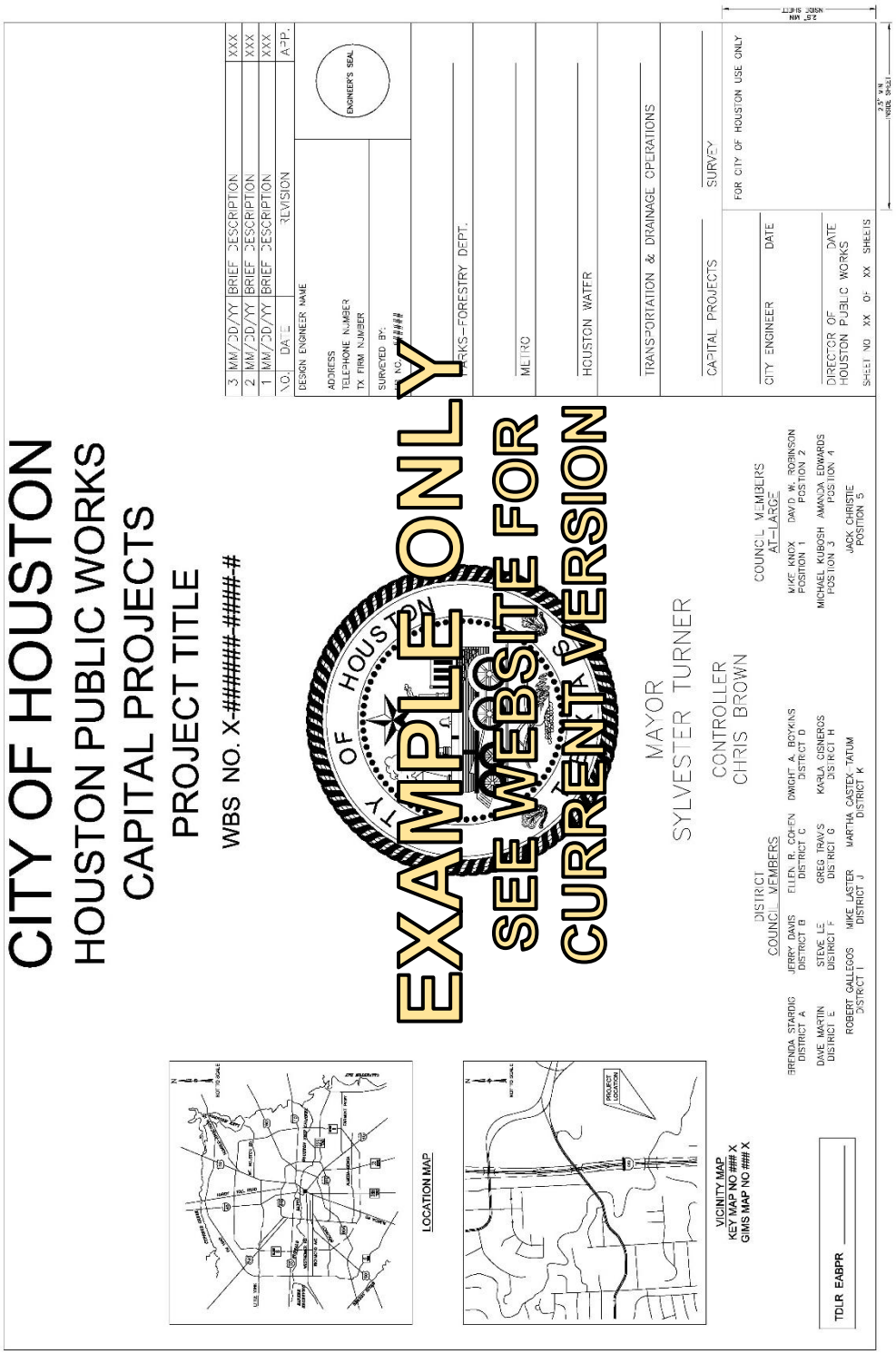


Figure 3.6 – CAPITAL PROJECTS COVER SHEET[5]

5 For the most up to date sheet go to
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued

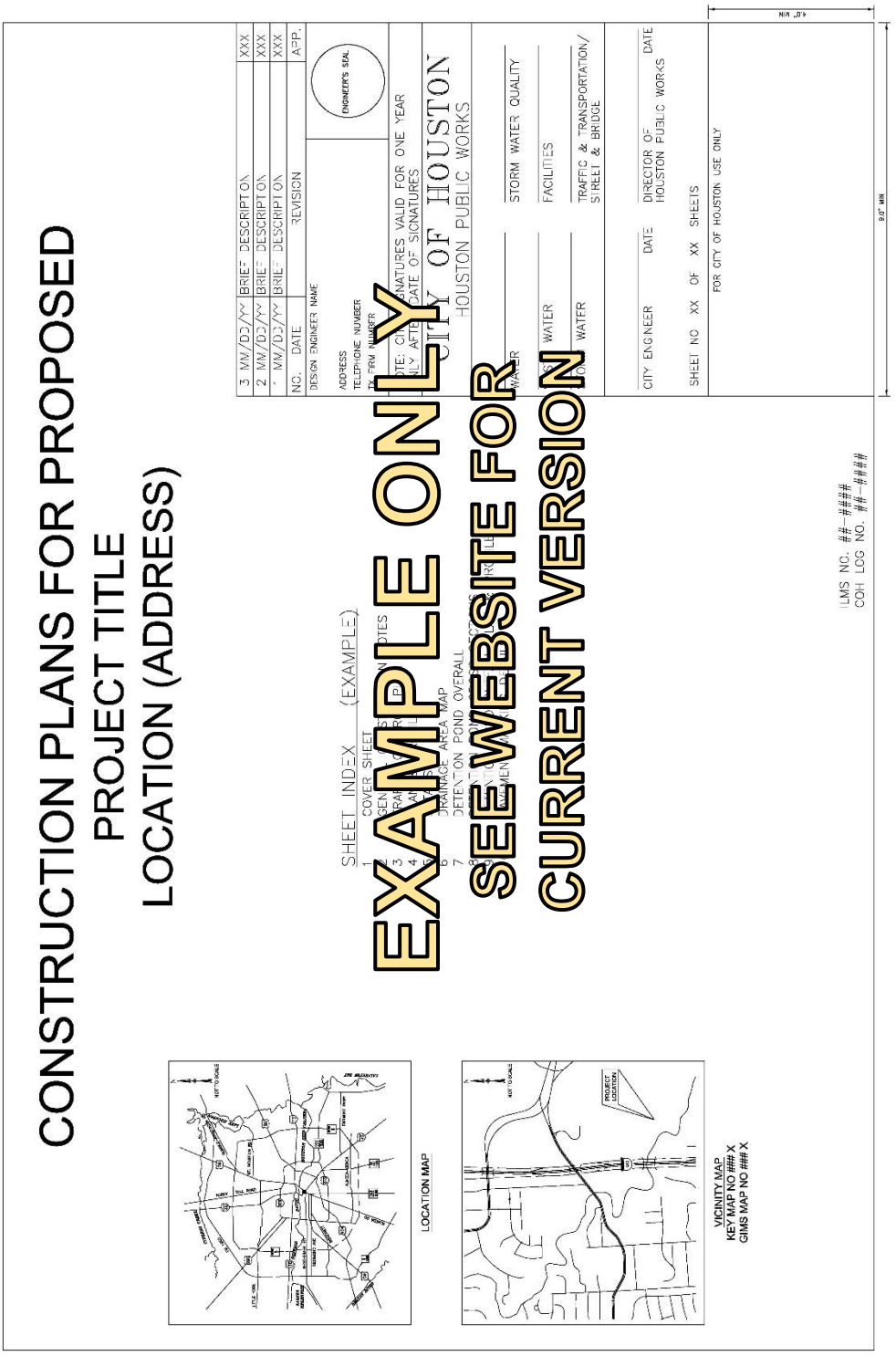


Figure 3.7 – NON- CAPITAL / PRIVATE PROJECTS COVER SHEET[6]

[6] For the most up to date sheet go to:
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued

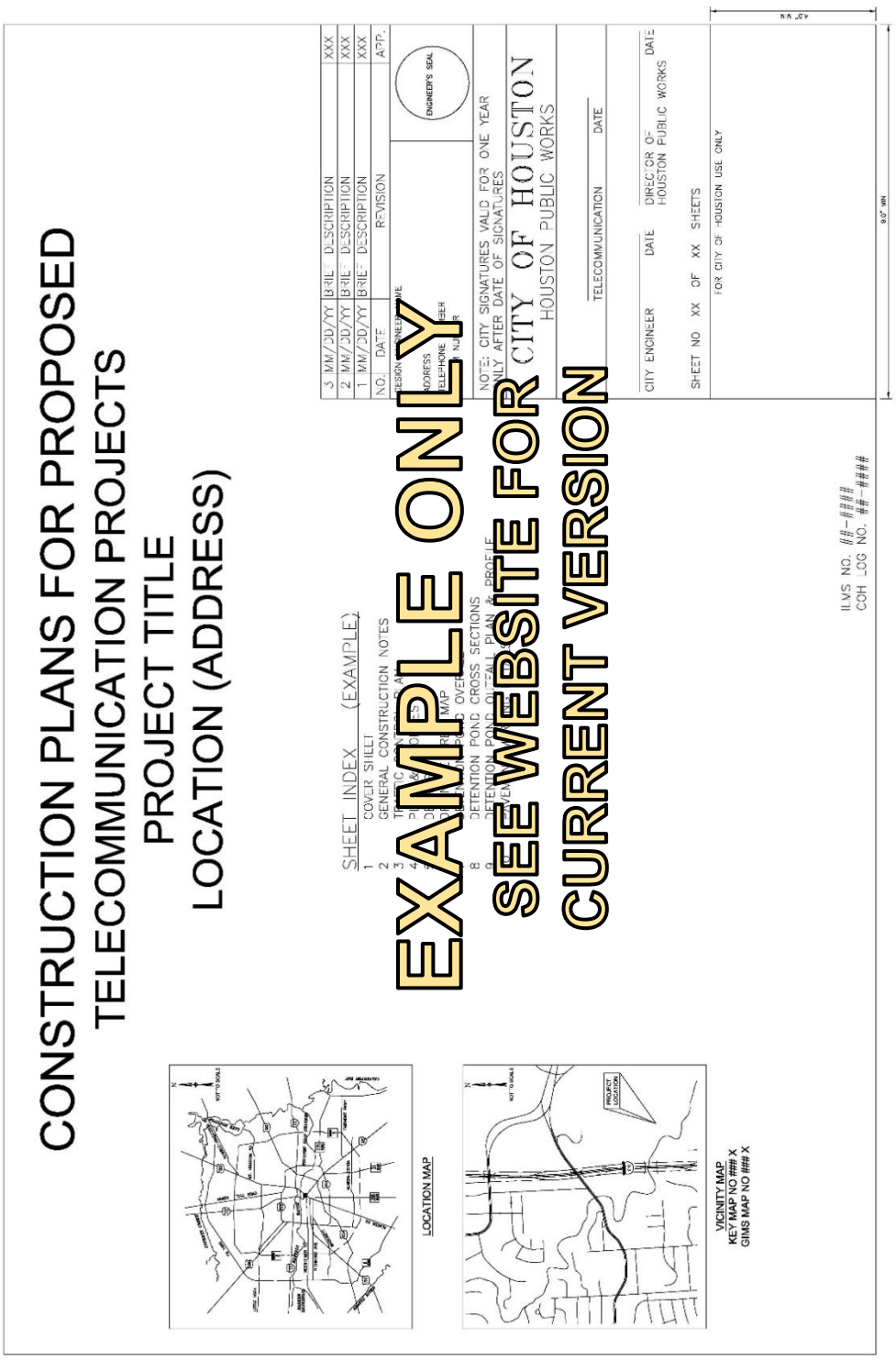


Figure 3.8 – TELECOMMUNICATION COVER SHEET[7]

[7] For the most up to date sheet go to:
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued

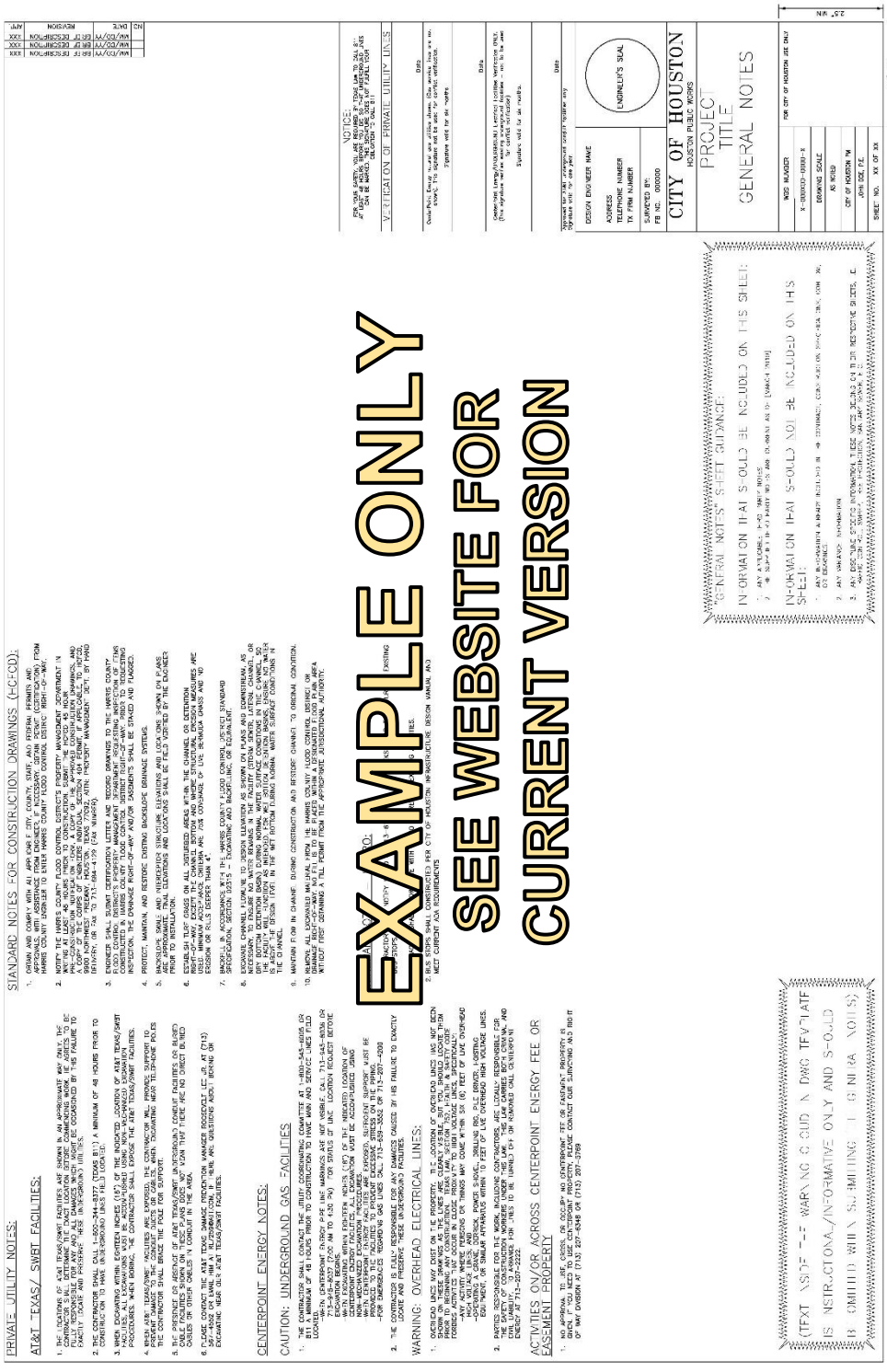


Figure 3.9 – GENERAL NOTES[8]

[8] For the most up to date sheet go to:
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued

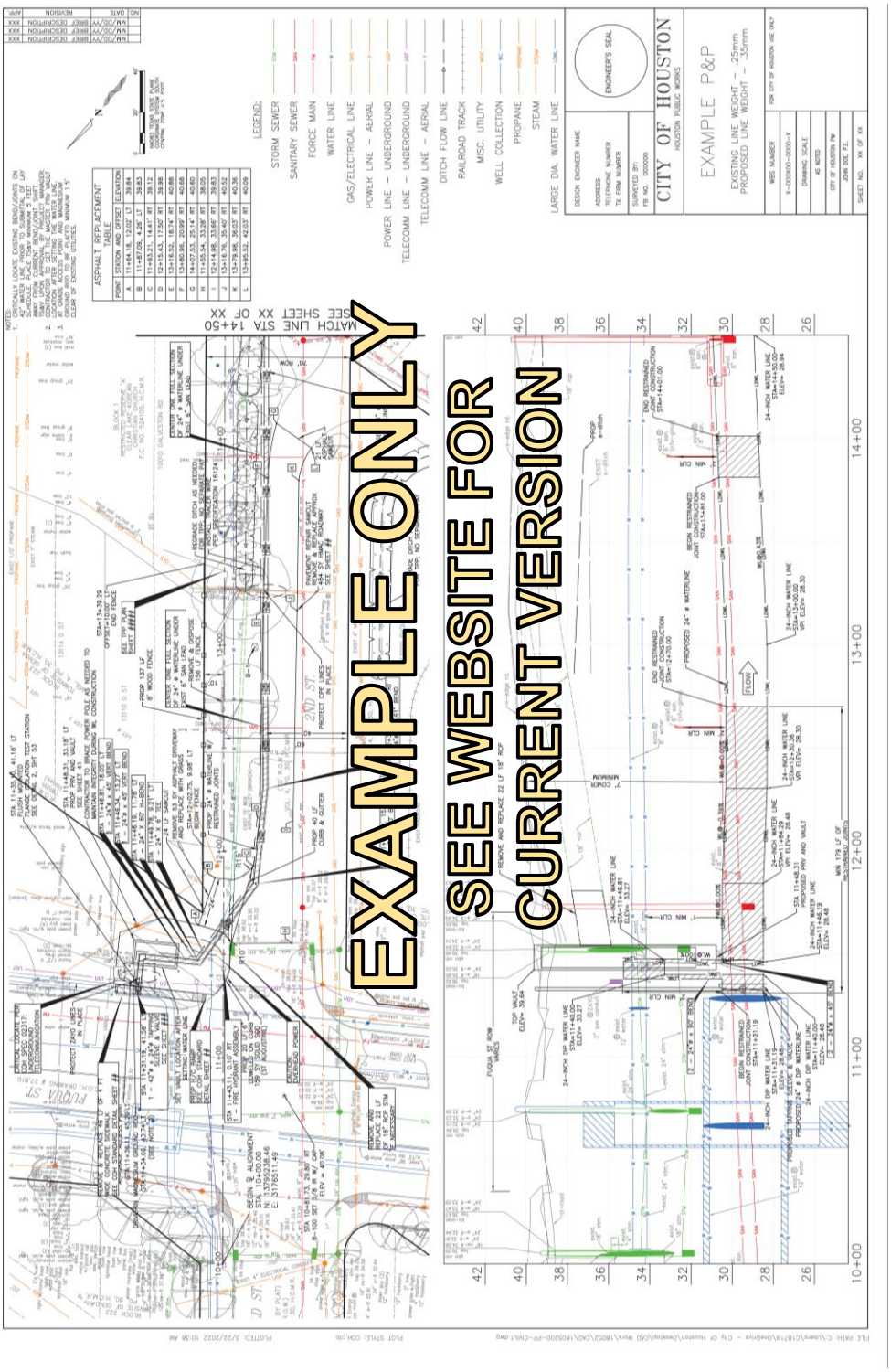


Figure 3.10 – PLAN AND PROFILE[9]

[9] For the most up to date sheet go to:
https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

3.6.01.B
continued



Figure 3.11 – BORE HOLE LAYOUT

3.6.01.B
continued

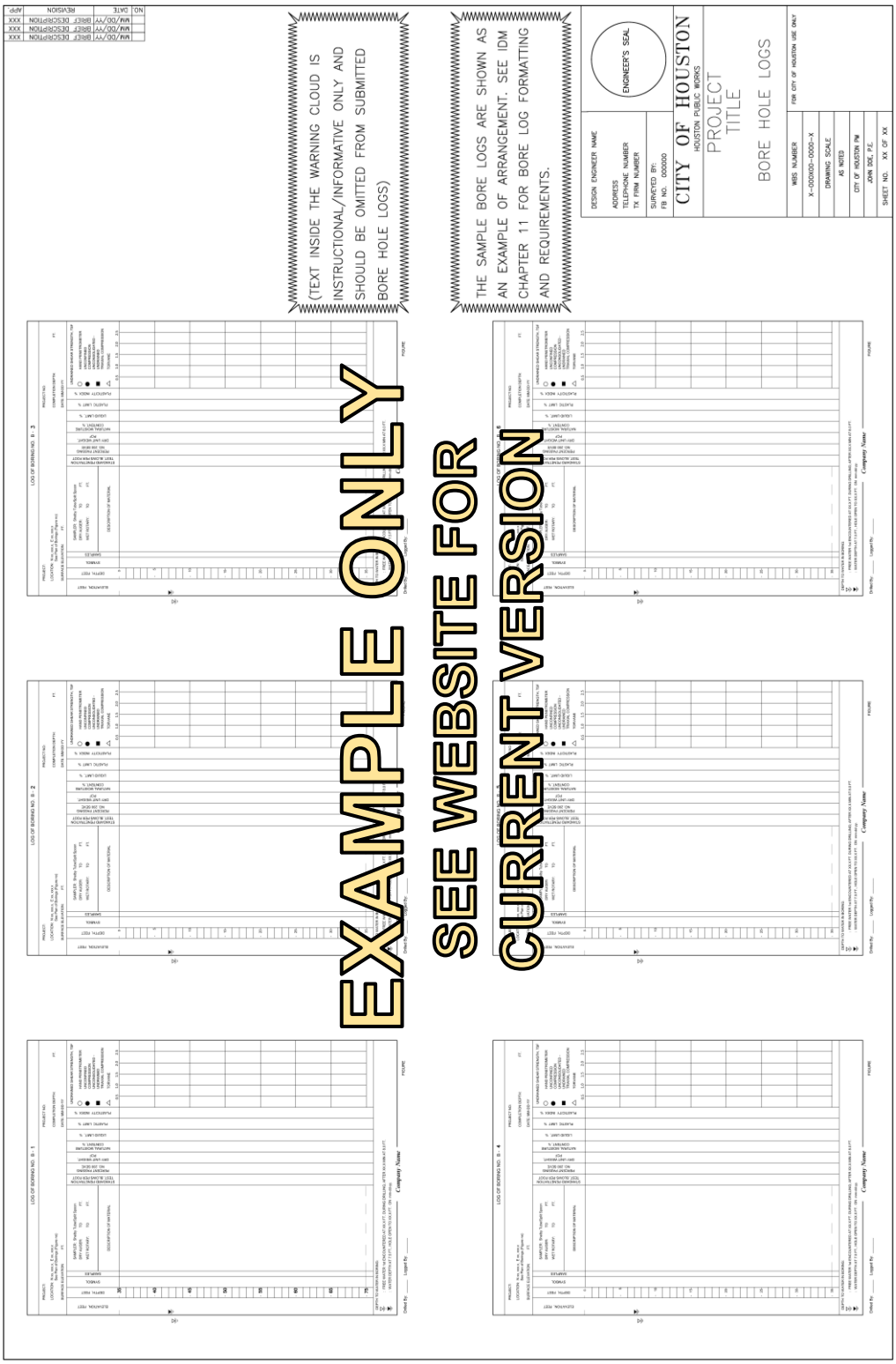


Figure 3.12 – BORE HOLE LOGS

SECTION 7 - RESOURCES

3.7.01 CAD TOOLS

3.7.01.A Listed below are the files that are provided by the City for use along with all the sections of Chapter 3. The files can be found here: https://www.houstonpermittingcenter.org/office-city-engineer/design-and-construction-standards

File Name	Description	File Type
1. COH	COH line types	.LIN
2. COH Line Types	COH line types	.PDF
3. COH	COH plot table	.CTB
4. COH Std Line Weights	COH standard line weights	.PDF
5. COH Drawing Template	COH drawing template	.DWT/PDF
6. COH Symbols	COH standard symbols	.DWG/PDF

3.7.01.B HELPFUL TEMPLATES

File Name	Description	File Type
1. coh_cp_title_block	COH standard title block	.DWG / .PDF
2. coh_cp_cover_sheet	COH standard Capital Projects cover sheet	.DWG / .PDF
3. coh_sheet_index	COH standard sheet index	.DWG / .PDF
4. coh_abbreviations	COH standard abbreviations	.DWG / .PDF
5. coh_symbol	COH standard symbols	.DWG / .PDF
6. coh_cp_general_notes	COH standard general notes	.DWG / .PDF
7. coh_non_cp_cover_sheet	Non-CP/private cover sheet	.DWG / .PDF
8. coh_non_cp_title_block	Non-CP/private title block	.DWG / .PDF
9. coh_telecomm_cover_sheet	Telecommunication cover sheet	.DWG / .PDF

END OF CHAPTER

City of Houston

Design Manual

Chapter 4

PLATTING REQUIREMENTS

Chapter 4
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Chapter 4

PLATTING REQUIREMENTS

SECTION 1 – PLATTING OVERVIEW

4.1.01 CHAPTER INCLUDES

4.1.01.A Coordination of platting requirements with the preparation of project drawings and specifications and their review and approval processing.

4.1.02 REFERENCES

4.1.02.A Chapter 42 – Subdivisions, Developments and Platting, Article II – Requirements and Procedures, latest revision.

4.1.02.B Texas Administrative Code, Title 22, Part 6 Texas Board of Professional Engineers and Land Surveyors.

4.1.03 DEFINITIONS

4.1.03.A Chief Surveyor - An authorized representative of the City having approval authority for privately-funded projects or having authority for administration of contracts for the City.

4.1.03.B Public Right-of-Way - Property dedicated or deeded for the purpose of public use.

4.1.04 GENERAL PLATTING REQUIREMENTS

4.1.04.A Platting requirements are found in Chapter 42 of the Code of Ordinances.

4.1.04.B Refer to Figure 4.1 and Figure 4.2 for flow charts of the process by which plats and related documents are submitted, reviewed, and approved by Houston Public Works. There are three classes of subdivision plat: a class I plat, a class II plat and a class III plat. Class I plats and class II plats are optional and may be used in lieu of a class III plat if the subdivision plat meets the qualifications of Sec. 42-23 b and c, Division I, Article II, Chapter 42, of the Code of Ordinances. Class I and class II plats do not propose the creation of any new streets; nor propose the dedication of any easements for public water, wastewater collection or storm sewer lines. A class I plat goes through an administrative review process within the Planning and Development Department. During that review questions may arise regarding the delivery of utilities that may be directed to Houston Public Works staff.

4.1.04.C All class II and class III plats submitted to the Planning and Development Department will be routed to Houston Public Works for review.

4.1.04.C continued

1. All class II & III plats located within the city limits as they existed in 1870 will be routed to the office of the Chief Surveyor for review. Review will be for the following items at a minimum:

    a. Compliance with standards contained in this design manual.

    b. Compliance with 22 Tex. Admin. Code § 138 (2021) and any amendments or recodifications to that statute thereafter.

4.1.04.D Design drawings (when required) shall be submitted to Houston Public Works with the name of the proposed plat clearly identified on the cover sheet. Design drawings shall be delivered in digital format as computer aided drafting file (.DWG) in accordance with Chapter 3 requirements.

4.1.04.E When the dedication of 20 feet in width or less of street Public Right-of-Way and/or sidewalk is required by separate instrument for plat approval, that dedication can be made through the submission of an easement dedication form (Form 584).

4.1.04.F When the dedication of more than 20 feet in width of street Public Right-of-Way and/or sidewalk is required by separate instrument for plat approval, the Real Estate section within Houston Public Works will oversee the dedication pursuant to the process established for such dedications.

SECTION 2 – PLATTING DESIGN REQUIREMENTS

4.2.01 DESIGN REQUIREMENTS

4.2.01.A Class III Preliminary Plat

1. The level of investigation to be performed for a class III preliminary plat is to identify major development impediments to water, wastewater collection and treatment, or storm drainage that are primarily the result of constraints external to the plat itself. Such constraints include, but are not limited to:

    a. Water Lines:

        (1) Long dead-end water lines.

        (2) Single feed water lines.

        (3) Inadequate capacity or pressure to the site.

        (4) Future plans for construction of major City facilities that will impact the site.

    b. Wastewater Collection System:

        (1) Inadequate Public Right-of-Way or wastewater easements.

        (2) Limited wastewater service capacity for the area.

        (3) Future plans for construction of major City facilities that will impact the site.

    c. Storm Drainage System:

        (1) Drainage outfall severely under capacity.

        (2) Encroachment into flood-prone areas or floodway.

        (3) Storm water detention or diversions of watershed drainage that impact the property.

        (4) Future plans for construction of major City facilities that will impact the site.

2. Houston Public Works will review class III preliminary plats and take one or more of the following actions:

    a. Pose no objection to the plat.

4.2.01.A.2 continued

b. Request a meeting with the applicant to discuss design and construction requirements.

c. Request specific additional information, easements, or improvements to the plat or the land within the purview of the department.

d. Request one-line drawings be submitted prior to detailed engineering drawings and final plat submittal.

3. Approval of a preliminary plat by Houston Planning Commission does not infer approval of proposed infrastructure. Review of infrastructure will take place upon submittal of one-line drawings, if required, which may occur after preliminary plat approval and must occur prior to final plat approval.

4.2.01.B Class II and Class III Final Plat

1. Houston Public Works will review class II and class III final plats and final design drawings, easement documents, and other data. Review will be for the following items, as a minimum:

a. Compliance with standards contained in this Design Manual.

b. Adequacy of service availability for:

(1) Water

(2) Wastewater

(3) Storm sewer or storm water detention.

c. Other design standards of Houston Public Works.

4.2.01.C Comments resulting from reviews described in Articles 4.2.01.A and 4.2.01.B will be reported to the Planning and Development Department for inclusion in CPC 101 Form.

4.2.02 DESIGN ANALYSIS

4.2.02.A For plats of land located inside the city limits, review of final design drawings and other documents required by Houston Public Works for final plat approval will address the following:

1. Resolution of conflicts with existing and proposed utilities.

2. Layout of water lines for maximum circulation of water. The pattern shall allow at least two sources of water to be constructed within the Public

4.2.02.A.2 continued

Right-of-Way or permanent easement. Side lot easements shall meet the requirements of Chapter 5, Easement Requirements, and Chapter 7, Water Line Design Requirements.

3. Adequate capacity in water and wastewater facilities to be utilized. The City may require a current letter of utility commitment prior to approval of a plat.

4. Adequacy of drainage facilities.

5. Sizing and identification/designation of easements within the plat and required easements outside the plat boundary.

6. Recordation of required off-site easements or lift station sites, their depiction on the site plan, and submittal to the City of record documents.

4.2.02.B For plats of land located outside the city limits, review of final design drawings and other documents required by Houston Public Works for final plat approval will address all items in Article 4.2.02.A plus the following:

1. When appropriate, a letter from the municipal utility district's president or board or from the property owner stating that all off-site easements that are not immediately obtainable (for example: those crossing fee strips, rail roads, or other areas under eminent domain) are in progress and that it is the intention of the municipal utility district or property owner to complete the acquisition of such easements. The letter will be accompanied by a certified survey plat and legal description of such easements.

2. That separately platted tracts requiring service are or will be directly served by public utilities located in or abutting Public Rights-of-Way or permanent access easements with overlapping public utility easements.

3. That necessary contracts and documents for inside the city limit and outside the city limit are approved and signed.

4. For a plat that includes portions both inside and outside the city limits and where there will be an imminent need for utility services, a current letter of utility commitment may be required prior to approval.

END OF CHAPTER

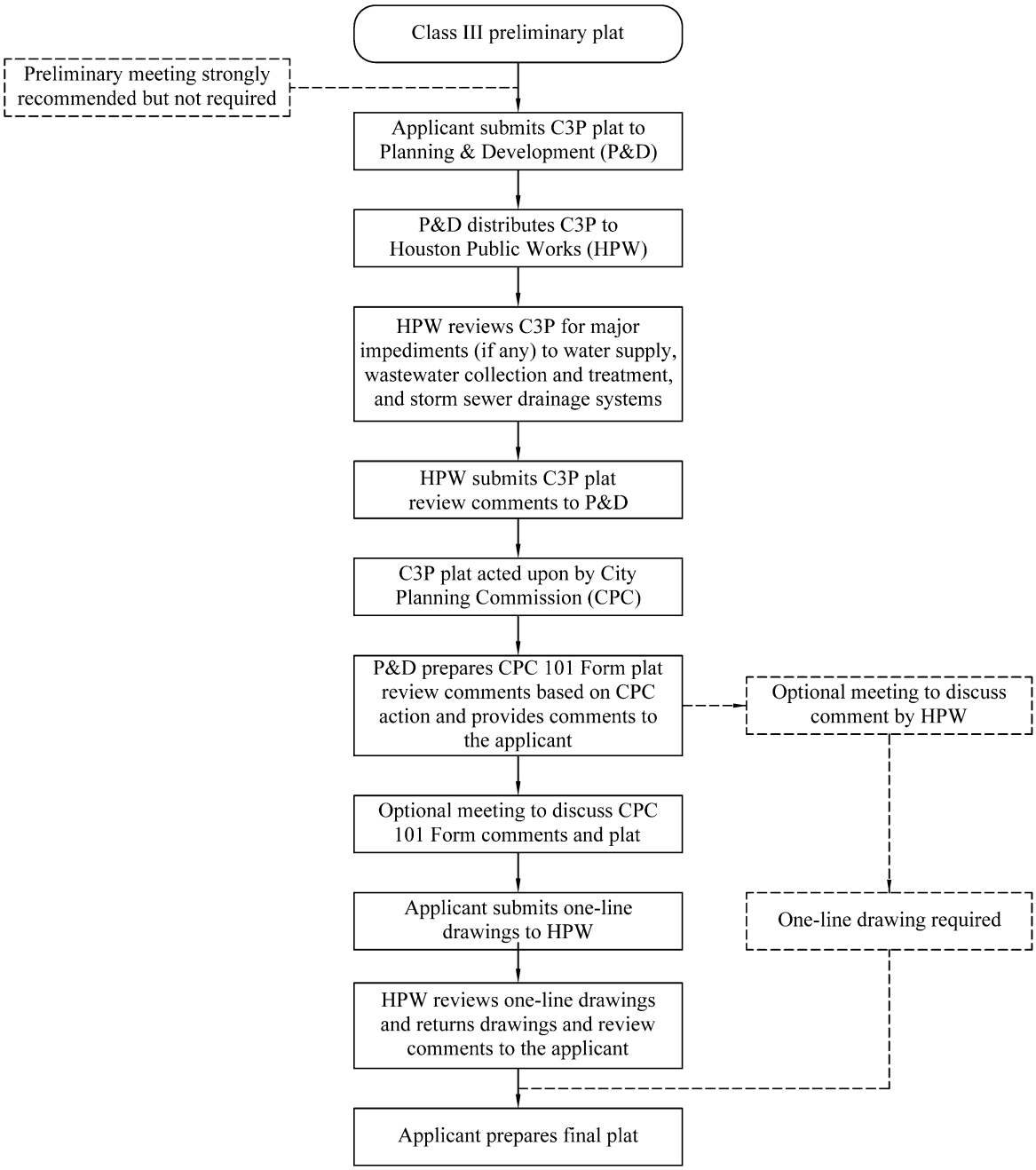


Figure 4.1 - CLASS III PRELIMINARY PLAT

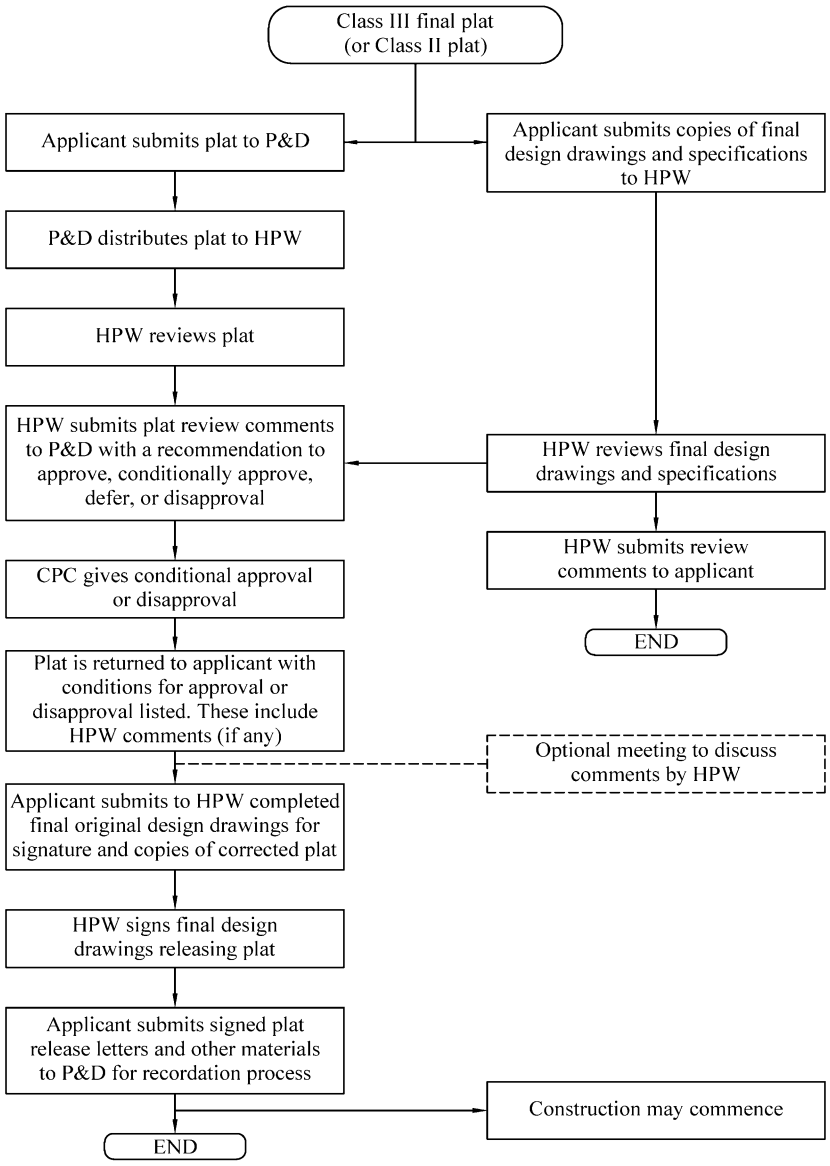


Figure 4.2 - CLASS III FINAL PLAT (OR CLASS II PLAT)

City of Houston

Design Manual

Chapter 5

EASEMENT REQUIREMENTS

Chapter 5
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Easement Requirements

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Chapter 5

EASEMENT REQUIREMENTS

SECTION 1 – EASEMENT DESIGN OVERVIEW

5.1.01 CHAPTER INCLUDES

5.1.01.A Requirements for allocating and recording Easements for water, wastewater, and storm drainage facilities located outside of Public Rights-of-Way.

5.1.01.B Easements for electrical and gas lines are not covered under this Design Manual.

5.1.02 REFERENCES

5.1.02.A City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting.

5.1.03 DEFINITIONS

5.1.03.A All-Weather Access – Cleared, graded, and stabilized access roadway or driveway that allows vehicles to easily enter and exit the Easement in all weather conditions.

5.1.03.B City Engineer - The authorized representative of the City, or the City's designee, having approval authority for publicly funded projects, privately funded projects, or having authority for administration of design and construction contracts for the City.

5.1.03.C Easement - Area set aside for installation, operation, and maintenance of utilities by public and private utility operators.

5.1.03.D Easement Boundary - Any side of the Easement that defines the boundary of the Easement.

5.1.03.E Extraterritorial Jurisdiction (ETJ) - The unincorporated territory extending beyond the corporate boundaries of the City established pursuant to Chapter 42 of the Texas Local Government Code, as may be amended from time to time.

5.1.03.F Outer-Easement Boundary – The Easement Boundary that is the furthest offset from the adjacent Public Right-of-Way.

5.1.03.G Permanent Access Easement (PAE) – Easement that provides permanent access as defined in the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments & Platting, Article I, §42-1.

5.1.03.H Public Right-of-Way – Property dedicated or deeded for the purpose of public use.

5.1.03.I Public Utility Easement (PUE) – Easement used for public utilities as defined in the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments & Platting, Article III, Division 5, §42-210.

5.1.03.J Registered Professional Land Surveyor (RPLS) - A surveyor currently registered and in good standing with the Texas Board of Professional Engineers and Land Surveyors (TBPELS).

5.1.03.K Semi-Public Right-of-Way - Property partially dedicated or deeded for the purpose of public use, wherein public interest is limited to either the surface or subsurface.

SECTION 2 – EASEMENT DESIGN REQUIREMENTS

5.2.01 GENERAL DESIGN REQUIREMENTS

5.2.01.A Where public utilities are located in, along, across or adjacent to private drives, private streets or Permanent Access Easements in platted single family residential lot subdivisions; such drives, streets or Easements shall have an overlapping Public Utility Easement to provide access and maintenance rights. Public Utility Easement rights shall be superior to Permanent Access Easement rights allowing the City ingress and egress for maintenance of utilities.

5.2.01.B Easements are to be defined and submitted as part of the recorded plat either shown on the plat or by metes and bounds description. The process for recording the plat is described in Chapter 4, Platting Requirements.

5.2.02 QUALITY ASSURANCE

5.2.02.A Recorded plats and metes-and-bounds descriptions of Easements must be prepared under the direction of a Registered Professional Land Surveyor. The surveyor must seal, sign, and date documents prepared under the surveyor's supervision.

5.2.03 PLAT AND EASEMENT REQUIREMENTS

5.2.03.A Requirements for Platted Easements.

1. For construction inside City limits, submit a copy to the Office of the City Engineer of the final plat accompanied by a CPC 101 form together with the original engineering drawings for approval and signatures.

2. For construction outside City limits but within Houston's ETJ.

   a. Where no Easements are required outside the plat boundary, follow the same requirements as for plats inside City limits given in Article 5.2.03.A.1.

   b. Where Easements are to be dedicated outside the plat boundary or through property under different ownership, follow the instructions in Article 5.2.03.A.1 for plats inside City limits and the following additional requirements:

      (1) Submit a copy of the recorded instrument creating the Easement or a metes-and-bounds description and a map of the Easement, along with a letter from the municipal utility district board or property owner stating the intent to obtain or dedicate necessary Easements. The Easement instrument shall be recorded prior or simultaneously to recordation of the plat.

5.2.03.A.2.b continued

(2) All off-site Easements necessary to serve a proposed development must be shown on the face of the plat, or an acceptable reference tie between the plat and Easements must be established between the two documents. Off-site Easements must be recorded prior to recordation of the plat.

5.2.03.B Requirements for Easements dedicated to the public or to the City:

1. Easements required for construction of a proposed project must be approved and accepted prior to approval of final design drawings or issuance of a permit for the proposed construction.

5.2.03.C Additional requirements for Easements dedicated only to the City:

1. Easements shall be either a part of the dedication on the plat of a subdivision, dedicated to the City on standard forms provided by the City for that purpose, or on forms approved by the City Attorney.

2. The person seeking to dedicate an Easement to the City shall furnish the City with a metes & bounds description and map, signed and sealed by a Texas Registered Professional Land Surveyor, showing the Easement and its location.

3. A construction permit will be granted upon acceptance by the City of recorded instruments dedicating the Easements.

5.2.04 EASEMENT DESIGN REQUIREMENTS FOR WATER LINES, SANITARY LINES, STORM LINES AND APPURTENANCES

5.2.04.A Maintain a minimum horizonal clearance between utilities as required in Chapter 9 and other chapters of this manual.

5.2.04.B If an access Easement is needed temporarily for reserves specifically restricted to lift station, wastewater treatment, water production or repressurization, refer to access Easement requirements in Section 42-190 of the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting.

5.2.04.C Easements for Water Lines and Appurtenances.

1. Water Lines.

   a. When outside a street Public Right-of-Way or Permanent Access Easement with overlapping Public Utility Easements, Easements must be dedicated and restricted for water lines only.

   b. Easements should be contiguous with Public Rights-of-Way.

5.2.04.C.1
continued

c. Water line Easements that cannot be contiguous with Public Right-of-Way shall meet all of the following criteria:

(1) Minimum Easement width shall be equal to twice the water line diameter plus the depth to the bottom of the water line from natural ground or final ground elevation, whichever is greater;

(2) Easement width shall be rounded up to the nearest 5-foot increment; and

(3) Minimum Easement width shall not be less than 20-feet or as required by Table 5.1 for large diameter water lines.

d. Provide All-Weather Access for water line Easements not contiguous with Public Right-of-Way, unless one already exists.

e. Proposed water lines located within an Easement contiguous with the street Public Right-of-Way or Public Utility Easement that is contiguous with street Public Right of Way:

(1) Small Diameter Water Lines.

(a) For lines 12-inches in diameter and smaller, the minimum Easement width shall be 15-feet. The centerline of the pipe shall be located 5-feet from either Easement Boundary.

(b) For lines 16-inches to 20-inches in diameter, the minimum Easement width shall be 20-feet. The centerline of the pipe shall be located 7-feet from either Easement Boundary.

(2) Large Diameter Water Lines (LDWL).

(a) The minimum Easement width required to install, operate, and maintain water lines are summarized in Table 5.1.

5.2.04.C.1.e.(2).(a)
continued

Table 5.1 – MINIMUM EASEMENT WIDTH FOR LDWLs

SIZE OF WATERLINE	EASEMENT WIDTH (2)
24” through 36” (1)(3)	20 ft
42” through 54” (4)	30 ft
60” through 72” (4)	40 ft
84” and Larger (4)	50 ft

Notes:
(1) Water lines shall be centered in 20-foot Easements.
(2) For Easements 30-foot and larger, provide at least 10-foot clearance between water line centerline and Easement Boundary.
(3) For water lines at depths greater than 15-feet, add an additional 10-feet to the permanent Easement. Depth shall be measured to the bottom of the water line from natural ground or final ground elevation, whichever is greater.
(4) For water lines at depths greater than 15-feet, add a 10-foot temporary construction Easement. Depth shall be measured to the bottom of the water line from natural ground or final ground elevation, whichever is greater.

f. Water line Easements are required for proposed water lines located inside of Public Right-of-Way if the exterior of the water line pipe is located within 5-feet of the Public Right-of-Way. The Easement shall be contiguous with the Public Right-of-Way and the Outer-Easement Boundary shall be located the following distance from the Public Right-of-Way:

(1) 12-inch diameter and smaller - minimum 5-feet.

(2) 16-inch to 20-inch in diameter - minimum 10-feet.

(3) 24-inch and larger, use Easement widths defined in Table 5.1.

g. Water lines along state rights-of-way shall be installed outside of the right-of-way in a separate contiguous Easement. Width of Easements shall be as provided in Article 5.2.04.C.1.e.

h. No back-lot Easements will be allowed for the installation of water lines.

i. Side-lot Easements must be accessible for maintenance. They will only be allowed if they result in eliminating dead end water lines.

j. Do not locate water lines 16-inch diameter and larger in side-lot Easements.

k. When using side-lot Easements, such Easements shall be a minimum of 20-feet in width, located on one lot or centered between two lots.

5.2.04.C.1.k continued

If the Easement is centered between two lots, the water line shall be centered within the 10-feet of one lot.

l. Commercial developments inside the City and in the ETJ requiring on-site fire hydrants must provide a minimum 20-foot water line Easement for water lines and fire hydrants.

m. Refer to Chapter 7 "Water Line Design Requirements" Article 7.2.01.E.4 for dedicated water main Easements for commercial developments with public on-site water mains for fire protection.

2. Fire Hydrants.

a. Use a minimum 10-foot by 10-foot Easement for fire hydrants located outside of Public Right-of-Way.

b. Do not locate fire hydrants in water line Easements or any water meter Easements.

c. Refer to Article 7.2.01.D.4.c for additional fire hydrant location requirements.

d. Use a minimum 5-foot by 5-foot Easement for flushing valves located outside of Public Right-of-Way. Flushing valves must be centered within the Easement.

3. Meters and Valves:

a. Two-inch and smaller meters and shut-off valves (stop boxes) shall be set within the Public Right-of-Way or water line Easement if possible. Otherwise, they shall be set in a minimum 5-foot by 5-foot sized separate water meter Easements contiguous with Public Right-of-Way.

b. Three-inch through six-inch meters shall be set in a minimum 10-foot by 20-foot sized separate water meter Easement contiguous with Public Right-of-Way.

c. Eight-inch and larger meters shall be set in a minimum 15-foot by 25-foot sized separate water meter Easement contiguous with Public Right-of-Way.

d. Water meter Easements shall be located contiguous with Public Rights-of-Way unless approved by the City. Access Easements a minimum of 15-feet wide will be required when not contiguous with a Public Right-of-Way.

5.2.04.C continued

4. Dedicated water meter Easements shall be placed in unpaved and porous areas.

5.2.04.D Easements for Wastewater Lines and Appurtenances.

1. Gravity sanitary sewer lines and force mains shall be located in either the Public Right-of-Way or Easements. Side-lot Easements may be used only with special approval. Back-lot Easements shall not be utilized except in the case of existing conditions or as approved by the City Engineer.

2. Gravity Sanitary Sewer Lines.

a. Easements adjacent to Public Rights-of-Way, Easements, or fee strips, including those owned by Harris County Flood Control District, CenterPoint Energy, and pipeline companies.

(1) Easements for gravity sanitary sewers 10-inches or less in diameter shall have a minimum width of 15-feet or a minimum width equal to the depth of the proposed sewer, whichever is greater.

(2) Easements for gravity sanitary sewers 12-inches or greater in diameter shall have minimum width of 20-feet or a minimum width equal to the depth of the proposed sewer, whichever is greater.

(3) Easements for gravity sanitary sewers 24-inches or greater in diameter that are to be installed by trenchless method of construction shall have a minimum width of 20-feet.

b. Gravity sanitary sewer Easements or other combined Easements for sanitary sewers which meet the conditions below shall have a minimum width equal to twice the sewer's diameter plus the flow line depth of the sewer from natural ground, proposed fill elevation, or 100-year floodplain fill elevation, whichever is greater; but not less than 25-feet. The qualifying conditions are:

(1) Runs through commercial reserves or across open country (acreage);

(2) Serves other existing or proposed platted commercial reserves or non-platted acreage tracts; or

(3) Is not immediately adjacent to Public Rights-of-Way, Easements, or fee strips, including those owned by Harris County Flood Control District, CenterPoint Energy, and pipeline companies.

5.2.04.D.2 continued

c. Gravity sanitary sewers shall be located in the center of the Easement, where feasible.

d. Gravity sanitary sewers less than 20-feet deep, which cannot be located in the center of Easements shall be located a minimum distance of half the depth from the nearest side of the Easement.

e. Gravity sanitary sewers installed in Easements separated from Public or Semi-Public Rights-of-Way by other private or utility company Easements, shall be extended along or across the private utility company Easement to provide access for maintenance of the sewer.

f. Gravity sanitary sewers along state rights-of-way shall be installed outside of the right-of-way in a separate contiguous Easement. Width of Easements shall be as provided in Article 5.2.04.D.2.a.

g. Easements described in Articles 5.2.04.D.2.a through 5.2.04.D.2.f, and Article 5.2.04.D.3 shall be open-ended Easements in conformance with City Code of Ordinances and planning requirements. Such open-ended sanitary sewer Easements shall be extended if necessary and shall be fully connected at both ends to public facilities including existing or proposed:

(1) Street Public Rights-of-Way

(2) Wastewater treatment plant sites

(3) Wastewater pump station sites

(4) Public Utility Easement of adequate size for maintenance access.

3. Force Mains:

a. Force mains of all sizes shall have a minimum Easement width of 20-feet for single lines which are not located adjacent to Public or Semi-Public Right-of-Way.

b. Force mains located in Easements adjacent to Public or Semi-Public Right-of-Way shall have a minimum Easement width of 10-feet subject to location and depth of the force main.

c. Force mains installed in Easements separated from Public or Semi-Public Rights-of-Way by other private or utility company Easements, shall be extended along or across the private utility company Easement to provide access for maintenance of the force main.

5.2.04.D.3 continued

d. Force main Easements shall be open-ended. See Article 5.2.04.D.2.g for open ended Easement requirements.

e. Force mains along state rights-of-way shall be installed outside of the right-of-way in a separate contiguous Easement. Width of Easements shall be as provided in Article 5.2.04.D.3.b.

4. Service Leads.

a. The minimum Easement for building service leads is 6-feet.

5.2.04.E Storm Drainage Lines and Appurtenances

1. Storm Sewer Lines.

a. To the extent practical, storm sewers shall be placed in street Public Rights-of-Way or Permanent Access Easements with overlapping Public Utility Easements in accordance with Chapter 6, Utility Locations.

b. The minimum Easement width required to install, operate, and maintain storm sewers are summarized in Table 5.2.

Table 5.2 – MINIMUM EASEMENT WIDTH FOR STORM SEWERS

SIZE OF STORM SEWER	MINIMUM EASEMENT WIDTH
24” through 36” (1)(3)	20 ft
42” through 72” (2)(3)	25 ft
84” and Larger (2)(3)	30 ft

Notes:

(1) Unless the storm sewer is located within a combined storm and sanitary sewer Easement, storm sewers shall be centered in 20-foot Easements.

(2) Unless the storm sewer is located within a combined storm and sanitary sewer Easement, storm sewers should be centered in the Easement. If the sewer cannot be centered, the horizontal clearance between the exterior of the storm sewer and the Easement Boundary shall be a minimum of 8-feet for sewers that are less than or equal to 15-feet in depth. For storm sewers greater than 15-feet in depth that cannot be centered within the Easement, the horizontal clearance between the exterior of the storm sewer and the Easement Boundary shall be a minimum of 16-feet.

(3) For storm sewers at depths greater than 15-feet, add an additional 15-feet to the permanent Easement. Depths shall be measured to the bottom of the storm sewer from natural ground or final ground elevation, whichever is greater.

5.2.04.E.1 continued

c. Back-lot Easements are discouraged and will require a variance from the City design standards.

d. Center culverts in side-lot storm sewer Easements.

e. Public and private facilities may require a dedicated storm water Easement. Refer to Chapter 9 "Stormwater Design and Water Quality Requirements," Section 9.2.01.H.5 "Ownership and Easements" for conditions.

f. Storm sewer Easements are required for proposed storm sewers located inside of Public Right-of-Way if the exterior of the storm sewer pipe is located within 5-feet of the Public Right-of-Way. The Easement shall be contiguous with the Public Right-of-Way and the Easement width shall be as follows:

(1) Minimum of 5-foot width when the storm sewer pipe outer wall is located between 3-feet to 5-feet from the Public Right-of-Way.

(2) Minimum of 10-foot width when the storm sewer pipe outer wall is located less than 3-feet from the Public Right-of-Way.

(3) For storm sewers at depths greater than 15-feet, add an additional 10-foot wide permanent Easement to the Easement width required by 5.2.04.E.1.f.(1) or 5.2.04.E.1.f.(2). Depths shall be measured to the bottom of the storm sewer from natural ground or final ground elevation, whichever is greater.

2. Storm Water Detention Basins.

a. Easements for storm water detention basins shall be dedicated by plat or by separate instrument filed in conjunction with plat approval. Such Easements shall be dedicated to the developer, owner, or water district.

b. Such Easements shall have a minimum 20-foot width for private basins surrounding the perimeter of the detention basin as measured from top of bank unless adjacent to a street Public Right-of-Way.

3. Easement Requirement For Sheet Flow Between Lots or Across Reserve Tracts of Land:

a. Provide a minimum 20-foot Easement to accommodate sheet flow that is routed between lots or across reserve tracts.

5.2.04.F Combined Storm and Sanitary Sewer Easements:

1. Total combined Easement width shall be rounded up to the nearest multiple of 5-feet.

2. For combined storm and sanitary sewer Easement not contiguous to the Public Right-of-Way or Semi-Public Right-of-Way:

   a. Combined Easement width shall be as specified in Article 5.2.04.D.2.b and Article 5.2.04.E.1.b, whichever is greater.

   b. The centerline of sanitary sewer lines or force mains shall be located not less than 10-feet from the edge of the Easement Boundary.

   c. Minimum horizontal clearance between the exterior of any storm sewer and either Easement Boundary shall be as required by Table 5.2, Note 2.

3. For combined storm and sanitary sewer Easements contiguous to Public or Semi-Public Right-of-Way:

   a. Combined Easement width shall be as specified in Article 5.2.04.E.1.b or a minimum width equal to the depth of the proposed sanitary sewer line, whichever is greater.

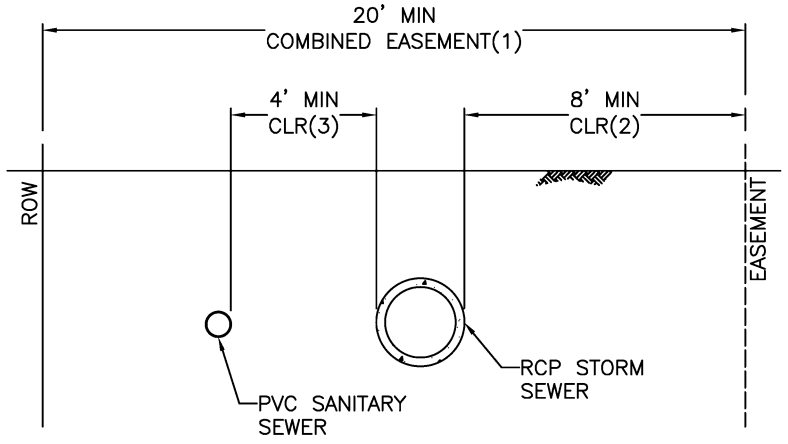
   b. When sanitary sewer lines are placed nearest to the Outer-Easement Boundary of combined Easements, the centerline of sanitary sewer lines or force mains shall be located not less than 10 feet from the edge of the Easement.

   c. When storm sewers are placed nearest to the Outer-Easement Boundary of combined Easements, the minimum horizontal clearance between the exterior of any storm sewer and the Outer-Easement Boundary shall be as required by Table 5.2, Note 2.

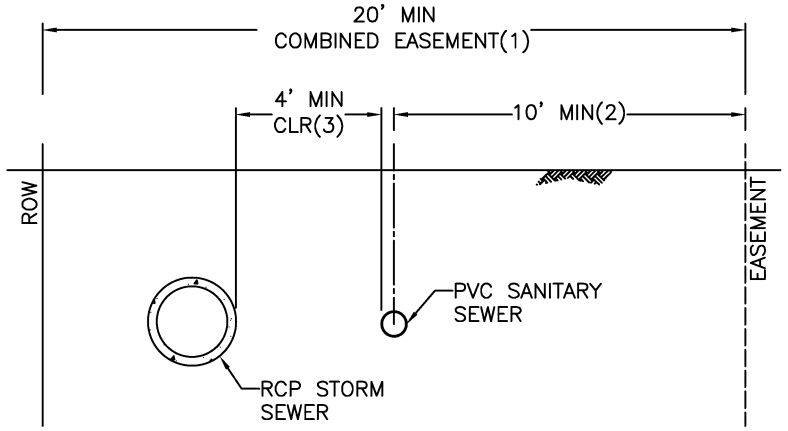
   d. See Figure 5.1 for an example to be used as a visual aid for these requirements. Figure 5.1 is not a substitute for the requirements in this section.

5.2.04.G No variances will be approved by the City Engineer unless there are extenuating circumstances.

5.2.04.G
continued



CASE (A):
STORM NEAREST TO OUTER EASEMENT BOUNDARY AND UTILITY DEPTH LESS THAN 15 FT



CASE (B):
SANITARY SEWER NEAREST TO OUTER EASEMENT BOUNDARY AND UTILITY DEPTH LESS THAN 15 FT

FIGURE NOTES:

(1) EASEMENT WIDTH SHOWN AS AN EXAMPLE AND IS NOT TYPICAL. SEE ARTICLE 5.2.04.F.3 FOR MINIMUM EASEMENT WIDTH REQUIREMENTS
(2) PIPE LOCATION AND HORIZONTAL CLEARANCE SHOWN AS AN EXAMPLE AND ARE NOT TYPICAL. SEE ARTICLES 5.2.04.F.3.b AND 5.2.04.F.3.c FOR REQUIREMENTS
(3) PIPE HORIZONTAL CLEARANCE SHOWN AS AN EXAMPLE AND IS NOT TYPICAL. SEE ARTICLE 5.2.04.A FOR CLEARANCE REQUIREMENTS

Figure 5.1 – SECTION VIEW EXAMPLES OF COMBINED STORM AND SANITARY SEWER EASEMENTS CONTIGUOUS TO PUBLIC RIGHT-OF-WAY (CASES A & B)

END OF CHAPTER

City of Houston

Design Manual

Chapter 6

UTILITY LOCATIONS

Chapter 6
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Utility Locations

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Chapter 6

UTILITY LOCATIONS

SECTION 1 - UTLITY LOCATIONS OVERVIEW

6.1.01 CHAPTER INCLUDES

6.1.01.A Location of utilities in rights-of-way and easements.

6.1.02 REFERENCES

6.1.02.A Typical utility location in 10-foot-wide and 14-foot-wide easements in back-to-back lots and perimeter lots as detailed in the most current drawing prepared by the Uniform Color Code (UCC).

6.1.02.B Typical utility locations within City rights-of-way.

6.1.02.C ASCE. (2002, October). Standard guidelines for the collection and depiction of existing subsurface utility data. American Society of Civil Engineers.

6.1.03 DEFINITIONS

6.1.03.A Easements - Areas set aside for installation and maintenance of utilities by public and private utility companies.

6.1.03.B Private Utilities - Utilities belonging to, operated, and maintained by private entities.

6.1.03.C Public Utilities - Utilities belonging to, operated, and maintained by public entities

6.1.03.D Right-of-Way - Public property dedicated or deeded to a municipality for the purpose of public use.

6.1.03.E Storm Sewer Lines - Closed gravity (non-pressure) conduits designed to collect and transport storm water from inlet locations to an open conduit outfall, ditch, creek, stream, bayou, river, holding pond, or bay. Inlets are surface mounted basins designed to collect and funnel storm water to the collection system. Storm sewers from the inlets to the collection system are usually defined as inlet leads.

6.1.03.F Subsurface Utility Engineering (SUE) – A branch of engineering practice that involves managing certain risks associated with utility mapping at appropriate quality levels, utility coordination, utility relocation design and coordination, utility condition assessment, communication of utility data to concerned parties, utility relocation cost estimates, implementation of utility accommodation policies, and utility design[1].

6.1.03.G Type 1 Permanent Access Easement - A permanent access easement at least 50 - feet in width that is designed and constructed like a public street in accordance with the design manual and contains one or more public utilities in an unpaved portion of the easement. Refer to Chapter 42 of the Code of Ordinances.

6.1.03.H Water Lines - Closed conduits designed to distribute potable water for human consumption and to provide fire protection. Line size and fire protection accessory locations are dependent on distance from primary source and quantity demand.

6.1.03.I Wastewater Sewer Lines - Closed conduits designed to collect and transport wastewater from residential, commercial, and industrial sites to plants for treatment prior to discharge into open conduits. Wastewater lines may be designed as gravity (non-pressure) flow lines or force (pressure) mains. Gravity flow lines usually fall into three categories in ascending size from service line to lateral line to main line. Service lines (source of wastewater) may discharge into a lateral line or main line.

[1] Refer to paragraph 6.1.02.C (ASCE, 2002)

SECTION 2 - UTLITY LOCATION DESIGN REQUIREMENTS

6.2.01 DESIGN REQUIREMENTS

6.2.01.A Whenever practical, locate public storm sewer, wastewater collection lines, water mains, and appurtenances within public rights-of-way in the manner described by this and corresponding subject-specific chapters in this manual, as well as related details and specifications.

6.2.01.B Research and resolve known conflicts of proposed utilities with existing utilities according to subject-specific criteria developed by the utility owner(s).

6.2.01.C Locate back lot utilities in compliance with UCC recommendations.

6.2.01.D Identify all existing and proposed utilities and related appurtenances in the manner established by the subject-specific chapters in this manual.

6.2.01.E Conduct where appropriate, a subsurface utility exploration (SUE) to definitively locate potential utilities (public and private) that are in conflict with the project. Located utilities shall be shown on the plans as "location verified" with the quality level of SUE listed.

1. Levels of SUE as defined by ASCE 38-02[2]

    a. Utility quality level A:

        1) Precise horizontal and vertical location of utilities obtained by the actual exposure (or verification of previously explored and surveyed utilities) and subsequent measurement of subsurface utilities, usually at a specific point.

        2) Minimally intrusive excavation equipment, such as vacuum excavation, is typically used to minimize the potential for utility damage.

        3) A precise horizontal and vertical location, as well as other utility attributes, are shown on plan documents.

        4) Accuracy is typically set to 15-mm vertical, and to applicable horizontal survey and mapping accuracy as defined or expected by the project owner.

[2] Refer to paragraph 6.1.02.C (ASCE,2002)

6.2.01.E.1 continued

b. Utility quality level B – Information obtained through the application of appropriate surface geophysical methods, such as pipe and cable locators, terrain conductivity methods, metal detectors, and ground-penetrating radar, to determine the existence and approximate horizontal position of subsurface utilities. Quality level B data should be reproducible by surface geophysics at any point of their depiction. This information is surveyed to applicable tolerances defined by the project and reduced onto plan documents.

c. Utility quality level C – Information obtained by surveying and plotting visible above-ground utility features and by using professional judgment in correlation with this information to quality level D information.

d. Utility quality level D – Information derived from existing records or as-builts.

2. Level of SUE Required

a. For private projects, if a quality level C or D SUE indicates that the proposed utility has a horizontal or vertical clearance that is less than what is required in this manual for water lines or sanitary sewer force mains, a quality level B SUE is required to confirm location of the existing water line or force main. If a quality level B SUE cannot provide an accurate horizontal and/or vertical location of the water line or force main, a quality level A SUE is required. If a quality level A SUE is required and the proposed utility is parallel to the existing water line or force main, the quality level A SUE is required at intervals of every 500 feet within the limits where there is less than sufficient horizontal clearance as indicated by the quality level B, C or D SUE. A quality level A or B SUE must be provided in order to be granted a variance for utility clearance.

b. For private projects in which underground trenchless construction will be performed, if a quality level C or D SUE indicates that the proposed utility will cross (above or below) an existing water line or sanitary sewer force main with less than 10 feet of vertical clearance from exterior of the existing water line or force main to exterior of the proposed utility, a quality level A or B SUE is required to confirm the location of the existing water line or force main. If minimum clearances cannot be maintained, see article 6.2.01.E.2.a.

c. At a minimum, a topographical survey equivalent to a quality level C SUE is required for every project in which excavation equal to or deeper than three (3) feet is performed and any other project in which the City requests a quality level C SUE. Driveway projects do not require a quality level C SUE.

6.2.02 SUBMITTALS

6.2.02.A Submittals are to be made according to the criteria established by the utility owner(s)

6.2.03 QUALITY ASSURANCE

6.2.03.A All existing utilities must be shown on project drawings. Sources of data include survey, record drawings, graphical information systems, and field visits. Field visits must be made to verify the project drawings accurately portray the existing conditions.

6.2.04 DESIGN

6.2.04.A Back Lot Utilities: Identify type of electrical service and select the appropriate width of the easement. For mixed overhead and underground service select the 14-foot-wide easement to provide versatility.

6.2.04.B Water Lines

1. Water lines may be located within a public right-of-way, within a Type 1 permanent access easement with overlapping public utility easements, within a dedicated easement adjacent to and contiguous with the right-of-way, or within separate dedicated water line easements, to meet the requirements of this manual. Water lines and related appurtenances shall be as specified in the subject-specific chapter(s) in this manual, as well as related details and specifications.

2. Water lines shall not be located in combination easements without approval of Houston Public Works. Water line easements shall not be combined with wastewater sewer easements.

3. Water lines, with the exception of transmission lines, shall be located within the right-of-way between the property line and back of curb or in a dedicated easement adjacent to and contiguous with the right-of-way.

4. Water lines and fire hydrants shall not be located in State rights-of-way. Water lines and fire hydrants should be located outside of the right-of-way in a separate contiguous easement. Width of easements shall be as provided in Paragraph 5.2.04.C.1.e & 5.2.04.C.2 Existing interagency utility agreements between the City and the State within State rights-of-way may supersede this requirement. Agreements shall be provided upon request for review and applicability.

6.2.04.C Wastewater Lines

6.2.04.C. continued

1. Wastewater lines shall be located in a public right-of-way, within a Type 1 permanent access easement with overlapping public utility easements or within a dedicated easement adjacent to the public right-of-way. Side lot easements may be used when required. Backlot easements shall not be utilized except in cases of pre-existing conditions and with approval of the City. Wastewater, force mains, and related appurtenances shall be as specified in the chapter (7, 8, and 9) in this manual, as well as related details and specifications.

2. Wastewater trunk or collector mains shall not be located inside lot easements without approval of the City.

3. Wastewater gravity sewer trunks, collector mains, and force mains shall be generally located on the opposite side of the right-of-way from the water main.

4. Wastewater force mains are generally located within the right-of-way between the property line and the back of curb, or in a dedicated easement adjacent and contiguous with the right-of-way.

5. When wastewater or force mains are parallel to the storm sewer, they shall not be constructed in the same theoretical trench widths.

6. Wastewater Sewer Lines shall not be located in State rights-of-way. Wastewater Sewer Lines should be located outside of the right-of-way in a separate contiguous easement. Width of easements shall be as provided in Paragraph 5.2.04.D.2 & 5.2.04.D.3 Existing interagency utility agreements between the City and the State within State rights-of-way may supersede this requirement. Agreements shall be provided upon request for review and applicability.

6.2.04.D Storm Water Lines

1. Storm water lines shall be located within public rights-of-way, within a Type 1 permanent access easement with overlapping public utility easements or approved easements. Approval of the location for storm water lines should be obtained from Houston Public Works prior to plan preparation.

2. Coordinate the proposed storm sewer alignment with water line location and future pavement widening.

6.2.04.E Private Utility Lines/Underground Structures

6.2.04.E continued

1. Proposed work, location, and placement of utilities shall be submitted to the Office of the City Engineer for review and permitting. A minimum separation distance of either three feet (or more as stated in other portions of this design manual and/or related specifications, standards, or details) of horizontal clearance when parallel, and two feet (or more as stated in other portions of this design manual and/or related specifications, standards, or details) vertical clearance when crossing, shall be maintained between the exterior of all private utilities and public utilities.

2. For other underground structures (e.g. foundations, footings, piers, posts, poles, etc.) that are greater than 3 feet deep, a minimum horizontal clearance of 5-feet shall be maintained between the exterior of private underground structures and public utilities.

3. Structures shall not be imbedded within sidewalks.

4. All proposed work must be coordinated with the City of Houston Capital Improvement Program.

5. Above-ground utility structures and appurtenances shall have a minimum of three feet of horizontal clearance from the right-of-way, unless approved by the City Engineer. Utility poles should be placed within two feet of the ROW line, unless approved by the City Engineer. These clearances do not apply to wireless service facilities: See Chapter 16. In no case shall above ground utility infrastructure from one utility entity be located within a clear distance of other infrastructure (retaining wall, exterior wall, trees, planters, light poles, traffic signals, other utility entity's infrastructure, etc.) that prevents use / travel along the sidewalk's path by persons in wheelchairs.

SECTION 3 - UTILITY LINES ON CITY OF HOUSTON BRIDGES AND OTHER STRUCTURES

Utilities mounted to bridges that go over waterways that fall under the jurisdiction of the Army Corp of Engineers, must meet their requirements and are subject to their approval.

6.3.01 UTILITY LINES ON CITY BRIDGES OVERVIEW

6.3.01.A These criteria are not applicable when removing and replacing a utility in kind on a bridge structure.

6.3.01.B The following information is adapted from the Texas Department of Transportation Bridge Project Development Manual, Chapter 4: Advanced Planning, Section 4: Utility Attachments; March 2018 Edition.

6.3.01.C To every extent possible, do not attach utility lines to bridges and separation structures because the proliferation of such lines and their maintenance constitutes a hazard to traffic and complicates widening or repair. Attaching utility lines to a bridge structure can materially affect the structure, the safe operation of traffic, the efficiency of maintenance, and the overall appearance.

6.3.01.D Where other arrangements for a utility line to span an obstruction are not feasible, Houston Public Works may consider the attachment of such line to a bridge structure. Any exceptions that are permitted will be handled in accordance with the conditions set forth in Title 43 TAC, Section 21.35 and 21.37 (relating to utility structures) and other pertinent requirements contained therein. Each such attachment will be considered on an individual basis and permission to attach will not be considered as establishing a precedent for granting of subsequent requests for attachment.

6.3.01.E Written permission is required from TxDOT's Bridge Division Office for any utility attachments to on-system bridges. On-system bridges are Federal-Aid highway/roadway bridges. In addition, written permission is also required from the City of Houston (Houston Public Works – Street and Bridge Maintenance) for these any utility attachments to on-system bridges. The reason is that the City of Houston is a stakeholder in terms of taking over maintenance of the bridges, and these bridges, because they cross City of Houston water bodies, watersheds, roads, paths, etc. Permit requests to perform the attachment work to on-system bridges shall be submitted to Office of the City Engineer (see paragraph 6.3.06) as well as any other regulatory agency with jurisdiction.

6.3.01.F Written permission is required from Houston Public Works - Street and Bridge Maintenance for any utility attachments to off-system bridges within the City of Houston's jurisdiction. Off-system bridges are non-Federal-aid roadway bridges.

6.3.01.G Permit requests to perform the attachment work to off-system bridges shall be submitted to Office of the City Engineer (see paragraph 6.3.06).

6.3.01.H Considerations for allowing or rejecting attachment of utilities to bridges include, but are not limited to the following:

1. Painting of Steel Bridges: Utility attachments may limit the ability of Bridge Maintenance crews to sandblast (prep) and paint steel bridge components. Panting is critical in maintaining steel bridges and extending their useful service life.

2. Hazardous Liquid or Gas Utility Lines: Requests for such lines will be reviewed on a case by case basis. Shut off valves may be required on either side of the bridge.

3. Bridge Maintenance / Repair: Some bridge maintenance / repair work may require vertical displacement of the bridge deck. This work includes replacing bearing pads, repairing bridge columns, or other bridge repair work. Such displacements may damage rigid pipe utilities, used for transporting liquids or gas, or utility conduits, used for carrying cable utilities.

4. Added Cost: There may be added cost for incorporating utility attachment to a bridge. This cost may be comprised of design costs, material costs, construction costs, change orders, schedule delays, etc.

5. Proposed attachment details submitted by the utility owner and the impacts the details may have on the bridge/structure.

6.3.02 DECISION AND NOTIFICATION TO ALLOW ATTACHMENT

6.3.02.A If it is decided to allow utility attachment to a bridge, written permission (Letters of Decision or Issuance of No Objection) will be issued. The following terms and conditions are associated with allowing a utility line to be attached to a bridge or other structure: These terms are not an all-inclusive list, and additional site-specific additions may be required.

1. Maintenance of utility, including all conduit and attachment material for supporting the utility on the bridge (or other structure) shall be the responsibility and at the cost of the utility owner.

2. The City of Houston is not responsible for any damage or out-of-service losses associated with the utility, its conduit (if applicable), coatings, or attachment hardware resulting from any event, including but not limited to bridge repair and maintenance work, such as sand-blasting and painting, raising the deck to replace bearing pads, and any other bridge repair or maintenance activities.

6.3.02.A continued

3. Utility owner shall remove its utility line, conduit, and attachments at the request of the City of Houston at any time. This includes, but is not limited to, shut down, disruption of service, de-inventory / evacuating of a liquid or gas utility pipeline, inerting a flammable liquid or gas utility pipeline, swabbing / cleaning a hazardous liquid pipeline, and traffic control for work areas and potential dropped object zones above roadways. Timing may be immediate if required to protect public safety or the environment. Timing may be urgent for bridge maintenance work. Removal shall be at the expense of the utility owner.

4. The utility owner shall reimburse (pay) the City of Houston Public Works all costs realized by the city to review and facilitate the supported utility on a bridge. The costs may include engineering / design services costs, material costs, and construction costs for new bridges/structures in the design process (not yet existing or being reconstructed) or for a third-party engineering contractor(s) or supplier(s) to review attachment details for existing bridges. The utility owner will still be responsible for reimbursement (payment) of costs realized by the city to review and facilitate the utility attachment if the utility owner ultimately decides not to attach its utility to the bridge for any reason.

5. Utility owner will be responsible for all costs associated with installation and attachment of the utility. This includes, but is not limited to, installation of the utility into pre-existing or pre-installed conduits if available, condition assessment of pre-existing conduits, attachment hardware for supporting the utility, tie-ins, materials not pre-installed by the City of Houston, electrical isolation and grounding of the utility as applicable, removal of existing conduit and attachments that may be inadequate, damaged, or corroded, work to install new conduit and attachment hardware, development and implementation of traffic control plans for the work, and installation execution plans.

6. Permits are required for performing the actual work of attaching the utility. Permit requests for the work shall be submitted to Office of the City Engineer (see paragraph 6.3.06).

6.3.03 OVERALL DESIGN GUIDELINES

6.3.03.A All requests for attachments to an existing City of Houston bridge/structure must be submitted to the City's Bridge Maintenance Office.

6.3.03.B All requests for attachments to a new City of Houston bridge/structure in the design process (not yet existing or being reconstructed) must be submitted to Houston Public Works – Street and Bridge Maintenance, / Interagency Coordinator in consultation with the Bridge Maintenance Office. Requests should be submitted (and addressed) as early as possible in the design process to minimize the cost to the City of Houston in the form of design changes, schedule delay, and change orders.

6.3.03.C All new bridge structures should include conduit for future utilities, per TxDOT's current design standards.

6.3.03.D Attachment Locations

1. Recommended attachment locations are on the overhang, as close as possible to the outside beam, or behind the outside beam. Behind the outside beam is preferred.

2. Hanging lines on the outside of the beams is not aesthetically pleasing and may be subject to vandalism. Attachments to water crossing structures should be placed on the downstream side where exposure to high water is less likely.

3. Bridge attachments shall not be made to any bridge rail or rail hardware, including anchor bolts. Bridge rails are the most susceptible to damage caused by motor vehicles, and hence are not a suitable location for utility placement. This will reduce the risk of damage to the utility, and it will reduce the need to get the utility owner involved when bridge rail repair is performed.

4. Do not hang lines from the bottom of beams. This decreases freeboard (water crossings) and clearance (road crossings), and hence increases the likelihood of damage.

5. It may be beneficial to carry lines across an obstruction using a separate utility structure rather than an attachment to a City of Houston Public Works bridge / structure.

6.3.04 DESIGN GUIDELINES PER TYPE OF UTILITY

6.3.04.A Communication Lines

1. When it is impractical to carry a self-supporting communication line across a stream or other obstruction, Houston Public Works may permit the attachment of the line to its bridges. On existing bridges, Houston Public Works generally requires that the line be enclosed in conduits and located on structures such that it does not interfere with stream flow, traffic, or routine maintenance operations. When a request is made prior to construction of a bridge, suitable conduits will be provided in the structure if the utility company bears the cost of all additional work and materials involved.

6.3.04.B Gas or Fuel Utility Lines

1. No gas or liquid fuel lines may be attached to a bridge or grade separation structure without the specific permission from Houston Public Works. Note that attachment of US Department of Transportation (49 CFR 192 and 49 CFR 195) transmission pipelines and attachment of oil and gas production flowlines/pipelines to City of Houston bridges and other structures are strictly prohibited. Transmission pipelines and production flowlines/pipelines require their separate and dedicated ROW and bridge/crossing. The only exception is that consideration may be given to temporary water or saltwater pipelines (Paragraph 6.3.04.E). See paragraph 6.3.04.D regarding costs.

6.3.04.C Power Lines

1. Power lines are not permitted on bridges under any condition with the exception of low-voltage distribution lines where the cost of independent facilities to carry these lines would be prohibitive. For this requirement, low-voltage lines must carry 600 volts or less.

6.3.04.D Utility Pipelines

1. When a utility company requests permission to attach a pipeline to a proposed bridge prior to construction, and the added load is sufficient to require an increase in the strength of the structure or use of more costly materials or type of construction, the utility owner is required to pay for the increase in cost.

6.3.04.E Temporary Water Lines or Saltwater Pipelines

1. Temporary water lines are sometimes requested to be attached to bridges by companies in the oil and gas industry. If considered, special review and procedures will be required to assure that leaks during operation and an approved de-inventory, swabbing/cleaning/pigging, air-drying, and containment procedure(s) does not cause accelerated corrosion of the bridge/structure when a line is removed. See paragraph 6.3.04.D regarding costs.

6.3.05 REQUESTS TO ATTACH A UTILITY TO AN EXISTING BRIDGE

6.3.05.A All requests shall be sent to the Bridge Maintenance Office and each request may include the following as determined applicable by Bridge Maintenance Office:

1. Alternatives Study
2. Hydraulic Impact Analysis (stream analysis and/or scour analysis)
3. Stress analysis showing the effect of the added load on the structure.

6.3.06 PERMITTING OF UTILITY WORK ON THE CITY OF HOUSTON BRIDGES

6.3.06.A All third-party utility work shall be submitted to the Office of the City Engineer for reviews and permitting.

6.3.06.B Plans shall:

1. Show proposed location of attachment
2. Show specific detail for the attachment
3. Identify materials
4. Traffic Control Plans, including staging, for all work areas
5. Traffic Control Plans, including staging for all dropped object zones for roads being crossed by a bridge on which utility attachment work is being conducted.
6. Installation execution plans
7. Provide Letters of Decision/Issuance of No Objection from the Bridge Maintenance Office for off-system bridges and written permission from TxDOT, with additional written permission from City of Houston Public Works for flammable or hazardous liquid utility pipelines, for on-system bridges.

END OF CHAPTER

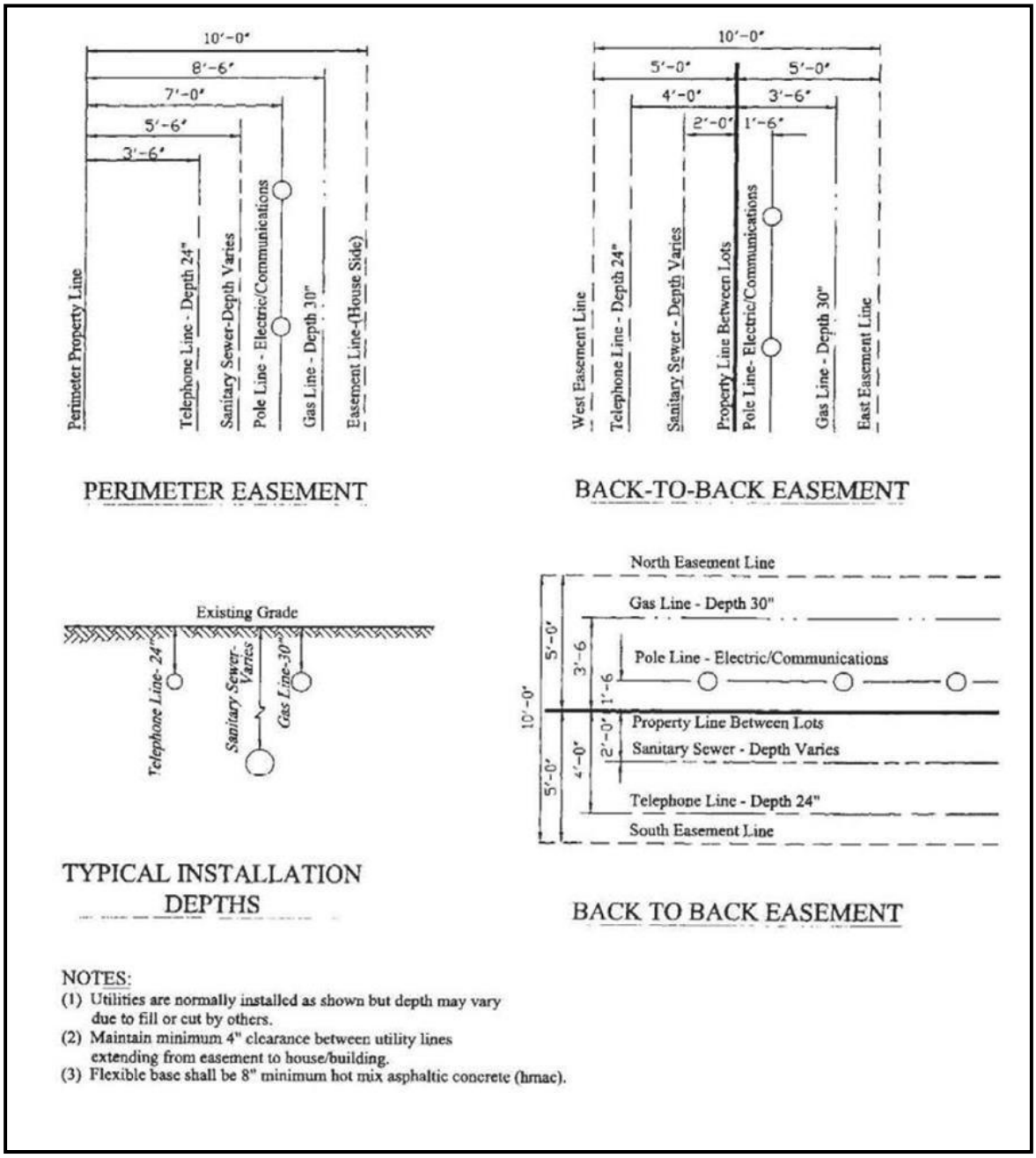


Figure 6.1 - TYPICAL UTILITY LOCATIONS IN 10-FOOT WIDE RESIDENTIAL EASEMENT

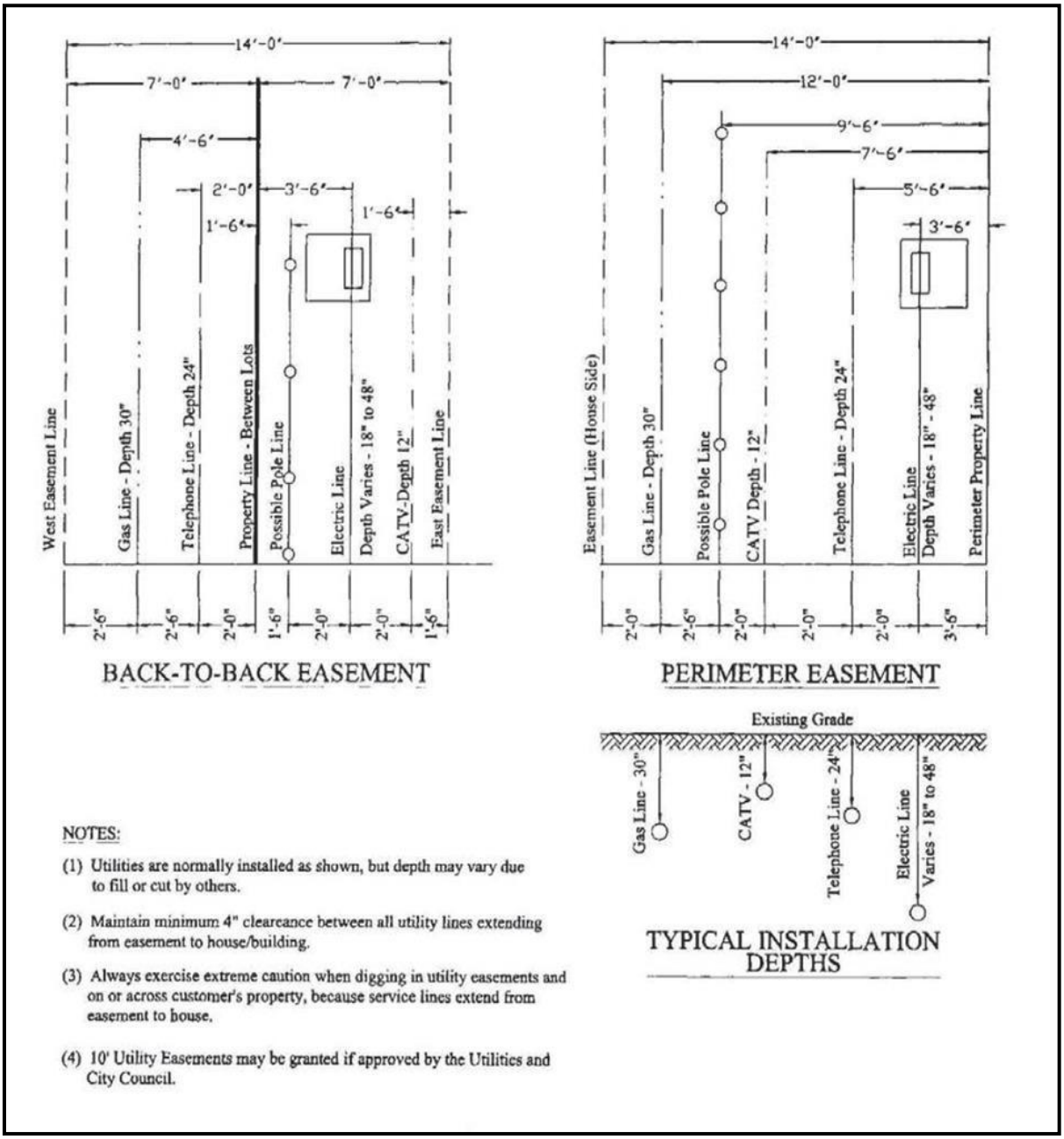


Figure 6.2 - TYPICAL UTILITY LOCATIONS IN 14-FOOT WIDE RESIDENTIAL EASEMENT
(NO BACKLOT SEWER)

City of Houston

Design Manual

Chapter 7

WATER LINE DESIGN REQUIREMENTS

Chapter 7
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Water Line Design Requirements

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Chapter 7

WATER LINE DESIGN REQUIREMENTS

SECTION 1 - WATER LINE DESIGN OVERVIEW

7.1.01 CHAPTER INCLUDES

7.1.01.A Criteria for the design of water lines.

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

7.1.02 REFERENCES

7.1.02.A American Water Works Association (AWWA).

7.1.02.B National Sanitation Foundation (NSF).

7.1.02.C Uniform Plumbing Code, latest edition and local amendments that the City has adopted[1].

7.1.02.D AASHTO LRFD Bridge Design Specifications, The American Association of State Highway and Transpiration Officials (AASHTO), latest edition.

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

7.1.02.F City of Houston IDM Chapter 13, Geospatial Data Deliverables.

7.1.02.G Vipulanandan, C., and Qiao, W. (2010). *Small Diameter Water Pipelines: Performance, Maintaining, Monitoring and Repairing* (Report No. CIGMAT/UH 1/9-2010).

7.1.03 DEFINITIONS

7.1.03.A As-Built Drawings - Final revised drawings at completion of the project, submitted by the contractor to the Engineer of Record and City, that captures all changes in work during the construction process shown as revisions on the as-bid drawings.

7.1.03.B Engineer of Record - A professional engineer who seals drawings, reports or documents for a project.

7.1.03.C Record Drawings - Final revised drawings prepared by the Engineer of Record on the original as-bid drawings documenting significant changes in work based solely upon the marked-up As-Built Drawings, addenda, revisions, change orders and other data furnished by the contractor.

[1]Refer to weblink for requirements: https://www.houstonpermittingcenter.org/building-code-enforcement/code-development#agency-links-416

SECTION 2 - WATER LINE DESIGN REQUIREMENTS

7.2.01 DESIGN REQUIREMENTS

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

7.2.01.B Lines.

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

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

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

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

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

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

   f. The terminus of the line shall end with a plug and clamp.

   g. Dead-end water lines are prohibited, and existing dead-end water lines within reasonable reach of the proposed project shall be evaluated for connection and dead-end elimination.

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

      When adjacent cul-de-sacs are present, extend water line to the adjacent cul-de-sac under the following conditions:

      (a) Obtain an appropriately sized water line easement as per City requirements.

7.2.01.B.g.(1)
continued

(b) Install water lines, with restrained joints, and inside a continuous steel pipe casing, from ROW to ROW, where appropriate. Continuous casing cannot contain horizontal or vertical deflections.

(c) Extend water line along both sides of the street and loop.

(d) The diameter of the looped water line shall be of the same size as the diameter of water line perpendicular to the cul-de-sac. The diameter of the water line shall not exceed 8- inch within the cul-de-sac without approval from OCE.

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

(f) Fire hydrants shall be spaced as if only a single line existed.

h. Water lines that cannot be installed in the ROW and are installed in side-lot easements must have restrained joints and be inside a continuous pipe casing from ROW to ROW. Continuous casing shall not contain horizontal or vertical deflections. Diameter of pipe shall not exceed 12 inches. Provide isolation valves within 100 feet of each end.

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

j. Fittings through intersections shall be placed outside pavement limits whenever possible.

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

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

m. A continuous trace wire, such as high strength copper-clad steel for open trench installations, and extra high strength copper-clad steel for trenchless installation, shall be specified for new non-metallic water lines according to the standard details and specifications.

n. Customers shall not take pump suction directly from City water lines. Design appropriate backflow device or approved air gap downstream of the meter and show in the plans.

7.2.01.C Location, Depth of Cover, and Separation Requirements

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

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

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

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

2. Locations within an easement:. Refer to Chapter 5, Easement Requirements for minimum easements widths and water line location relative to easements.

3. Water lines and their appurtenances shall have minimum horizontal clearance of 4 feet as measured from each outside wall, to adjacent utilities, other than sanitary sewer.

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

7.2.01.C continued

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

6. Depth of cover

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

Table 7.2 - DEPTH OF COVER FOR WATER LINES

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

(1) Cement stabilized embedment required.
(2) Minimum 6 feet of cover where crossing railway.
(3) Water lines installed within predominantly high plasticity, fat clay (CH) soils shall be installed with an additional 2 feet of cover beyond the absolute minimum requirements (Vipulanandan & Qiao, 2010).

   b. Deflection of joints shall not exceed the maximum deflection recommended by pipe manufacturer.

   c. No vertical or horizontal offsets or bends allowed for water lines that require continuous casings.

   d. Offsets require callouts in the profile view of the drawings that match the required calculated minimum length of the restrained joint.

   e. Use restrained joint pipe for lines 20-inch diameter and smaller with less than 4 feet or more than 8 feet of cover. The following direct bury alternates may be used:

      (1) Ductile iron pipe pressure 250 psi with approved restrained joints.

      (2) PVC pipe with integral restrained joint system, or ductile iron restrained joints fittings, epoxy lined and coated. Use AWWA C900 DR 18 for PVC restrained joints. Use 250 psi AWWA C900 DR 14 for vertical offsets.

      Use only ductile iron and PVC products listed on OCE approved products list and/or in accordance with City Standard Specifications.

7.2.01.C.6.e continued

(3) For depth of cover greater than 16-feet, use ductile iron pipe or PVC inside continuous steel casing.

(4) Water line depth greater than 20-feet shall be minimized by all practical means.

7.2.01.D Appurtenances

1. Appurtenance location shall minimize conflicts with pavement, landscaping, other structures, other utilities, and vehicular traffic.

2. Isolation Valves

   a. Spacing - set at maximum distances along the line as follows, however, use sound engineering judgement to identify placing of valves, and any locations where additional valves may be necessary to enable isolation of any given segment of the water line for maintenance.

      (1) 4-inch through 12-inch diameter - 1000 feet.

      (2) 16-inch and 20-inch diameter - 2000 feet.

   b. Location:

      (1) Normally, locate valves at street intersections along the street right-of- way lines projected across the water line. Tapping sleeves and valves are excluded from this requirement. Maintain a minimum of 30 feet from the centerline of the outside rail. Do not propose valves inside ramps or at curbs.

      (2) Isolate fire hydrants and flushing valves from the water line with a valve located in the fire hydrant or flushing valve branch, closest to the tee. This valve shall not be located in the slope or flow line of roadside ditches.

      (3) Intermediate valves, not located on the projection of the right-of-way line, shall be located on lot lines or 5 feet from fire hydrants but not set in driveways.

      (4) Locate valves a minimum of 9 feet horizontally from sanitary sewer crossings and 4 feet horizontally from other utilities crossings.

      (5) Valves located near reducers shall be located on the smaller diameter pipe.

7.2.01.D.2.b continued

(6) Provide flanged outlet and mount isolation valve directly on the flange on any branches to larger diameter water line.

c. Valve Type (Unless otherwise specified):

(1) 20-inch and smaller - Gate valves.

(2) Gate valves should be used for all meter installation.

d. Number of Valves:

(1) Total number of valves at any water line intersection shall equal total number of lines leading out from the intersection point minus one, three valves for a cross, and two valves for a tee for 20-inch diameter lines and smaller. Fire hydrant branch tees are excluded from this requirement.

3. Air Valves (Air Release, Air/Vacuum, Combination)

a. Air valves are not required on water lines 12-inch and smaller except at aerial crossings.

b. Locate air valves in a manner that provides protection from tampering and vehicular traffic.

c. Vent piping is to be located along property (lot) lines whenever feasible. Avoid locating vent piping in esplanades.

d. Locate air valves such that inlet/outlet vent piping elevation is in accordance with the City of Houston Code of Ordinances Chapter 19 Section 19-33, or four (4) feet above natural ground whichever is greater.

e. Use of air valves shall be in accordance with acceptable engineering practice and sound engineering judgement. Typical applications are:

(1) Combination valve at high points.

(2) Combination valve along long descents at 1250 to 2500 feet intervals.

(3) Combination valves along decrease in downslopes.

(4) Combination or Air Release along long horizontal runs at 1250 to 2500 feet intervals.

(5) Air/Vacuum along long ascents.

(6) Air/Vacuum along decrease in an upslope.

7.2.01.D continued

4. Fire Hydrants and Flushing Valves

Firefighting capability is required to be at a minimum pressure of 20 psi under combined fire and drinking water flow conditions. The minimum fire flow for the residential area should be 1,500 gpm.

a. Spacing:

(1) Single-family residential development - 500-foot maximum spacing.

(2) All other developments - 350-foot maximum spacing.

b. Location in or along street right-of-way:

(1) Locate fire hydrants primarily at street intersections.

(2) Locate fire hydrants at point of curvature (PC) or point of tangency (PT) of the intersection curb radius, 3 feet behind curb or projected future curb.

(3) On streets with roadside ditches, set the fire hydrants within 5 feet of rights-of-way lines.

(4) Set intermediate fire hydrants on lot lines, as extended to pavement, when located between right-of-way intersections. These locations may be adjusted 5 feet either way to avoid driveways or obstructions. In either case, do not locate fire hydrants closer than 3 feet from curbed driveways or 5 feet from non-curbed driveways.

(5) a. Fire hydrants may be set in the esplanade section of City streets when locations at back of curbs are not feasible. In such cases, the preferred location is 7 feet behind back of curb to provide access for parkway mower. In no instance shall the fire hydrant be closer than 3 feet from back of esplanade curb or closer than 10 feet from esplanade nose.

b. Fire hydrants shall not be located between parallel adjacent Rail Tracts in Railway Transit Corridor.

(6) For commercial building with fire service connections, place an additional fire hydrant on the same side of the street as the required connection. This hydrant is not counted in fire hydrant spacing.

(7) Dedicated fire lines shall be labeled “Fire Line” in the drawings.

(8) The fire hydrant or blowoff valve shall be located considering adequate drainage to avoid flooding during flushing.

7.2.01.D.4.b continued

(9) Do not cut, plug and abandon or relocate fire hydrants for surface improvements. Explore alternate means to prevent tapping new connections into existing water lines, including curving or local narrowing of proposed sidewalks.

c. Location of fire hydrants or flushing valves outside and adjacent to street rights-of-way:

(1) The City Fire Marshall will establish and approve the location of fire hydrants and flushing valves in apartment complexes, platted private street developments, and other multi-family developments within the City.

(2) Locate fire hydrants and flushing valves in protected, easily-accessible areas behind curb lines.

(3) For fire hydrants which are located adjacent to water lines for fire protection constructed in 10-foot wide water line easements, the fire hydrant shall be centered in a minimum 10-foot by 10-foot separate easement.

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

e. Fire hydrants branches shall be designed to have a 5-foot bury where possible. No bends or offsets in a fire hydrant branch will be allowed. In case of conflict DIP fire hydrant leads may be used for a minimum of 3-foot of bury.

f. Fire hydrant leads shall have restrained joints.

5. Fittings

a. Normally use "all bell" (designated AB) for fittings for diameter 12-inch and smaller, unless a restrained joint (designated as RJ) is required to protect the water line from horizontal or vertical offsets. Provide calculations to determine limits of required restrained joints. Show the length of restrained joints on drawings in the profile view.

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

7.2.01.E Water Meter Service

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

    a. Obtain water meter count from City Project Manager.

    b. Obtained water meter count shall be confirmed for accuracy in the field at the time of the post survey walk through.

    c. Label all meter line sizes in drawings as per water meter report and any modifications made as a result of the project.

    d. For meters 2 inches and smaller and Shut-off valves (stop boxes), provide concrete meter boxes for meters located under sidewalks. Refer to Chapter 5, Easement Requirements, for easement requirements.

    e. For meters 3 inches and larger, provide plan and profile for OCE approval. Refer to Chapter 5, Easement Requirements, for easement requirements.

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

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

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

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

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

    k. Irrigation meters will require a backflow preventer of PVB type and shall be installed 12” above the highest sprinkler head.

    l. Water meters must be located outside of building structures.

7.2.01.E.1 continued

m. Both open and closed fire systems connected to the City of Houston water distribution system must be metered with a City of Houston approved fire rated meter.

(1) Open type fire systems, as defined in City of Houston Ordinance Chapter 47, must have a Reduced Pressure Zone Device (RPZ) or tank with air gap for back flow protection.

(2) Chemical injected fire systems are required to install a RPZ before injection point.

(3) Closed type fire systems, as defined in City of Houston Ordinance Chapter 47, must have a minimum double check valve backflow assembly.

n. Fire systems shall not be designed based on pressures obtained from fire flow tests which are indicative only as pressure at a given time; rather, with the understanding that system pressures fluctuate and that the City provides a minimum pressure of 35 psi during normal and 20 psi under combined fire and drinking water flow conditions.

2. Refer to Submittals Paragraph 7.2.02, and Drawings Paragraph 7.2.05 of this Chapter, for approval and drawing requirements for meter service leads 4-inch diameter and larger, and metered sprinkler connections.

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

4. Provide a dedicated water main easement for commercial developments with public on-site water mains for fire protection or, provide fire service meters adjacent to the public right-of-way with an above ground reduced pressure zone type backflow preventer downstream of the meter for each private fire line.

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

6. Services 2-inches and larger shall require connections to be designed and included in plan set to be submitted to the Office of the City Engineer for review and approval.

7. Reusing of an existing water service lead will only be allowed after the inspection by HPW inspectors.

7.2.01.F Water Line Crossings

7.2.01.F continued

1. Public and private utility crossings other than sanitary sewer: Where a water line crosses another utility other than a sanitary or storm sewer, a minimum of 12 inches of vertical clearance must be maintained between the outside wall of the water line and the outside wall of the utility. If there are provisions in this manual for other clearances, the more conservative will govern.

    a. Water line crossings shall be designated with an isolation valve on both sides of the crossing.

    b. Minimum horizontal and vertical clearance from existing PCCP water lines shall be 5 feet.

    c. Minimum horizontal and vertical clearance from existing Asbestos Concrete pipes that are to remain in service shall be 4 feet.

2. Stream or ditch crossings

    a. Elevated crossings, general:

        (1) Elevated crossings shall be designed in accordance with the City of Houston Code of Ordinances Chapter 19 Section 19-33, and shall not have the bottom of the water line pipe placed lower than the low chord of the nearest adjacent bridge. Floodplain Management Office (FMO) approval required.

        (2) Water lines shall be steel pipe and shall extend a minimum of 15 feet beyond the last bend or to the right-of-way line of the crossing, whichever is greater.

    b. Elevated crossings on existing structures:

        (1) 12-inch diameter and smaller water lines supported on existing or proposed bridges, must meet the following criteria. Coordinate location of lines, in advance, with OCE.

            (a) Have adequate structural capacity.

            (b) Have sufficient clearance above bent cap elevation for installation (including air valve(s)) under the bridge.

    c. Elevated crossings on separate structures:

        (1) Use a separate elevated supporting structure for 16-inch diameter and larger water lines unless otherwise approved by OCE. Locate separate structures a minimum of 10 feet clear from other existing or proposed structures.

7.2.01.F.2.c continued

(2) Support the line on columns spaced to accommodate structural capacity of the pipeline considering deflection and loading.

(3) Base column support design on soil capacity, spacing, loading, and structural requirements.

(4) Provide sufficient span length to accommodate the cross section of future widening of the stream or ditch, if available.

(5) Provide appropriately sized air release valves at the highest point of the water line.

(6) Provide pedestrian pipe guards on elevated crossings.

(7) Elevation of the bottom of the water line shall be located in accordance with the City of Houston Code of Ordinances Chapter 19 Section 19-33.

d. Underground Crossings:

(1) Provide a minimum 5-foot clearance above top of pipe to the ultimate flow line of the ditch.

(2) Provide sufficient length to exceed the ultimate future development of the stream or ditch.

(3) Water lines shall be restrained joint pipe in continuous steel casing and shall extend a minimum of 15 feet beyond the last bend or to the right-of-way line of the crossing, whichever is greater.

(4) No water line underneath detention pond or amenity lake is allowed.

(5) Water line shall be installed with an isolation valve on both sides with a 40 foot minimum clearance from the end of casing on at least one side.

3. TxDOT and County Road Crossings

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

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

7.2.01.F.3 continued

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

4. Railroad Crossings

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

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

c. Crossings are to be made perpendicular to rail.

d. Design Engineer shall use a licensed Corrosion Engineer to evaluate pipe and casing materials and the effect to and from rail systems, and to provide any design elements which may be necessary to protect water line from corrosion

5. Oil or Gas Pipeline Crossings: Do not use metallic pipe when crossing oil or gas lines unless using a licensed Corrosion Engineer with a properly designed cathodic corrosion protection system. Maintain a minimum 2-foot vertical separation between the pipeline and water line.

6. On-site Fire Loops within Commercial Developments

a. For commercial developments inside the City and in the ETJ requesting on-site water mains, comply with the following requirements to allow maintenance and future repair operations:

(1) Do not allow placement of structures, paved parking or equipment pads over the easement.

(2) Provide 20-foot-wide longitudinal pavement joints along easement lines where the water line is located under driveway.

(3) Fire loops should be placed under the unpaved and porous area except at driveway crossings .

(4) Fire loops maybe placed in the Type 2 permanent access easement meeting all other requirements.

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

7.2.01.G continued

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

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

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

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

7.2.01.H Open Cut Construction:

1. Limits of open-cut trenches shall be taken into account. Engineer shall avoid encroaching into backfill of other utilities.

2. Proper shoring in accordance with acceptable engineering practice shall be considered and specified where appropriate.

7.2.01.I Additional Requirements

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

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

3. Project schedule shall be determined with the understanding that the City's need to provide water to residents may result in denial to shutdown critical water lines during warmer peak demand months.

4. Project design shall consider the available construction zone. Change of depth of cover over existing PCCP water lines is not allowed. Any loading and vibrations near PCCP water lines shall be minimized.

7.2.01.J Connections to Existing Water Lines

1. Wet connections are normally preferred in any locations where:

   a. Existing water line is to be abandoned and a cut, plug & abandon is required to complete existing water line abandonment.

7.2.01.J.1 continued

b. Size on size connection is necessary and a full size tap is not feasible.

c. Limited work zone is available to perform a tap.

2. Tapping Sleeve and Valve connections are normally preferred when there is adequate work zone and clearances to existing utilities:

a. To tie into an existing line that will remain in service.

b. Connecting perpendicularly one standard pipe size smaller than the existing water line.

c. Needed to supply water for testing. A minimum of one Tapping Sleeve and Valve connection shall be provided per contiguous project, unless another water source is available.

7.2.01.K Circulation and Flushing for Water Quality:

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

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

7.2.01.L Interconnections

1. For interconnections between utility districts outside the City, written approval must be obtained from the TCEQ and provided to the City in the design submittal.

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

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

4. Customers shall not take pump suction directly from City water lines. Design appropriate backflow device or approved air gap downstream of the meter and show in the plans.

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

7.2.01.L continued

6. Agreement between districts shall provide for annexation of the meter site by one district and shall require the installation of a meter. The installation and full cost shall be provided by the district not annexing the meter site.

7. A connection between any public water systems and City of Houston requires written approval from TCEQ and shall be included in the design submittal to the City. If a customer has his own well or other supply, an appropriate backflow preventer or approved air gap must be installed to prevent water from flowing into City water lines.

7.2.01.M Water Lines Separation from Sanitary Sewers

1. Water Lines Parallel to Gravity Sanitary Sewers and Force Mains:

   Locate water lines a minimum of 9 feet horizontally apart, measured from outside wall to outside wall, when parallel to gravity sanitary sewers and force mains. Use the following procedure when stated separation cannot be achieved:

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

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

      Following alternate shall be used only, if the above cannot be achieved

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

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

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

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

7.2.01.M.2.b
continued

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

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

1. Minimum clearance is 2 feet for non-pressure rated SS and pressure rated SS (with at least 150 psi pressure rating). If less than 2 feet can not be achieved, then the line is to be encased.
2. Minimum clearance is 2 feet for non-pressure rated SS and 1 foot for pressure rated SS.
3. Required if existing SS is disturbed and/or there is evidence of leakage.
4. Not required for augered WL unless there is evidence of leakage, completely fill augered hole with bentonite/clay mixture.
5. Not required for augered SS, completely fill augered hole with bentonite/clay mixture.
6. Not allowed.
7. Both Waterline and Wastewater main or lateral must pass a pressure and leakage test as specified in AWWA C600 standards.
8. Restraint joint sections including water line protections shall be shown on profile view.

7.2.01.M continued

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

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

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

5. TCEQ Rules and Regulations for Public Water Systems shall apply if they are more conservative than the requirements set forth in this manual.

7.2.01.N Restraint System

1. Concrete thrust blocks may be approved on a case by case basis and may be used in conjunction with restrained joint system as approved or required by OCE. In cases where concrete thrust blocks are utilized, at a minimum the Engineer shall include block dimensions and locations on Drawings. The proximity to other utilities and structures must be taken into account when specifying the use of thrust blocks.

2. Joint restraint shall be calculated for all fittings that require thrust restraint. Joint restraints that require calculations shall be shown on plan.

7.2.02 SUBMITTALS

7.2.02.A Conform to the following submittal requirements in addition to those of Chapter 1 - General Requirements. An electronic copy in Adobe Acrobat (.pdf) format is required with all submittals. All .pdf files shall be flattened prior to submittal to the City and shall have a minimum of 400 dpi resolution. See additional requirements in Chapter 3 for electronic drawings submitted in .pdf format.

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

7.2.02.C Water Meter Service

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

7.2.02.C continued

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

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

7.2.02.E Interconnections

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

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

   b. Interconnections of districts.

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

3. Private interconnections to City water lines 24-inch and larger are not allowed.

7.2.02.F Record Drawings

1. After the completion of construction, Engineer of Record shall prepare and submit Record Drawings in accordance with Chapter 1 – General Requirements. Use revision clouds to document significant changes in work based solely upon the marked-up As-Built Drawings, addenda, revisions, change orders and other data furnished by the contractor. In addition, include the following:

   a. Any materials that were left in place by the Contractor such as shoring, or other elements.

   b. Water line pipe material(s) including the type of lining and coating. Document using either of the following methods:

      (1) Add the pipe material on the project Layout Sheet, in a tabular format, separated by station number when there is a change in pipe material.

      (2) If there is no project Layout Sheet, add the pipe material on the Notes Sheet, in a tabular format, separated by station number when there is a change in pipe material.

      (3) If there is no project Notes Sheet, add the pipe material on the Cover Sheet, in a tabular format, separated by station number when there is a change in pipe material.

7.2.02.F.1.b continued

(4) Label each plan and profile sheet, at the appropriate location.

c. For every different type of valve used in the project, include the water line valve manufacturer, number of turns, and direction to open. Document using either of the following methods:

(1) Add the valve information on the project Layout Sheet, in a tabular format, separated by station number when there is a change in valve type.

(2) If there is no project Layout Sheet, add the valve information on the Notes Sheet, in a tabular format, separated by station number when there is a change in valve type.

(3) If there is no project Notes Sheet, add the valve information on the Cover Sheet, in a tabular format, separated by station number when there is a change in valve type.

(4) Label on each plan and profile sheet, at the appropriate location.

7.2.02.G Geospatial Data Deliverables: Provide GIS datasets in accordance with Chapter 13 – Geospatial Data Deliverables for projects that are proposing or modifying assets identified in Chapter 13 that are or will be operated and/or maintained by the City.

7.2.03 QUALITY ASSURANCE

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

7.2.04 DESIGN ANALYSIS

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

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

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

7.2.05 DRAWINGS

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

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

1. Branch line extends 20 feet or more, and/or
2. Branch lines have vertical bends.
3. When proposed lines, including services larger than 2-inches, cross Railway Transit facilities.
4. Any water taps size 4" or larger.

7.2.05.C Appurtenances: Identify, describe, and enclose proposed water line and appurtenances in rectangular box on drawings. The location of all proposed water line, valves, fire hydrants, water meters and backflow preventors shall be identified and shown on drawings.

1. Valves
   a. Designate 2-inch through 16-inch gate valves with box as GV&B.
   b. Provide complete description and size for other valves.
2. Water meters, service leads, and un-metered sprinkler connections
   a. Show the location of service line tees, tapping sleeve and valves, valve boxes, and temporary plugs to be installed to serve future 2-inch diameter or larger meters.
   b. Label water meter types (domestic, irrigation, fire).
   c. Develop plan and profile sheets for 4-inch diameter and larger leads and connections.

7.2.05.D Construction Features

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

7.2.05.D continued

2. Trenchless Construction

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

   b. If construction is predominately by trenchless construction:

      (1) Clearly show on drawings, areas and locations in which trenchless pits will not be permitted.

      (2) Clearly identify areas where special pipe material or offset sections are required to comply with these guidelines.

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

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

7.2.05.E Future Planned Improvements.

1. When feasible, show and label as “Future, by Others” planned improvements by City, County, TxDOT, Metro, private entities which could impact the proposed water line, or aspects of its design.

7.2.05.F Refer to Chapter 11, Section 4, for geotechnical information required on the drawings.

END OF CHAPTER

APPENDIX A - ADDITIONAL DESIGN REQUIREMENTS FOR LARGE DIAMETER WATER LINES

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

1.01 DESIGN REQUIREMENTS AND CRITERIA

1.01.A Hydraulic Modeling:

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

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

   a. Design Velocity:

Table A.1 - DESIGN VELOCITY

SIZE OF LINE	Desired (ft.sec)	Maximum (ft/sec) *
≥ 24-inch & ≤ 36-INCH	3	5
≥ 42-INCH & ≤ 96-INCH	5	7
> 96-INCH	7	9

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

   b. Pipe Friction Factors:

Table A.2 - HAZEN WILLIAMS "C" FACTOR

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

1.01.A.2 continued

c. Maximum pressures anticipated are the greater of:

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

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

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

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

1.01.B Transient (Surge) Analysis

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

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

3. General Criteria

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

(1) Pipe material properties;

(2) Pipe wall thickness;

(3) Fluid properties; and

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

1.01.B.3.a continued

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

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

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

d. The allowable surge pressure range for each analysis shall be -5 psi to 150 psi. Additional criteria and assumptions used in the analysis shall be identified in a Technical Memorandum signed and sealed by a Professional Engineer licensed in the State of Texas and submit to the Project Manager for review with each submittal milestone.

1.01.C Alignment

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

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

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

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

1.01.C continued

5. Public and Private Utility Crossings: The minimum horizontal and vertical separations to a LDWL are summarized in Table A.3 and Table A.4, respectively. Engineer shall consider additional clearance based on material, age, depth of cover, condition of existing utility, and geotechnical conditions. Consideration shall be given to backfill zones of the existing and proposed utilities. Provide a special shoring design when trench width of existing water line with trench width of proposed utility overlap.

Table A.3 - MINIMUM HORIZONTAL SEPARATION REQUIREMENTS

Water Horizontal Separation Requirement [1][2]		Type of Parallel Utility [5]				
		Water Line	Non-Pressure Rated Sanitary Sewer [3]	Pressure Rated Sanitary Sewer [3]	Storm Sewer	All other Utilities/ Pipelines
LDWL Water Pipe Material	Fiberglass Reinforced Pipe	4 feet	9 feet	9 feet	4 feet	4 feet
	HDPE	4 feet	9 feet	9 feet	4feet	4 feet
	Ductile Iron	4 feet	9 feet	9 feet	4 feet	4 feet
	PCCP	5 feet or 1 WL Pipe Diameter whichever is greater	9 feet	9 feet	5 feet or 1 WL Pipe Diameter whichever is greater	5 feet
	Bar Wrap Concrete Cylinder	4 feet or 1 WL Pipe Diameter whichever is greater	9 feet	9 feet	4 feet or 1 WL Pipe Diameter whichever is greater	4 feet
	Steel	4 feet	9 feet	9 feet	4 feet	4 feet

(1) Minimum clearances are measured from outside of pipe to outside of pipe.

(2) Avoid overlapping trench width of proposed water line with trench width of existing utility, to the extent possible.

(3) Place 1 full section of SS centered at WL crossing and provide restraint joints on SS

(4) For water lines 54-inches in diameter and greater, provide at least 5 feet horizontal clearance from OD to OD from other buried utilities or buried structures.

(5) For possible reduction in separation limits, see Section 7.2.01.M.3.

1.01.C.5
continued

Table A.4 - MINIMUM VERTICAL SEPARATION REQUIREMENTS

Water Vertical Separation Requirement Table [1]		Type of Parallel Utility[3]				
		Water Line	Non-Pressure Rated Sanitary Sewer [2]	Pressure Rated Sanitary Sewer [2]	Storm Sewer	All other Utilities/ Pipelines
LDWL Water Pipe Material	Fiberglass Reinforced Pipe Above Utility	2 feet	2 feet	2 feet	2 feet	2 feet
	Fiberglass Reinforced Pipe Below Utility	4 feet	4 feet	4 feet	4 feet	4 feet
	HDPE Above Utility	2 feet	2 feet	2 feet	2 feet	2 feet
	HDPE Below Utility	4 feet	4 feet	4 feet	4 feet	4 feet
	Ductile Iron Above Utility	1 foot	2 feet	1 foot	2 feet	1 foot
	Ductile Iron Below Utility	2 feet	2 feet	2 feet	2 feet	2 feet
	PCCP Above Utility	6 feet	6 feet	6 feet	6 feet	6 feet
	PCCP Below Utility	5 feet	5 feet	5 feet	5 feet	5 feet
	Bar Wrap Concrete Cylinder Above Utility	4 feet	4 feet	4 feet	4 feet	4 feet
	Bar Wrap Concrete Cylinder Below Utility	6 feet	6 feet	6 feet	6 feet	6 feet
	Steel Above Utility	2 feet	2 feet	2 feet	2 feet	2 feet
	Steel Below Utility	3 feet	3 feet	3 feet	3 feet	3 feet

[1] Minimum clearances are measured from outside of pipe to outside of pipe.
[2] Place 1 full section of SS centered at WL crossing and provide restraint joints on SS.
[3] For possible reduction in separation limits, see Section 7.2.01.M.3.

1.01.C continued

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

7. Locate drain line outlets, at areas that will permit draining a majority of the pipe. Place at least one drain line outlet between high points and each set of in-line isolation valves.

    a. Where a local storm sewer system is within close proximity, design storm sewer leads from the drain line service manhole to a nearby drainage facility that is capable of accepting flow when draining the water line. System should be designed to drain by gravity, where possible. Do not connect into storm sewer system that is not owned by City.

    b. Where there is no City-owned storm sewer system within proximity, install drain line outlet and manhole without storm sewer lead.

    c. When flush water is expected to be drained into a storm sewer system owned by another entity such as TxDOT, obtain permit and comply with the owning entity's requirements.

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

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

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

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

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

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

    e. Add callout "CRITICAL LOCATE PER COH SPEC 02317" where:

        (1) Proposed water line crosses existing buried utilities where the horizontal and vertical location cannot be verified with field information.

        (2) Proposed work either crossing or within 10-feet of LDWL.

1.01.C continued

10. Required minimum clearances and separations from adjacent objects to the OD of the water line are required to be called out once per drawing sheet, if they are typical, and as many times as necessary to correctly show changing clearances and separations.

1.01.D Pipe Design Basis

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

2. Where different from standard specifications, design shall identify special features, such as: minimum wall thickness, special coatings, linings, shoring or joint requirements. Unusual or unique considerations shall be described in details and/or project specifications as necessary.

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

Table A.5 - PIPE MATERIALS

TYPE	SIZE (INCHES)
Fiberglass Reinforced Pipe	≤ 30
Ductile Iron	≤ 64
Prestressed Concrete Cylinder (PCCP)	≥ 24
Bar-Wrapped Concrete Cylinder	≤ 60
Steel	≥ 24

4. Engineer must evaluate the requirements for the project and make a recommendation for any specific pipe material in portions of the alignment where applicable. Submit to DWO for consideration. Criteria used to evaluate pipe material for specific installation shall include: system flexibility, hydraulic efficiency, manufacturer and availability, surge protection, corrosion protection, special crossing requirements, operational cost, maintenance, susceptibility to environment and cost.

5. Design drawings must incorporate accurate wall thickness, inside and outside diameter, thrust restraint lengths, bends, fittings, appurtenances.

1.01.D continued

6. Additional Requirements for PCCP and Bar Wrap Cylinder Pipe: The engineer shall also address the following minimum elements; assessment of loads on the adjacent utilities when installing pipe, additional horizontal and vertical clearances required to other utilities including the outside dimension of the pipe, ways to ensure the interior and exterior joints will be successfully grouted including the application and curing of the grout before proceeding with backfill operations, and impacts to power lines due to clearance issues with the equipment required to install the pipe.

1.01.E Corrosion Control

1. All LDWL projects must include corrosion protection recommendations incorporated into the design documents.

2. Corrosion monitoring and/or corrosion control recommendations to be provided by a NACE International certified Cathodic Protection Specialist or certified Corrosion Specialist (referred to herein as Corrosion Engineer) in accordance with the technical standards, test methods and recommended practices of NACE International, AMPP, ASTM, and AWWA as applicable.

3. Provide written Soil Corrosivity Study and include monitoring and/or corrosion control protection in the design.

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

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

   b. Name, firm and signature of Corrosion Engineer;

   c. Introduction to project and scope of work;

   d. Field soil resistivity testing procedures and results. Resistivities are to be collected at 20 feet, 15 feet, 10 feet, 5 feet and 2.5 feet below ground level – in coordination with the geotechnical borings. Layer resistivities for the above depths are also to be provided;

   e. Laboratory results of chemical analysis. The laboratory work shall include in-situ and saturated soil resistivities, pH, chloride ion, sulphate ion and bicarbonate ion levels;

   f. Interpretation of results/collected data;

   g. Determination of likelihood, sources and locations of stray AC and DC current;

   h. Sources of AC power (when impressed current cathodic protection is recommended), including coordinating power drop location with the utility owner.

1.01.E.4 continued

i. Soil corrosivity conclusions; and

j. Corrosion monitoring and/or corrosion control recommendations.

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

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

      (1) All pipe material and coatings available to the contractor.

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

      (3) Electrical Isolation from adjacent metallic pipelines, casing and structures. Unless otherwise specified, each project should be designed to be isolated from adjacent projects. Consider monolithic joints where isolation is critical.

      (4) Impact to and from external stray current interference sources (both AC and DC) along the alignment, including adjacent or crossing utilities. Include other buried utilities and pipelines subject to impressed current cathodic protection systems.

      (5) Testing locations. Test stations are to be placed in easily accessible locations and include coordination for connections to any foreign utilities recommended by corrosion engineer.

1.01.F Valves

1. Isolation Valves

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

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

1.01.F.1 continued

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

d. Maximum spacing shall correspond to Table A.6. Additional isolation valves may be required to provide operational flexibility of the overall system:

Table A.6 - ISOLATION VALVE TYPE AND SPACING

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

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

e. For butterfly valves, orientation of valve must be shown in Drawings.

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

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

2. Air Valves

a. Locate air valves such that inlet/outlet vent piping elevation is in accordance with the City of Houston Code of Ordinances Chapter 19 Section 19-33, or four (4) feet above natural ground whichever is greater. Vent elevation greater than four feet above natural ground shall require design of support details.

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

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

3. Other Valves

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

1.01.G Accessibility

1. Manholes

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

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

2. Access Manways

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

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

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

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

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

1.01.H Thrust Restraints

1. Thrust restraint for new lines shall be provided by means of restrained joints.

2. For connections to existing lines, supplemental restraint or blocking on the existing pipe may be necessary and should be evaluated for inclusion into the design.

   a. Evaluate existing pipe and provide methods as well as limits necessary to properly restrain existing pipe.

   b. Calculate restrained joint lengths or thrust block sizing for existing line when connecting proposed line to existing line.

1.01.H.2 continued

c. Obtain record information for existing line, including pipe lay schedule, if available, to determine location and type of existing joints.

3. Thrust restraint calculations shall be performed to determine the minimum restrained joint lengths and be based on the use of Prestressed Concrete Cylinder Pipe (PCCP), unless a specific pipe material is required, in which case the appropriate AWWA method for thrust restraint calculations should be used. Thrust restraint design calculations shall be signed and sealed by a professional Engineer and provided to the Project Manager prior to (90%) design submittal.

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

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

         (a) Working Pressure: 150 psi

         (b) Maximum Total Pressure Due to Surge: 225 psi

         (c) Field Test Pressure: 150 psi

      (2) Soil Parameters:

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

         (b) Pipe to soil friction factor based on saturated soil conditions

            i. PCCP, or other cement mortar coated pipe = 0.35

            ii. Tape coated, polyurethane coated or epoxy coated pipe (including epoxy over cement mortar coated pipe) = 0.30

            iii. For ductile iron pipe, reduce friction factor by 0.7 based on use of polyethylene encasement.

   b. Calculations for specific pipe materials shall be based on the following:

      (1) PCCP and Bar-Wrapped: See Table A.7 below:

1.01.H.3.b.(1) continued

Table A.7 - PCCP THRUST RESTRAINT DESIGN METHOD

Horizontal & Vertical Up Bends	Thrust Restraint Design Program (TRDP) (Latest Version)
Vertical Down Bends	AWWA M9, Third Edition, Eq 9-14
Minimum steel cylinder thickness	AWWA M9, Latest Edition

(2) Ductile Iron Pipe: AWWA M41 or DIPRA Thrust Restraint for Ductile Iron Pipe (latest edition).

(3) Steel Pipe: AWWA M11 (latest edition).

(4) Fiberglass Reinforced Pipe: AWWA M45 (latest edition).

c. Passive resistance of soil will not be permitted in calculation of thrust restraint for some pipe materials.

1.01.I Plant Connections and Expansions

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

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

1.01.J LDWL Interconnections: When making connections to existing LDWLs, specific piping layout design and details must be included with diagrams and support to avoid damage to existing LDWL. Details must be provided with scaled dimensions and showing locations and types of joints for existing LDWL.

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

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

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

1.01.K continued

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

4. TxDOT and County Road Crossings

   a. Steel tunnel liner is required for proposed LDWL.

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

5. Railroad Crossings

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

6. Oil and Gas Pipeline Crossings

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

7. Harris County Flood Control District (HCFCD)

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

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

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

1.01.L Minimum Easement Widths:

1. Refer to Chapter 5 “Easement Requirements” for LDWL easement requirements.

1.01.M Water line Shut-Down Requirements

1.01.M continued

1. Shut down of water line 24" and larger shall only occur during low-demand months (typically between November and February) and when DWO has determined the surrounding system is able to meet the water demands. Coordinate with DWO on the shut-down requirements and determine any additional requirements that need to be incorporated into the design. Drawings shall contain the following minimum notices for contractor to adhere to during construction:

    a. Contractor shall coordinate shut down plan with DWO at least 4 weeks before the scheduled shutdown.

    b. Contractor shall provide 48-hour advance notice to the DWO prior to water line shutdown and participate in a meeting with DWO to discuss detail and sequencing procedure for the proposed work.

    c. No shut down will occur unless all required material and equipment are on site.

1.02 INSTALLATION METHODS

1.02.A Open Cut Installation

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

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

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

4. Identify existing structures or features that may be impacted by zone of influence, and include protection measures, such as special shoring, where applicable.

1.02.B Trenchless Installation

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

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

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

1.02.B continued

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

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

5. Crossings with tunnel liner plates:

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

    b. For roadway crossings, live load shall include minimum HL-93 loading conditions as defined by AASHTO LRFD Bridge Design Specifications.

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

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

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

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

    a. For roadway crossings, live loads shall include minimum HL-93 loading conditions as defined by AASHTO.

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

    c. A minimum factor of safety of 2.0 shall be used with a maximum deflection of 3% in the casing calculations. Larger factors of safety may be required as determined by the Design Engineer.

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

1.02.C Installation Parallel to Existing LDWL

1. For trenchless parallel to or other excavations adjacent to existing LDWLs, design considerations must consider protection for the existing LDWL.

1.02.C continued

2. Obtain as built and lay schedule information for existing LDWL and perform SUE investigation as needed to verify horizontal and vertical location. Update Drawings based on findings.

3. Confirm that new water line can be installed without construction vehicles, equipment, or material staging over existing LDWL. Identify Limits of Construction which exclude area over existing LDWL. Identify the work zone restrictions on the Drawings so that no spoils or fill material can be placed over existing LDWL.

4. A minimum separation distance of at least 10 feet must be maintained between the outside diameter of existing LDWL and edge of trench or excavation.

    a. Where minimum 10-ft separation cannot be achieved, provide special shoring safety measures. Special shoring may be interlocking steel sheet piling or other approved system designed to prevent ground movements such as structures, pavements or utilities. Refer to Standard Specification 02317, Paragraph 1.08.

    b. Engineer to provide limits of special shoring on the drawings. Where applicable shoring is required, Contract Documents must include a guide specification establishing payment description and minimum requirements for special shoring.

5. For existing LDWLs that are flexible pipes, such as steel pipe, the existing LDWL must remain pressurized and in continuous service during construction operations. This is essential to limit risk of deflection and out-of-roundness of the existing line. Additionally, the pressurized pipe will lessen any effects on the open trench wall and decrease risk of collapse.

6. For propose work that will result in exposing the existing LDWL that is PCCP, coordinate with City of Houston of Houston Drinking Water Operations to review the feasibility and schedule the work.

1.02.D Above Grade Installation

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

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

1.02.D continued

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

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

1.02.E Special Construction Requirements for Work in Vicinity of Existing PCCP

1. Call out "Caution PCCP" for all work within 10-feet of PCCP waterlines.

1.03 ADDITIONAL SERVICES

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

1.03.B Subsurface Utility Engineering (SUE)

1. General Criteria

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

b. Perform utility quality levels D, C, B, as defined by Chapter 6 of this manual, on all projects, and level A in locations that is consistent with sound engineering judgement in accordance with Chapter 6 of this manual.

2. SUE Results

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

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

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

(2) Owner of the utility.

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

(4) Survey elevation of the top and at least one side of the utility at the test hole.

1.03.B.2.b
continued

(5) Survey elevation of existing grade over the utility at the test hole.

(6) Northing/Easting coordinates of the utility at the test hole.

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

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

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

(10) If the project is federally/state funded, then federal/state SUE requirements about shall be followed.

END OF APPENDIX A

City of Houston

Design Manual

Chapter 8

WASTEWATER COLLECTION SYSTEM DESIGN REQUIREMENTS

Chapter 8
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Chapter 8

WASTEWATER COLLECTION SYSTEM DESIGN REQUIREMENTS

SECTION 1 – WASTEWATER COLLECTION SYSTEM OVERVIEW

8.1.01 CHAPTER INCLUDES

8.1.01.A Criteria for the design of wastewater collection systems.

8.1.01.B This Chapter addresses the design of the wastewater collection systems within the public Right-Of-Way or a dedicated public easement. Sanitary sewers located on private property that are not in such a dedicated easement, are under the jurisdiction of the Plumbing Code, and will be reviewed by the Code Enforcement Branch.

8.1.02 REFERENCES

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

8.1.02.B City of Houston Engineering Design Guidelines Manual for Submersible Lift Stations.

8.1.02.C City of Houston Design Guideline Drawings for Submersible Lift Stations.

8.1.02.D Uniform Plumbing Code, latest edition and local amendments that the City has adopted[1].

8.1.02.E City of Houston IDM Chapter 13, Geospatial Data Deliverables.

8.1.02.F Refer to City of Houston Building Code Enforcement List of Adopted Codes[1]

8.1.03 DEFINITIONS

8.1.03.A Public Sewer - A closed conduit which conveys wastewater flow and which is located within a public Right-Of-Way, or a dedicated public sanitary sewer easement, or a Type 1 Permanent Access Easement (PAE) that is a minimum width of 50 ft . A public sewer is maintained and operated by the City and is intended to serve more than one residential, commercial, or industrial site. Refer to IDM Chapter 6 for definition of Type 1 Permanent Access Easement.

8.1.03.B Private Sewer - A closed conduit which conveys wastewater flow and is constructed and maintained by a private entity (e.g. homeowner's association). Private sewers may be located in areas such as a private street or common area. Private sewers are subject to the design and construction requirements of the Infrastructure Design

[1]Refer to weblink for City requirements: https://www.houstonpermittingcenter.org/building-code-enforcement/code-development#agency-links-416

8.1.03.B continued Manual or Plumbing Code, whichever is more stringent, and must discharge to public sewer.

8.1.03.C Service Lead – A portion of sanitary sewer pipe located within the public Right-Of-Way or public easement that connects a building sewer to a sewer main and is owned and maintained by the City. A service lead may not exceed 150 linear feet. No more than the equivalent of two single-family residences may be served by one service lead.

8.1.03.D Building Sewer – A private sewer that connects a building to a service lead that is wholly located within private property. If routed through another tract of land, it shall be located in a private easement, which will include the City as a third party in the easement documents. Building Sewers will be owned and maintained by the owner of the property being served, including portions that may be routed through another tract of land through a private easement. Design shall adhere to the Design Manual or Plumbing Code, whichever is more stringent.

8.1.03.E Community sewer - A private sewer that serves more than two single-family residences. Community sewer will adhere to this manual using an 8-inch pipe terminating in a manhole and will be located within a private easement, which will include the City as a third party in the easement documents. It will be owned and maintained by the owner(s) of the properties being served by the community sewer.

8.1.03.F Project Area - The area in the immediate vicinity of a public sewer to be constructed. This includes the entire road Right-Of-Way and any adjoining easements used for the proposed wastewater line construction.

8.1.03.G Stack - A minimum 6-inch riser pipe, constructed on public sewer or lead, with a maximum of 6-feet of cover on the stack. A stack will be used for connecting service leads to deep public sewers.

8.1.03.H Stub-Outs- A minimum 5-feet of sewer pipe extended from the manhole for future expansion and terminated with a sanitary sewer plug.

8.1.03.I Force Main- A pressure-rated conduit which conveys wastewater from one pump station to one discharge point.

8.1.03.J Single-family residence – A residential establishment serving a single family, or household, which may not include separate living quarters. In those instances where there is no meter on the water supply to the principal household, separate living quarters shall be considered as a separate residence and a separate sewer service charge shall be applied (Refer to City of Houston Code of Ordinances Chapter 47, Article III, Sec.47-121).

SECTION 2 - WASTEWATER COLLECTION SYSTEM DESIGN REQUIREMENTS

8.2.01 DESIGN REQUIREMENTS

8.2.01.A Drawings to be furnished

1. To obtain a permit for the construction of a proposed public sewer or service lead crossing a public Right-Of-Way to an existing public sewer, a plan and profile drawing of the proposed sewer shall be prepared and submitted to the City for approval.

8.2.01.B Drawing/Design Information

1. The detailed drawings will show the exact location of the proposed line in the street, alley, or easement with respect to the edge of the particular Right-Of-Way, the transit base line, any nearby utilities, ”0.2 percent flood elevation” as defined by Chapter 19 Section 19-33 of the City of Houston Code of Ordinances within the project area, major landscaping, and other structures affecting construction.

2. Sewers and manholes shall be identified by number, letter, combination of, or other identification and shown on the sanitary sewer layout sheet.

3. Where sewers are to be placed between existing pavement and the street Right-Of- Way line (or interior easement line) show the existing ground line at both sides (or the closest side for sewers near the edge) of the Right-Of-Way or adjacent sewer easement. Prior approval will be required if proposed sewers are to be placed under existing pavements or toppings.

4. For connection to the City sanitary sewer system include one of the following: a copy of the City's Wastewater Capacity Reservation (WCR) letter or, a copy of the City's Wastewater short form, and a Wastewater Impact Fee Receipt for any proposed wastewater design.

8.2.01.C Drawing Requirements

1. All sewers and connections must be shown in both plan and profile (P&P) views. A record drawing number for all existing public sewers in the P&P shall be provided.

2. The profile shall show other underground and surface utilities and facilities, both in parallel and at crossings; the size, grade of the proposed line, the elevations of the proposed line to hundredths of a foot at manholes, changes of grade and dead ends; and the proposed finished grade over the sewer. It shall show the actual ground line as it exists prior to construction of the sewer. Where proposed fill or cut is contemplated, the proposed new ground line shall be shown as a separate line from the actual ground line (label both lines and use contrasting line types to identify each). Type of pipe and bedding shall comply with City of Houston Standard Specifications and Standard Details.

8.2.01.C continued

3. Commercial sanitary sewer layout sheets for large areas and with a scale of 400 feet or more per inch must have an additional set of layout sheets at not more than 200 feet per inch, with match lines and a small index map showing which portion of the overall layout that the layout of each sheet represents.

4. A scale of not more than 200-feet per inch on the layout sheet will provide the following information:

    a. All easements containing or adjoining sanitary sewers are shown and labeled (including recording information),

    b. Label locations where pipe size or material change,

    c. Identify manhole by letter and/or number,

    d. The sewer alignment shall accurately reflect the relative location of the sewer as shown on the detailed plan view,

    e. Service leads that cross street pavement or serve adjacent property are to be shown on the layout. The detail plans and profiles shall show the flow lines of service leads at the street or easement Right-Of-Way, as well as at manholes where private sewer connections are allowed or required,

    f. The number and size of the lots depicted on both the overall sewer layout sheet and the individual plan-and-profile drawings shall match the number and size of the lots depicted on the final plat after recordation,

    g. The size and direction of flow for existing and proposed sewers shall be shown on the overall sanitary sewer layout sheet,

    h. The location of the proposed sewer within the public Right-Of-Way, easement adjacent to the public Right-Of-Way, or side lot easement (if allowed by the City), and

    i. The overall sanitary sewer layout sheet shall show the area, in acres, which the proposed sewer is designed to serve. Include a location map which references the acreage to nearby major thoroughfares and boulevard streets. The scale used for the project area location map shall be: 1" = 2000' or less and shall be shown on the map.

5. The plan view shall show, at a minimum, the following information for the project area:

    a. Topographical features,

    b. Stationing for the proposed sewers,

8.2.01.C.5
continued

c. Existing buried and overhead utilities (i.e. gas, electric, telecom, etc.),

d. Any significant landscaping or other structures which might impact construction or construction-related activities,

e. The width and type of existing and proposed easements,

f. Proposed service leads,

g. The limits of the proposed bore or tunnel,

h. Locations where pressure pipe is to be installed for water line crossings, and

i. Terrain changes, retaining walls, overhangs, buildings, billboards and any other structure within 25 feet of the proposed line.

6. The profile view shall show, at a minimum, the following information for the project area:

a. Underground and surface utilities/facilities which are either parallel to the proposed sewer or cross the proposed sewer,

b. The proposed sewer's diameter, grade and length for each manhole section,

c. The flow line elevation for sanitary sewers and service leads at each manhole,

d. The rim elevation of existing and proposed manholes,

e. The flow line elevation at each sheet match line (i.e., from one sheet to another),

f. Type of pipe bedding and backfill shall be included in the Standard Details,

g. The finished grade for proposed and existing pavement. Where cut and fill are proposed, the proposed new ground line should be shown as a separate line from the existing ground line (label both lines and use contrasting line types to identify each),

h. The existing ground line for the near side of the public Right-Of-Way where a sewer is to be placed between the edge of existing pavement and the edge of the public Right-Of-Way,

i. The existing ground line at the centerline of the proposed sanitary sewer where a sanitary sewer is to be placed within an easement. Show any proposed cut and fill as described above. Show the finished grade of any proposed and existing pavement,

8.2.01.C.6 continued

j. The flow line elevation of service leads where the service lead crosses the edge of the public Right-Of-Way or the dedicated easement adjacent to the public Right-Of-Way,

k. Locations where pressure pipe and/or casing is to be installed for water line crossings or special conditions (i.e. limited clearance, special protection requirements, etc.),

l. The limits of special backfill and proposed stacks shall be identified by stations indicated on the design plans, and

m. Vertical elevation breaks in profiles shall not be used without clearly identifying breaks on each sheet and dimension the break line elevation difference.

7. Drawings for single-family residential subdivisions shall show the proposed location, by stations, of all service leads, and stacks.

8. Refer to Chapter 11, Section 4, for geotechnical information required on the drawings.

8.2.01.D Service Leads

1. Service leads shall be located either at the side property line between two adjoining lots, or as directed by the City. Service leads shall not be connected to the backlot easement unless both (a) there is no front lot sewer to connect to, and (b) the development consists of no more than one service unit. A single 6-inch service lead located at the property line between two adjoining lots would serve two single-family residences with a wye placed at the end of the service lead. Do not extend the wye beyond the edge of either the public Right-Of-Way or dedicated public easement.

2. Service leads measuring more than 50-feet in length and parallel to the street Right-Of-Way or public sewer easement shall be treated as a public sewer having both a starting and ending manhole, except for cul-de-sac(s)'.

3. Service leads for single-family developments shall not connect to a manhole unless otherwise stated in this manual. Private sewers from developments with more than 5000 gallons-per-day flow shall discharge into a proposed or existing manhole. Where the flow line of the private sewer is 24-inches or greater above the flow line of the manhole, provide a standard City of Houston outside drop to the manhole. Some design exceptions or additional requirements may be made for flow connections to large (36-inch and larger ID sewers) or deep (>20 feet flow line depth) public sewers, depending on the individual circumstances.

8.2.01.D.3 continued

a. Service leads shall be provided to serve every lot within a proposed development, whether inside the city limits or in the ETJ. Provide detail(s) for all typical near-side and far-side sewer connections, including 1-side or 2-sided stacks.

b. Service leads shall be 6-inches in diameter (minimum). If the length of a service lead exceeds 100-feet or the width of the public Right-Of-Way by more than 20-feet, the minimum diameter shall be 8-inches and a manhole shall be utilized for connection to the public sewer. Service leads exceeding 150-feet in length shall be designed as a public sewer.

c. Service leads with a diameter of 6-inches shall utilize full body fittings (extruded or factory-fabricated) for connection to a proposed public sewer or an approved saddle-type connector for connection to an existing public sewer.

d. Saddle-type connectors shall be installed with the stub oriented between the spring line (3 o'clock and 9 o'clock positions) and 45 degrees from the spring line (1:30 and 10:30 positions). Full body fittings used to connect a service lead to a proposed public sewer shall be oriented in the same manner.

e. The service lead shall be designed to minimize the use of bends as conditions permit.

f. Service leads exceeding the limits defined in Paragraph 8.2.01.D.2 shall have a manhole at each end; as well as a plan-and-profile drawing for each Right-Of-Way crossing. All or part of these service leads which are located in a public Right-Of-Way, alley or dedicated sanitary sewer or public utility easement(s) may be treated as a public sewer; depending upon the location of the terminal manhole and any intermediate manholes.

g. For existing lots (which are not served in accordance with these guidelines) that requests a sewer connection and the distance to the nearest existing sewer is less than 50 feet, as measured parallel to the street Right-Of-Way, the sewer connection is under the jurisdiction of the Uniform Plumbing Code, (latest edition that the City has adopted) provided that: a road bore is not required or a major thoroughfare (or collector) road is not being cut, both of which require City approval and an engineering drawing.

h. The location where the service lead crosses the property line shall be shown on the plans and marked in the field. Provide a typical detail of the durable marker to be placed where the service lead crosses the property line.

i. All private sewers, private force mains, and appurtenances, thereto, that are intended to be located inside the public Right-Of-Way must have an encroachment permit with plan and profile sheets.

8.2.01.E General Requirements

1. Connect service leads to stacks, wyes or tees as shown on the City's GeoLink[2]. Where none are shown, a licensed plumber is responsible for placing a City approved saddle for connection to the public sewer and the City Inspector is responsible for determining that the saddle is watertight and properly installed.

2. Materials and construction shall conform to latest City of Houston Standard Specifications, including standard leak test.

3. Unless noted otherwise, all public sewers and service leads shall be embedded in cement-stabilized sand from 6-inches below the pipe to 12-inches above the pipe and for the full trench width. All such bedding shall be compacted to the density required by Standard Specifications. Cement-stabilized sand shall have a 48-hour compressive strength of 100 psi minimum. The cross-section described in this paragraph is defined as the pipe embedment zone.

4. Backfill excavated areas and trenches under or within one foot of existing or proposed pavement with cement-stabilized sand from the top of the pipe embedment zone up to one foot below the paving sub-grade. Cement-stabilized sand must develop 100 psi minimum compression at 48 hours. Backfill shall be compacted to 95 percent standard Proctor density.

5. The actual location of all special backfill and of proposed stacks shall be shown by stations on the drawings.

6. Public sewers and force mains shall be located in either the public Right-Of-Way or easements. Refer to Chapter 5, Easement Requirements, for side-lot and back-lot easement requirements.

7. Generally, the location of the public sewer within a dedicated easement shall be along the centerline of the easement. However, in those instances where the easement is adjacent to the public Right-Of-Way, the location of the sanitary sewer and its manholes shall be approved on a case-by-case basis by the Director of Houston Public Works, or the Director's designee. Required easement widths are addressed in Chapter 5, Easement Requirements. Additional information regarding the location of sanitary sewers is contained in Chapter 6, Utility Locations.

8. The final determination as to that portion of a street, alley, or sanitary sewer easement to be occupied by a proposed sewer or force main rests with the City. The Director or designee will take into consideration existing, planned and proposed facilities such as manholes, pavement, pipes/conduits, along with existing trees and shrubs, or other unique surface conditions when arriving at a decision.

[2] https://geohub.houstontx.gov

8.2.01.E
continued

9. The drawings for the sewer shall show the location of any pipe, duct, other structure(s), hazardous obstacles and/or protected vegetation known to exist that might interfere with the construction of the sewer and call to the attention of the City any known obstacles that might be encountered in constructing the sewer in any location under consideration. The Professional Engineer of Record shall determine the existence of pipes, ducts, and any above stated obstacles by visually inspecting the site, researching all available public and private records, and conducting subsurface investigations when necessary.

10. Manholes located within Houston Special Flood Hazard Areas, as defined by Chapter 19 of the City of Houston Code of Ordinances, shall have manhole covers that are gasketed and bolted down to prevent inflow. Manhole covers shall be floodproofed to the base flood elevation required by Chapter 19 Section 19-33 of the City of Houston Code of Ordinances. The Engineer of Record (EOR) shall provide a gasketed and bolted manhole detail in Drawings. Manhole vents must be located at least every 1500’ or per the latest TCEQ requirements in Chapter 217 Subchapter C, whichever is more stringent. Vent piping shall be designed in accordance with COH standard detail 02082-06 and City of Houston Code of Ordinances Chapter 19 Section 19-33. Engineering judgement and Aesthetics shall be considered in selecting the location of vent piping. Tunnels must be vented in accordance with TCEQ requirements.

11. A cleanout diameter must be at least equal to the diameter of the pipe to which it is attached.

12. New manholes shall not be located between the top of banks for ditches or swales, unless approved by the City.

13. Manhole covers shall not be placed within driveways and where possible, manhole covers shall not be designed within the tire path along roadways.

14. For Wastewater lines along State Right-of-Way, refer to Chapter 5 for easement requirements.

8.2.01.F Line Size

1. The minimum pipe diameter for a public sanitary sewer shall be 8-inches.

2. Service leads 4-inches in diameter shall be confined to the limits of the lot which they serve and shall serve only the equivalent of one single-family lot. No 4-inch sewer shall be laid in any street, alley, dedicated sewer easement or Right-Of-Way.

3. Service leads 6-inches in diameter shall not serve more than the equivalent of 2 single-family lots or other types of small land tracts.

4. Service leads of 6-inch and 8-inch diameter for single-family residential lots shall have a minimum grades as shown in Table 8.1.

8.2.01.F continued

5. For all service leads that requires a street bore, submit a copy of the wastewater capacity letter to establish the required size of the line.

6. For commercial service leads, the minimum size service lead shall be 8-inches in diameter. Connect all service leads directly to a manhole.

7. Public sewers shall be laid at a size and depth to conform to designs permitting an orderly expansion of the sewer system of the City and so as to avoid a duplication of lines in the future.

8. The City shall be the final judge as to size and depth required and any exception to service leads as previously defined.

8.2.01.G Line Depth

1. Public sewers shall be laid with the top of the pipe a minimum of 3-feet below the surface of the natural ground without side ditches.

2. Sewers laid in the street Right-Of-Way with curb and gutter paved streets shall have a minimum cover of 4-feet from the top of the pipe to top of the curb.

3. Sewers laid in street Right-Of-Way with crowned roads and side ditches shall have a minimum cover of 6-feet from the average ground line at the adjacent street Right- Of-Way to the top of pipe.

4. Where the minimum cover as specified in Paragraphs 8.2.01.G.1, 8.2.01.G.2, and 8.2.01.G.3 is not possible, the sewer shall be laid with Class 150 (150 psi) pressure pipe with cement-stabilized sand backfill as shown in Standard Details. Ductile iron pipe shall be lined with a material listed on the City of Houston Approved Product List and applied by either the pipe manufacturer or an approved applicator. Liners shall meet requirements of TCEQ 217.56(c)

5. Maximum depth for 8-inch, through 12-inch diameter collection lines shall be 20-feet from average ground surface of the trench width to pipe invert. Depths greater than 20-feet are subject to approval by the City Engineer if justified for site-specific reasons during the preliminary engineering phase of the project design.

8.2.01.H Line Grades

1. The following table lists the minimum grades for 6-inch to 27-inch diameter public sewers. (6-in. diameter is for service leads only). The minimum grade is based on a minimum full pipe velocity of 2.3 feet per second (fps). The maximum grade is based on a maximum full pipe velocity of 4.5 fps. In both cases, the Manning Formula has been used with an n coefficient of 0.013. The use of different pipe materials will not alter the use of 0.013 for the purposes of the Design Manual.

8.2.01.H.1 continued

Table 8.1 - GRADES FOR WASTEWATER LINES

NOMINAL INTERNAL PIPE DIAMETER (INCHES)	MINIMUM GRADE TO DEVELOP V= 2.3 FPS (PERCENT)	MAXIMUM GRADE TO DEVELOP V=4.5 FPS (PERCENT)
6	0.70	2.46
8	0.44	1.73
10	0.33	1.21
12	0.26	0.97
15	0.19	0.72
18	0.15	0.57
21	0.13	0.46
24	0.11	0.38
27	0.09	0.33

2. For sewers larger than 27-inches in diameter, the Professional Engineer of Record shall determine the appropriate grade utilizing the Manning Formula, n = 0.013 and a minimum full pipe velocity of 3.0 fps.

8.2.01.I Line Alignment

1. Gravity sewers shall be laid in straight alignment with uniform grade between manholes. Deviations from straight alignment shall be justified by complying with the TCEQ requirements and approved by the City. Deviations from uniform grade without manholes shall not be allowed.

8.2.01.J Manholes

1. Manholes shall be prefabricated or precast, as per Standard Specifications and Details, unless the Professional Engineer of Record submits a cast-in-place manhole design for review and approval by the City. The Professional Engineer of Record shall determine the need for a liner or coating on concrete manholes. Liner or coatings will be as per Standard Specifications. Fiberglass manholes, per Standard Details are not allowed within the existing or proposed pavement but are allowed outside the street Right-of-Way. Precast manholes shall incorporate a boot-type connector for sewer diameters up to 24-inches. For sewer diameters greater than 24-inches, utilize either the boot-type connector (if available) or an integral gasket. Precast manholes shall conform to the latest ASTM requirements. Manhole covers shall be 32-inches as shown in the Standard Details.

2. Location: For public sewers, manholes shall be placed at changes in alignment, changes in grade, junction points, and either at street, alley, or easement intersections as designs may require.

8.2.01.J.2 continued

a. Sewers laid in easements shall have a manhole in each street crossed by the sewer.

b. The maximum distance between manholes shall be determined from the following table for 8-inch to 48-inch pipe diameters. Spacing for manholes on mains with diameters larger than 48-inches installed by tunneling methods or open-cut methods shall be determined on an individual project basis.

Table 8.2 - MAXIMUM DISTANCE BETWEEN SANITARY SEWER MANHOLES

PIPE DIAMETER (I.D.) IN INCHES	MANHOLE MAXIMUM SPACING IN FEET
8-15	400
18-48	800
Greater than 48	As approved by the City

c. A design objective is to have sewers with the same, or approximately the same, flow line elevation intersect each other at a 90-degree angle. However, where a true perpendicular intersection cannot be obtained, and where the entering sewer intersects the receiving sewer at, or about, the same flow line elevation, one or more manholes shall be located so that a minimum angle of 80 degrees at the point of intersection can be achieved for the public sewer. When the entering sewer is on the upstream side of the manhole, the minimum angle between the sewers may be reduced to a 45-degree angle provided:

(1) A distinct flow channel can be maintained within the manhole when the flow line elevations of the sewers are at or within one pipe diameter of the smaller pipe; or

(2) The flow line elevation of the entering pipe is above the crown of the primary sewer and clearance can be provided between the sewers.

(3) The design is in compliance with City of Houston Standard Details (02082N-02 & 03)

d. Place manholes at the terminal (most upstream) end of all public sewers. Clean-outs will not be utilized except at the end of each service lead.

8.2.01.J.2
continued

e. Existing manholes located within the city limit shall be identified by the alphanumeric system established by the Department. Refer to Department's "Geolink[3]" map's "Wastewater Manholes" data layer for the 8-digit ID #s. If the manhole has no ID #, use the manhole's "Feature ID #" from the "Identify" query-generated pop-up database box.

f. Criteria for Connections to and Utilization of Manholes:

(1) Connections between public sewers at the manhole shall adhere to the following criteria when possible:

(a) The elevation of the crown of the discharging sewer shall either match the elevation of the crown of the receiving sewer or be approved as a special case by the City.

(b) A standard outside drop connection as shown in City of Houston Standard Details is required when the difference in elevation between discharging sewer flow line and receiving sewer flow line is greater than 24-inches.

(2) The routing of a service connection directly to an existing manhole will be allowed only if:

(a) The flow line elevation of the existing sanitary sewer is more than 10 feet below grade and there is no available stack and the lot to be so connected is a single-family, owner-occupied, single lot residence connection to an existing manhole; or

(b) The lot to be so connected is a single-family, single lot connecting to a manhole in a cul-de-sac.

(c) Satisfies discharge requirements of service leads requiring manholes (see Paragraph 8.2.01.D.3).

(3) When routing an approved service lead to a manhole the wall penetration shall not be greater than 10-inches in diameter and shall be sealed using approved water stop and grout, see Paragraph 8.2.01.J.2.f.(2).

(4) When routing an approved service lead to an existing manhole with invert elevation more than 24-inches lower, the connections shall utilize an outside drop and shall adhere to the following criteria, see Paragraph 8.2.01.J.2.f.(3):

[3] https://geohub.houstontx.gov

8.2.01.J.2.f.(4)
continued

(a) The manhole wall penetration shall not be greater than 10-inches in diameter,

(b) The outside drop shall be a minimum of 6-inches in diameter and shall be constructed of SDR 26 PVC pipe (ASTM D 3034),

(c) The outside drop shall be located 45-degrees from the upstream side of the public sewer,

(d) Usage of an internal drop will be reviewed on a case-by-case basis. A minimum of 48-inches of clear space shall be maintained inside the manhole between the drop and the opposing manhole wall. The drop pipe shall be firmly and frequently affixed to the manhole wall utilizing stainless steel bands and anchor bolts. All existing coatings shall be repaired per manufacturers recommendations upon completion,

(e) An internal drop shall terminate with a 45-degree bend. The 45-degree bend shall not extend below the top-of-pipe elevation of receiving sanitary sewer, and

(f) The wall penetration shall be sealed using an approved water stop and grout.

(5) When the line is more than 20-feet below grade or the line is greater than 36-inch in diameter a site-specific design is required.

3. Benches and Inverts: The bottom of the manhole shall be provided with a "U" shaped channel that is a smooth continuation of the inlet and outlet pipes. The depth of the "U" shaped channel shall be at least equal to the largest pipe diameter. In manholes with pipes of different sizes, the tops of the pipes shall be placed at the same elevation and flow channels in the invert sloped on an even slope from pipe to pipe. The bench provided above the channel shall be smooth and uniformly sloped at a minimum of 1-inch per foot to a maximum of 1.5 inches per foot, from the wall to the top of the invert channel.

4. Large manholes: All manholes connecting pipes larger than 36-inch and junction boxes shall have the lower corners filleted to prevent solids deposition.

8.2.01.K Lift Stations

8.2.01.K
continued

1. Lift station design shall comply with the City of Houston Engineering Design Guidelines Manual for Submersible Lift Stations and Design Guideline Drawings for Submersible Lift Stations, latest revision. The designer shall submit a Final Design Submittal Checklist (available from the City), signed and sealed by the Design Engineer, to ensure that the lift station is designed in compliance with the requirements of applicable codes and regulations. Include a copy of the Engineering Design Report satisfying TCEQ criteria.

8.2.01.L Metro Solutions - Guided Rapid Transit

1. Location of Public Sewers

   a. Public sewers crossing under tracks shall be in steel casing, with minimum pipe size of 10-inches.

   b. Sewer leads (building connections) shall not cross under tracks.

   c. Extend the public sewer stub for a minimum of "depth of sanitary sewer cover + 5 feet" beyond pavement limits.

   d. Relocate existing public sewers for a minimum of 15 feet from centerline of the nearest proposed track.

   e. SDR 35 PVC pipe is not allowed.

   f. Minimum cover of the pipe shall be determined by the Guided Rapid Transit Load Distribution calculations, use the greater of the calculated live or dead loads.

8.2.02 UNSERVED SITES REQUIRING ON-SITE SEWAGE FACILITIES (OSSF) (SEPTIC TANKS)

8.2.02.A Engineer shall conform to applicable County criteria.

8.2.03 SUBMITTALS

8.2.03.A Preliminary Design - Submit the following for review and comment:

1. Copies of any documents, which show approval or exceptions to the City design criteria.

2. Design calculations for line sizes and grades.

3. Contour map for overall area.

4. Plan-and-profile sheets showing proposed improvements (City projects only).

8.2.03.A. continued

5. Geotechnical soils report for the project (City projects only).

8.2.03.B Final Design - Submit the following for approval:

1. Final documents of the above plus plan-and-profile sheets and geotechnical soils reports for non-City projects.
2. Review prints.
3. Original drawings.
4. Complete copy of project specifications.
5. A final engineering design report shall be developed following the latest edition of TCEQ Chapter 217 and submitted to the City for each project. This report shall bear the signed and dated seal of a Professional Engineer registered in the State of Texas who is responsible for the design.

8.2.03.C Geospatial Data Deliverables: Provide GIS datasets in accordance with Chapter 13 – Geospatial Data Deliverables for projects that are proposing or modifying assets identified in Chapter 13 that are or will be operated and/or maintained by the City.

8.2.04 QUALITY ASSURANCE

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

8.2.05 RESEARCH REQUIREMENTS

8.2.05.A Discuss project concepts outlining proposed features and usage with City of Houston, Houston Public Works.

8.2.05.B Research existing utility and Right-Of-Way information.

8.2.05.C Verify that no restrictions exist that will deny approval of the project concept.

8.2.06 DESIGN ANALYSIS

8.2.06.A A calculation of design flows for the complete development project.

8.2.06.B Calculations for design of any treatment plant required for the development.

8.2.06.C Calculations for effect of the 25-year storm outfall from any proposed treatment plant.

8.2.07 DRAWINGS

8.2.07.A Drawings shall include layout sheets with contours, plan-and-profile sheets, and detail sheets for special items and treatment plants.

END OF CHAPTER

City of Houston

Design Manual

Chapter 9

STORMWATER DESIGN REQUIREMENTS

Chapter 9
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Chapter 9

STORMWATER DESIGN REQUIREMENTS

SECTION 1 – STORMWATER DESIGN OVERVIEW

9.1.01 CHAPTER INCLUDES

9.1.01.A Criteria for the design of storm drainage improvements.

9.1.01.B Criteria for the design of stormwater pollution prevention procedures and controls for construction activities.

9.1.01.C Criteria for the design of permanent stormwater pollution prevention facilities and controls to minimize impacts for New Development and decrease impacts for Redevelopment on tracts of land within the City of Houston.

9.1.02 POLICY

9.1.02.A Design Requirements:

1. Drainage criteria administered by the City of Houston and complemented by Harris County and the Harris County Flood Control District (HCFCD) for newly designed areas provide protection from Structural Flooding from a 100-Year storm event. This is accomplished through application of various drainage enhancements, such as storm sewers, roadside ditches, open channels, Detention and overland (sheet) run-off. The combined system is intended to prevent Structural Flooding from extreme events up to a 100-Year storm.

2. Recognizing that each site has unique differences that can enhance the opportunity to provide proper drainage, the intent of these criteria is to specify minimum requirements that can be modified provided that the objective for drainage standards is maintained. For projects which require a site-specific approach and where unique engineering solutions will achieve drainage objective, a request for consideration of alternative standards (pipe flow, overland Sheet Flow, and Detention storage) shall be submitted to the City of Houston, Houston Public Works, Office of the City Engineer (1002 Washington), for review and approval.

9.1.02.B Ponding in streets and roadside ditches for short duration is anticipated and designed to contribute to the overall drainage capacity of the system. Storm sewers and roadside ditch Conduits should be designed considering a balance of capacity and economics. These Conduits should be designed to convey less intense, more frequent rainfalls with the intent of allowing for traffic movement during these events. When rainfall events exceed the capacity of the storm sewer system, the additional runoff is intended to be conveyed or stored overland in a manner that reduces the threat of Structural Flooding.

9.1.02.C Sheet Flow

1. All proposed New Development, Redevelopment, or Site Modifications shall not alter existing or natural Overland Flow patterns and shall not increase or redirect existing Sheet Flow to adjacent private or public property[1].

2. Where the existing Sheet Flow pattern is blocked by construction (i.e. raising the site elevation) of the development, the Sheet Flow shall be re-routed within the developed property to return flow to original configuration or to the public R.O.W.

3. Except under special circumstances dictated by natural or existing drainage patterns, no Sheet Flow from the developed property will be allowed to drain onto adjacent private property. No impact will be allowed onto adjacent property. The estimated volume of displaced Sheet Flow shall be calculated, and the rerouted flow pattern shall have adequate volume to provide that adjacent property is not impacted by the development.

4. Sheet Flow from the developed property will be allowed to drain (via Sheet Flow) into the adjacent R.O.W. for Single Family Residential (SFR) developments for cases defined in Articles 9.2.01.C.4.b.(2).(a) and 9.2.01.C.4.b.(3).(a).[1], and meet the other requirements in 9.1.02.C.

5. With exception to article 9.1.02.C.4, no Sheet Flow from the developed property will be allowed to drain (via Sheet Flow) into the adjacent R.O.W. Any increased quantity discharge should only be discharged to the R.O.W. at the approved point of connection (which have enough capacity to handle the discharged) via a subsurface internal drainage system.

[1] Texas Water Code 11.086 – Overflow Caused by Diversion of Water
(a) No person may divert or impound the natural flow of surface waters in this state, or permit a diversion or impounding by him to continue, in a manner that damages the property of another by the overflow of the water diverted or impounded.

9.1.02.D The City is a participant in the National Flood Insurance Program (NFIP). The flood insurance program makes insurance available at low cost where the municipal entity implements measures that reduce the likelihood of Structural Flooding. The design criteria in this chapter are provided to support the NFIP. All development located within the City limits shall comply with Chapter 19, Floodplain, of the Code of Ordinances.

9.1.02.E Approval of storm drainage is a part of the review process for planning and platting of a New Development, site plan review process for Redevelopments, and the permitting process for Site Modifications. Review and approval of plats is conducted by the Department of Planning and Development. Review of storm drainage is conducted by Houston Public Works.

9.1.02.F Joint Project Funding

1. The City will consider joint project funding with a private entity for construction of drainage systems that improve existing drainage infrastructure. The City's first priority will be to fund those projects included in the Capital Improvement Plan (CIP).

2. Where feasible, City funding will be leveraged with other funding sources including private entities, civic organizations, and other public agencies (Harris County, HCFCD, Corps of Engineers, Housing and Community Development, and other funding sources).

3. For drainage systems that have been identified as deficient and are not scheduled to receive funding in the current CIP, the City will consider authorizing improvements performed by the private entity which comply with the City's objectives and may be a candidate for a Developer Participation Contract (DPC)[2] contract as described in Code of Ordinances, Article IV - Section 47-164.

[2] Refer to City of Houston Infrastructure Development Services, Developers Participation Contract webpage for more information: https://www.houstonpermittingcenter.org/infrastructure-development-services/developer-participation-contracts - agency-links-2576

9.1.02.G The criteria in this chapter apply to all projects located in the City limits and to expanding utility districts and new utility districts located in the City's Extraterritorial Jurisdiction (ETJ). However for Detention facilities and their Outfalls that directly discharge to other jurisdictions, the criteria of the receiving jurisdiction shall govern. The receiving jurisdiction's review and approval is required.

9.1.02.H Property owners and public agencies are responsible for not adversely impacting the community, neighbors, future property owners, or City facilities in terms of flood risks, erosion, Infiltration and siltation.

9.1.02.I Projects shall meet the standards of this chapter. The Office of the City Engineer (OCE) may grant exceptions or deviations from these requirements on a project-by-project basis.

9.1.02.J Unless an exception or credit is allowed in other articles in this chapter, any proposed impervious area will require Detention. Detention rate is defined in Section 9.2.01.H.

9.1.02.K For a Low Impact Development (LID) technique to be considered as pervious, the infiltration rate shall be greater or equal to 0.5 inches per hour and shall be confirmed by an Infiltration test report. See SECTION 6 for LID requirements.

9.1.03 REFERENCES

9.1.03.A 40 CFR 122 - EPA Administered Permit Programs: The National Pollutant Discharge Elimination System.

9.1.03.B AASHTO LRFD Bridge Construction Specifications, 4th Edition, 2017.

9.1.03.C AASHTO LRFD Bridge Design Specifications, 10th Edition, 2024.

9.1.03.D A Guide to Developing and Maintaining Low Impact Development Techniques in Houston, Current Edition.

9.1.03.E ASCE Standard Reference Number 7, Minimum Design Loads for Buildings and Other Structures.

9.1.03.F ASTM C33 - Standard Specification for Concrete Aggregates.

9.1.03.G Atlas 14 – Refer to 2019 Harris County Flood Control District (HCFCD) Policy Criteria and Procedures Manual (PCPM).

9.1.03.H City of Houston, Code of Ordinances:

1. Chapter 19 – Floodplain.

9.1.03.H continued

2. Chapter 42 – Subdivisions, Developments and Platting.
    a. Article I – In General.
    b. Article II – Requirements and Procedures.
3. Chapter 47 – Water and Sewers.
    a. Article IV – Development and Utility System Extensions.
    b. Article XII – Storm Water Discharges.
    c. Article XV – Drainage Impact Fees.

9.1.03.I City of Houston, Comprehensive Drainage Plan (CDP) and Houston Stormwater Master Plan (SWMP).

9.1.03.J City of Houston, Infrastructure Design Manual.

1. Chapter 1, General Requirements – Refer to list of references.
2. Chapter 2, Survey Requirements.
3. Chapter 5, Easement Requirements.
4. Chapter 10, Street Paving Design Requirements.
5. Chapter 13, Geospatial Data Deliverables.

9.1.03.K City of Houston, Standard Details and Working Drawings.

9.1.03.L City of Houston, Standard Specifications.

9.1.03.M Clean Water Act (CWA) – Refer to City of Houston Ordinance Section 47-601.

9.1.03.N FHWA-HIF-13-006, Tech Brief: Pervious Concrete.

9.1.03.O FHWA-HIF-15-009, Tech Brief: Porous Asphalt Pavements with Stone Reservoirs.

9.1.03.P Handbook of Hydraulics, Brater and King.

9.1.03.Q Harris County Flood Control District (HCFCD) Policy, Criteria, and Procedures Manual (PCPM), current edition[3].

9.1.03.R Harris County Flood Control District (HCFCD), Hydrology and Hydraulics Guidance Manual, current edition.

9.1.03.S International Building Code (IBC), edition with local amendments adopted by the City of Houston[4].

9.1.03.T Minimum Design Criteria (MDC) for Implementation of Certain Best Management Practices for Stormwater Runoff Treatment Options, 2001 edition[5].

9.1.03.U Minnesota Department of Transportation, Technical Memorandum No, 22-04-B-02, Use of Plastic Pipe for Storm Sewer and Culverts on Trunk Highways, 2022.[6]

9.1.03.V National Weather Service Documents:

1. National Oceanic and Atmospheric Administration (NOAA) - Atlas - Precipitation - Frequency Atlas of the United States (Texas) – current edition.

2. TP-100 Storm Sewer Design Applications.

3. TP-101 Guidelines for Consideration of Overland Flow for the Extreme Event for Improvement Projects in the City of Houston, Harris County, Texas Region.

9.1.03.W Native Plant Society of Texas Houston Chapter, Native Plant Guide.

9.1.03.X Regulations of Harris County, Texas for the Construction of Driveways and/or Culverts on County Easements and Right-Of-Ways, 2005.

9.1.03.Y Stormwater Management Handbook for Construction Activities, City of Houston, Harris County, Harris County Flood Control District, 2006 or current edition.[7]

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[3] https://www.hcfcd.org/Resources/Technical-Manuals/2019-Atlas-14-Policy-Criteria-and-Procedures-Manual-PCPM

[4] Refer to weblink for City requirements: https://www.houstonpermittingcenter.org/building-code-enforcement/code-development - agency-links-416

[5] https://www.eng.hctx.net/Portals/23/Publications/criteria_2001_edition.pdf

[6] https://edocs-public.dot.state.mn.us/edocs_public/DMResultSet/download?docId=17917826

[7] https://www.cleanwaterways.org/Portals/73/downloads/professional/construction_handbook_full.pdf

9.1.03.Z Stormwater Quality Management Guidance Manual (SWQGM), City of Houston, Harris County, Harris County Flood Control District, 2001 or current edition.[8]

9.1.03.AA Texas Department of Transportation Hydraulic Design, Manual, current edition.

9.1.03.BB Texas Department of Transportation, Structural Design Considerations for Specifying Thermoplastic Pipe, 2023.[9]

9.1.03.CC Texas Pollutant Discharge Elimination System (TPDES) General Permit No. TXR150000 (known as the Construction Stormwater General Permit)

9.1.03.DD Texas Water Code 11.086.

9.1.03.EE Uniform Plumbing Code, latest edition with local amendments adopted by the City of Houston[10].

9.1.04 DEFINITIONS AND ACRONYMS

9.1.04.A Aggregate - Materials used to strengthen the overall composite material for constructing stormwater infrastructure. An example would be rounded riverbed gravel.

9.1.04.B Applicant - The owner of the land on which the New Development or Significant Redevelopment will occur, or authorized agent.

9.1.04.C Best Management Practices (BMP) – Devices, practices, or methods that are used to manage stormwater runoff by controlling peak runoff rate, improving water quality, and managing runoff volume. BMPs can be categorized into different types such as storage practices, vegetative practices, pollution prevention, and Low Impact Development.[11]

9.1.04.D Bioretention/Biofiltration – Stormwater quality management facility that retains runoff in a shallow basin, usually less than 18 inches in depth and provides Infiltration of runoff through designed soil media to filter pollutants. Bioretention basins can be landscaped to be an attractive site amenity. Rain gardens are a form of Bioretention.

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[8] https://www.cleanwaterways.org/Portals/73/downloads/professional/guidance_manual_full.pdf
[9] https://ftp.txdot.gov/pub/txdot/brg/specifying-thermoplastic-pipes.pdf
[10] Refer to weblink for City requirements: https://www.houstonpermittingcenter.org/building-code-enforcement/code-development - agency-links-416
[11] International Stormwater Best Management Practices (BMP) Database, www.bmpdatabase.org

9.1.04.E Blue Roof – Temporary capture and Detention of rainwater on a building roof, capable of accommodating extra rain load. Rainwater can be slowly released, evaporated or used for non-potable activities (irrigation, toilet flushing).

9.1.04.F Central Business District (CBD) - The area of downtown Houston as defined in the City of Houston Code of Ordinances, Chapter 42 - Subdivisions, Developments & Platting, Article I, Sec. 42-1.

9.1.04.G Conduit – Any open or closed device for conveying flowing water examples, culverts, ditches, and storm sewers.

9.1.04.H Constructed Wetland Basin – Series of engineered and constructed shallow basins and ponds that are based on the ecological function of natural wetlands. These facilities create growing conditions suitable for wetland and marsh plants while providing runoff storage to provide water quality and flood reduction benefits. Constructed wetlands provide physical, chemical, and biological water quality treatment of stormwater runoff. Natural wetlands are more or less self-maintaining systems; whereas, constructed wetlands for storm water treatment purposes require active management.

9.1.04.I Critical Elevation – The maximum Hydraulic Grade Line elevation a system is allowed to exhibit when conveying the design rainfall. This elevation is related to the Level of Service of the primary system.

9.1.04.J Design Ponding Depth – The depth of water adjacent to an inlet during the Design Rainfall Event. Depth is measured from the bottom of the inlet opening for curb opening or from the top of the grate openings. This depth is used in inlet capacity calculations.

9.1.04.K Design Rainfall Event – Rainfall intensity upon which the drainage facility will be sized.

9.1.04.L Detention – A technique of temporarily storing stormwater in an area to reduce the stormwater runoff discharge rate from a site.

9.1.04.M Developer Participation Contract (DPC).

9.1.04.N Direct Driveway Access - A driveway that is essentially perpendicular to the street and provides vehicular access from the street to the parking area. Refer to Figure 9.2 for example.

9.1.04.O Drainage Area – The surface area determined by topography that contributes rainfall runoff to a point of interception. The drainage area represents the drainage system service area and is not limited by the project boundary or street R.O.W. The possibility of Overland Flow contributions from adjacent Drainage Areas during certain extreme events shall be considered for accurate assurance of Level of Service.

9.1.04.P Drainage Area Map – Service area map of the watershed or drainage system presented as specified in 9.7.01.B.5.

9.1.04.Q Dwelling Unit – A structure, or a portion of a structure, that has independent living including provisions for non-transient sleeping, cooking and sanitation.

9.1.04.R Engineer of Record – A Professional Engineer who seals Drawings, reports, and documents for a project.

9.1.04.S Engineered Soil – Cement-Based Engineered Soil technology used to stabilize the soil on a work site where it is not solid enough to safely support a building or roadway. Portland cement is blended with soil (sometimes including Aggregate) and water and then compacted. The resulting mix, known as soil cement, provides a secure and stable base for construction. It is also used for flood control structures.

9.1.04.T Engineered Soil Media – Low Impact Design (LID) practice used to reduce storm runoff volume and loading of pollutants in the discharge from its contributing Drainage Area. Engineered Soil incorporates a growing media with the native soil to create a functional soil designed for high infiltration, filtration, and plant sustainability. The layer should be compacted only with boot compaction or water flooding to allow for surface percolation through the Engineered Soil layer and into the surrounding native soil or Underdrain.

9.1.04.U Federal Emergency Management Agency (FEMA).

9.1.04.V Flood Insurance Study (FIS) - The formal document and associated models used to define the floodplain boundaries. An appraisal of the community's flood problems in a narrative that describes: a) the purpose of the study; b) historic floods; c) the area and flooding sources studied; d) the engineering methods employed. FIS serves as the basis for rating flood insurance and for regulating floodplain development and carrying out other floodplain management measures.

9.1.04.W Forebay – A separate deep pool of water at the entrance to a stormwater management facility designed to allow larger particles to settle out. For large facilities, it must include a maintenance ramp to facilitate periodic sediment removal.

9.1.04.X Green Stormwater Infrastructure (GSI) – A resilient approach to managing impacts from wet weather events. GSI reduces and treats stormwater at its source while delivering environmental, social and economic benefits. GSI is a term that is used to describe a range of techniques to manage and filter stormwater.

9.1.04.Y Green Roof – A roofing system that is covered with growing media and vegetation that enable rainfall capture and/or evapotranspiration of stored water.

9.1.04.Z Harris County Flood Control District (HCFCD).

9.1.04.AA Hydraulic Grade Line (HGL) – A line representing the pressure head available at any given point within the drainage system.

9.1.04.BB Impervious Area, Impervious Cover, or Impervious Surface – Impervious Area, Impervious Cover, or Impervious Surface means any area that has been compacted or covered such that it does not readily absorb water or does not allow water to percolate through to undisturbed underlying soil strata. Surface materials considered impervious shall include, but not be limited to, bricks, pavers, concrete, asphalt, compacted oil-dirt, compacted or decomposed shale, oyster shell, gravel, or granite, and other similar materials. Surface features utilizing such materials and considered impervious shall include, but not be limited to, decks (whether on pier and beam or directly over soil), foundations (whether pier and beam or slab), building roofs, parking and driveway areas, sidewalks, compacted or rolled areas, paved recreation areas, swimming pools, dry or wet Detention ponds, shade structures and other features or surfaces that are built or laid on the surface of the land and have the effect of increasing, concentrating, or otherwise altering water runoff so that runoff is not readily absorbed. Infiltration report of soil testing, signed and sealed by a Professional Engineer licensed in the State of Texas, must confirm surface can provide infiltration through underlying soil strata at a rate of 0.5 inches/hour or greater to be considered permeable.

9.1.04.CC Infiltration – The vertical movement of stormwater through the ground, plants and soil in a system without an Underdrain or liner that also recharges groundwater.

9.1.04.DD Infiltration Rate – The downward velocity at which water enters the soil through rainfall or irrigation events, typically expressed in inches per hour.

9.1.04.EE Infiltration Trench – An excavated trench backfilled with stone Aggregate and lined filter fabric. A small portion of the runoff, usually the Water Quality Volume, is diverted to the Infiltration Trench, which is located either underground or at grade. Pollutants are filtered out of the runoff as it infiltrates the surrounding soils.

9.1.04.FF Infrastructure Design Manual (IDM)

9.1.04.GG Level of Service (LOS) Evaluation – A condition assessment to determine the stormwater system's level of performance with respect to site-specific numeric criteria (e.g. assessment of stormwater system capacity for a 2-Year or 100-Year return period of rainfall).

9.1.04.HH Long Run Culvert – A culvert that is 40-feet or longer in length.

9.1.04.II Low Impact Development (LID) – A land planning and engineering design approach to manage stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to replicate the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. LID based practices are used to reduce stormwater runoff volume and pollutant loading from developed sites. LID is interchangeable with GSI.

9.1.04.JJ Maintenance Activity – Any work that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site (e.g., the routine grading of existing dirt roads, asphalt overlays of existing roads, the routine clearing of existing right-of-way, and similar Maintenance Activities). These activities do not include any increase in impervious area, and the altered surface to be restored to original condition. For detailed requirements, refer to 9.2.01.H.3.n.

9.1.04.KK Municipal Separate Storm Sewer System (MS4) – A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

1. Owned or operated by the U.S., a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to state law) having jurisdiction over the disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under state

9.1.04.KK.1 continued

law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under the §208 that discharges to surface water in the State;

2. That is designed or used for collecting or conveying stormwater;

3. That is not a combined sewer; and

4. That is not part of a Publicly Owned Treatment Works (POTW) as defined in 40 CFR §122.2.

9.1.04.LL Multi-Unit Residential (MUR) Development – As defined in the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting, Section 42-1.

9.1.04.MM No Adverse Impact (NAI)

9.1.04.NN National Pollutant Discharge Elimination System (NPDES) – Permit system addressing water pollution by regulating point sources that discharge pollutants to the Waters of the United States (WOTUS). Created in 1972 by the Clean Water Act (CWA), the program is authorized to state governments by EPA to perform many permitting, administrative, and enforcement aspects of the program.[12]

9.1.04.OO New Development – Development of an Undeveloped Parcel of land.

9.1.04.PP Outfall – A point where an MS4 discharges to Waters of the U.S. and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels, or other conveyances that connect segments of the same stream or other waters of the U.S. and are used to convey Waters of the U.S.

9.1.04.QQ Overland Flow – Flow resulting from a rainfall event that is routed along surface streets or surface channels in a defined manner.

[12] National Pollutant Discharge Elimination System Permit Number TXS001201.

9.1.04.RR Professional Engineer – An engineer currently licensed and in good standing with the Texas Board of Professional Engineers and Land Surveyors (TBPELS).

9.1.04.SS Registered Professional Land Surveyor (RPLS) – A surveyor currently registered and in good standing with State of Texas Board of Professional Engineers and Land Surveyors (TBPELS).

9.1.04.TT Rainfall Frequency – Probability of a rainfall event of defined characteristics occurring in any given year at a given location. Information on Rainfall Frequency is published by the National Weather Service. For the purpose of storm drainage design, the following frequencies are applicable:

1. 2-Year Frequency – A rainfall intensity having a 50 percent probability of occurrence in any given year, that occurs on the average every 2 years over a long period of time.

2. 3-Year Frequency – A rainfall intensity having a 33 percent probability of occurrence in any given year, that occurs on the average every 3 years over a long period of time.

3. 5-Year Frequency – A rainfall intensity having a 20 percent probability of occurrence in any given year, that occurs on the average every 5 years over a long period of time.

4. 10-Year Frequency – A rainfall intensity having a 10 percent probability of occurrence in any given year, that occurs on the average every 10 years over a long period of time.

5. 25-Year Frequency – A rainfall intensity having a 4 percent probability of occurrence in any given year, that occurs on the average every 25 years over a long period of time.

6. 50-Year Frequency – A rainfall intensity having a 2 percent probability of occurrence in any given year that occurs on the average every 50 years over a long period of time.

7. 100-Year Frequency – A rainfall intensity having a 1 percent probability of occurrence in any given year, that occurs on the average every 100 years over a long period of time.

8. 500-Year Frequency – A rainfall intensity having a 0.2 percent probability of occurrence in any given year, that occurs on the average of every 500 years over a long period of time.

9.1.04.UU Redevelopment – A change in land use that alters the Impervious Surface from one type of development to either the same type or another type, or green field, and alters the drainage patterns internally or externally to the development.

9.1.04.VV Regulated Construction Activity – Construction activities, including clearing, grading, and excavation that disturb either one acre or more, or less than one acre if the activities are part of a larger plan of development or sale to be in accordance with TPDES General Permit No. TXR150000. For developments that are less than one acre tract, the activities shall be subject to Ordinance Section 47-741.

9.1.04.WW Residence Time – The length of time that runoff remains in a pond, which is known as the pond's Hydraulic Residence Time (HRT). Removal efficiency is primarily dependent on the HRT.

9.1.04.XX Sheet Flow – A shallow depth of runoff on a sloping and/or relatively flat surface that does not have a precisely defined bounding condition.

9.1.04.YY Single Family Residential (SFR) – As defined in the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting, Section 42-1.

9.1.04.ZZ Significant New Development – Development on a currently Undeveloped Parcel of land one acre or larger without regard to the amount of land that will actually be disturbed, except for development on an existing undeveloped and undivided parcel of one acre or more of one single-family Dwelling Unit and/or the types of non-commercial building(s) typically associated with a single-family Dwelling Unit, including, but not limited to, a garage, carport or barn. If the occupancy for any structure excluded under the foregoing exception at any time changes to a commercial use, the owner of the property will at that time have to comply with all requirements of this program. The term also does not include a stormwater Detention basin that includes a water quality feature. The required Stormwater Quality Permit must include Detention.

9.1.04.AAA Significant Redevelopment – Increase of 0.2 acre or more to the Impervious Surface on one acre or larger developed parcel, but does not include a stormwater Detention basin that includes a water quality feature. The required Stormwater Quality Permit must include Detention.

9.1.04.BBB Site Modifications – A site improvement that alters the area of Impervious Surface (e.g., an addition to an existing structure or creating additional parking), or a change in existing storm water collection, conveyance or runoff conditions for the developed site (e.g., replacing existing parking surface with pervious pavement).

9.1.04.CCC Spread – Calculated only for design rainfall. The width of flow in the gutter, measured laterally from the roadway curb, approaching an inlet.

9.1.04.DDD Storm Sewer Junction Box – Precast or cast-in-place concrete, square or rectangular structure used to merge upstream pipes, accommodate changes in pipe size or direction, or provide service access to the storm sewer system by the addition of a circular manhole structure to the top of the junction box.

9.1.04.EEE Stormwater Pollution Prevention Plan (SWPPP) – A site-specific, written document that: Identifies potential sources of stormwater pollution at the construction site; describes practices to reduce pollutants in stormwater discharges from the construction site. Reduction of pollutants is often achieved by controlling the volume of stormwater runoff (e.g., taking steps to allow stormwater to infiltrate into the soil). Identifies procedures the operator will implement to comply with the terms and conditions of a construction general permit.

9.1.04.FFF Stormwater Quality Management Plan (SWQMP) – Document describing how flow and water quality are going to be addressed and managed through programs and projects.

9.1.04.GGG Stormwater Quality Permit or SWQ Permit – A current, valid permit issued pursuant to Article XII, Chapter 47, Division 2 of the City Code of Ordinances. A SWQ Permit shall be obtained for all New Development and Significant Redevelopment sites that will construct or modify their Detention features. This requirement applies only to the Detention feature if the facility has or will have permit coverage for stormwater discharges from industrial activity issued by the state.

9.1.04.HHH Structural Flooding – The Water Surface Elevation (WSE) from the storm event exceeds the finished slab elevation of the building (for pier and beam construction the top of first floor elevation), resulting in water entering the residential or commercial structure.

9.1.04.III Texas Pollutant Discharge Elimination System (TPDES) – Regulatory program to control discharges of pollutants to surface waters. The TCEQ Texas Pollutant Discharge Elimination System (TPDES) program has federal regulatory authority over discharges of pollutants to Texas surface water, with the exception of discharges associated with oil, gas, and geothermal exploration and development activities, which are regulated by the Railroad Commission of Texas.[13,14]

9.1.04.JJJ Type 2 Permanent Access Easement – A permanent access easement at least 28-feet in width that is designed and constructed like a private street serving a development that has no public utilities other than a public water line, connected to one or more fire hydrants, that provides no domestic water services.

9.1.04.KKK Underdrain – An underground structure with void spaces and a conveyance to a nearby storm sewer system or similar conveyance. Removes water from under a Bioretention system or porous LID system.

9.1.04.LLL Undeveloped Parcel – A parcel on which there are no structures at the time that a construction permit, subdivision plat or other city approval is applied for or required.

9.1.04.MMM United States Army Corps of Engineers (USACE).

9.1.04.NNN Vegetated Swales – Stormwater quality management channels that convey runoff and remove pollutants by filtering and Infiltration through the soil. Pollutant management is related to the slope, vegetation density, and soil type; thus, an optimum swale would have a shallow slope, dense vegetation, and porous soils to maximize water quality treatment benefits.

9.1.04.OOO Water Quality Volume – Target established by the City of Houston for New Development based on capturing 90% of the rainfall events in a year. This is also known as the 90th percentile storm event. For Redevelopment, the Target Water Quality Volume is based on the 85th percentile storm event.

[13]Texas Pollutant Discharge Elimination System (TPDES) Permit No. WQ0004685000 (known as the Municipal Separate Storm Sewer System - MS4 permit)
[14] Texas Pollutant Discharge Elimination System (TPDES) General Permit No. TXR050000 (known as the Industrial Stormwater Multi-Sector General Permit)

SECTION 2 - STORMWATER DESIGN REQUIREMENTS

9.2.01 DESIGN REQUIREMENTS

9.2.01.A Drainage facilities designed per this chapter shall meet requirements of the City of Houston Standard Specifications and Standard Details. Applicable software (two-dimensional hydraulic modeling) shall be used to perform 2-Year and inlet design analysis and design of storm drainage systems as follows:

1. City CIP Projects – In conjunction with design analysis using applicable software (two-dimensional hydraulic modeling), designs shall comply with guidelines provided in Technical Paper No. 100 (TP-100), Storm Sewer Design Applications for the City of Houston, Texas, CIP Projects, February 2005, or the latest published date.

2. Private projects within City limits which include City funding participation. See article 9.2.01.A.1 City CIP Projects.

3. 100% Privately-funded project located in City limits – alternative equivalent analysis procedures will be accepted.

4. Projects in new or expanding utility districts located in City's ETJ – alternative equivalent analysis procedures will be accepted.

9.2.01.B Determination of Runoff

1. Rational Method – A method for calculating the peak runoff for a drainage system using the following equation for runoff:

	Q	=	I x (CA)
Where:	Q	=	runoff (cfs)
	I	=	rainfall intensity (inches per hour)
	C	=	runoff coefficient
	A	=	area (acres)

a. Calculation of Runoff Coefficient

(1) The runoff coefficient C values in the rational method formula will vary based on the land use. Land use types and C values which can be used are as follows:

9.2.01.B.1.a.(1) continued

Land Use Type	Runoff Coefficient (C)
Residential Districts	
Lots more than 1/2 acre	0.35
Lots 1/4 - 1/2 acre	0.45
Lots less than 1/4 acre	0.55
Townhomes	0.60
Multi-Family areas	
Less than 20 Service Units/Acre	0.65
20 Service Units/Acre or Greater	0.80
Business Districts	0.80
Industrial Districts	
Light Areas	0.65
Heavy Areas	0.75
Railroad Yard Areas	0.30
Parks/Open Areas	0.18
Pavement/R.O.W.	0.80

(2) Alternatively, the runoff coefficient C in the Rational Method formula can be calculated from the equation:

$$C = 0.6I_a + 0.2$$

Where: C = runoff coefficient
I_a = impervious area/total Drainage Area

(3) If the alternate form is to be submitted, the calculation of C shall be provided as part of the drainage calculations.

b. Rainfall Intensity

(1) Determination of Time of Concentration: Time of concentration can be calculated from the following formula:

$$T_c = 10A^{0.1761}+15$$

Where: T_c = time of concentration (minutes)
A = subdrainage area (acres)

(2) Calculate Intensity the intensity calculation is based on duration equal to the time of concentration. The intensity is calculated as follows:

$$I = b/(d + T_c)^e$$

Where: I = Rainfall intensity (inches per hour)
T_c = Time of concentration (minutes)

9.2.01.B.1.b.(2) continued

Where b, d, and e are coefficients dependent on the rainfall event, as provided in Table 9.1 below and are based on City depth-duration-frequency values.

Table 9.1 – RAINFALL INTENSITY COEFFICIENTS

Rainfall Frequency	b	d (min.)	e
2-Year	48.35	9.07	0.7244
5-Year	52.32	7.88	0.6900
10-Year	54.68	6.96	0.6623
25-Year	57.79	5.89	0.6294
50-Year	61.00	5.46	0.6096
100-Year	60.66	4.44	0.5797
500-Year	62.17	2.95	0.5196

Note: The rainfall data presented above is the latest available as of the date of Chapter 9 issuance. The City may adopt revised data not reflected in this table. It is the engineer's responsibility to ensure that current accepted rainfall intensity calculations are being utilized for the analysis.

(3) Intensity Duration Frequency (IDF) Curves, depict the intensity-duration curves to be used for storm sewer and roadside ditch design in the City and the ETJ. The source of these curves is data from Atlas 14 IDF Curves, assistance with NOAA Atlas 14 Updates to the Harris County Flood Control District (HCFCD) Policy Criteria and Procedures Manual (PCPM) adopted July 9, 2019. The Atlas 14 IDF Curves report is based upon the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 11, Version 2.0 Texas (Atlas 14).

(a) Harris County Flood Control District (HCFCD) developed three (3) Hydrologic Regions based on the Atlas 14 rainfall distribution. The City of Houston requires the rainfall intensity for storm sewer design must be determined using the Region 3 data.

(b) The City acknowledges that Harris County and Harris County Flood Control District have adopted new data based on Atlas 14.

2. Application of Runoff Calculation Models

9.2.01.B.2 continued

a. Rational Method: The Rational Method will be used to estimate peak flows for individual Drainage Areas up to 200 acres in size, and for project areas up to 640 acres in size. Project areas greater than 200 acres must be broken down into smaller Drainage Areas for analysis, with each Drainage Area being less than 200 acres in size. The Rational Method will be used for design on areas served by storm sewers up to 640 acres in size.

b. Runoff Watershed Modeling: For areas greater than 640 acres, use the methodology specified in the HCFCD Hydrology and Hydraulics Guidance Manual.

c. Hydrograph Development Dynamic Conditions – For development of runoff hydrograph for use in dynamic modeling utilize Clark Unit Hydrograph Method.

d. Hydrograph Development Static Conditions – For evaluation of Detention volume the approved methodology for hydrograph development shall be based upon the National Resources Conservation Services Dimensionless Unit Hydrograph or Malcolm's Small Watershed Method.

3. Hydrograph Development

a. Where necessary to calculate runoff hydrographs, the peak flow of the hydrograph should match the Rational Method peak flow as calculated above. The hydrograph should be calculated using the entire Drainage Area, the Flood Insurance Study (FIS) rainfall distribution, Green & Ampt loss rates, and the Clark Unit Hydrograph (TC&R) methodology. These methodologies are described in the HCFCD Hydrology and Hydraulics Guidance Manual. For design and impact analyses, Green & Ampt parameters as included in the effective hydrologic model for the watershed, rather than using the values from the FIS models. Selection of the Clark Unit Hydrograph parameters will be done as follows: TC will be calculated as described above, with a minimum value of 10 minutes, and the storage coefficient (R) will be selected such that the peak flow matches the rational method peak flow. There will be a different R value for each rainfall event.

9.2.01.C Design of Storm Sewers

1. General Considerations

a. Continuity Equation:

$$Q = VA$$

9.2.01.C.1.a continued

Where: Q = discharge (cfs)
V = velocity (ft/sec)
A = cross sectional area of flow (square feet)

b. Manning's Equation:

$Q = (K/n)AR^{2/3}S_f^{1/2}$

Where: Q = discharge (cfs)
K = 1.49 for English units,
n =
0.013 for thermoplastic and concrete pipes
0.015 for concrete boxes
0.024 for CMP pipes
A = cross sectional area of flow (square ft)
R = hydraulic radius (ft) (area/wetted perimeter)
S_f = friction slope (head loss/length)

c. Drainage systems for curb-and-gutter pavement shall consist of underground closed Conduits.

d. City CIP Projects or New Development that is anticipated to become City infrastructure and R.O.W.:

(1) The City's Comprehensive Drainage Plan (CDP) and Houston Stormwater Master Plan (SWMP) may indicate that a larger diameter storm sewer is planned in the area proposed for paving improvements. The Transportation and Drainage Operations of HPW has information on proposed improvements and should be consulted for impact on New Development.

e. Private Drainage Systems:

(1) Storm sewers for private drainage systems should conform to the Uniform Plumbing Code and the International Building Code including City of Houston Amendments[15] for development within the City limits. The City recommends the contents of this chapter as a guideline for best practices for all storm sewers within the City or its ETJ.

2. Design Frequency

[15] https://www.houstonpermittingcenter.org/houston-code-archive

9.2.01.C.2 continued

a. New Development: The design rainfall event for sizing storm sewers in newly developed areas will be at minimum a 2-Year rainfall event. The proposed storm sewers shall also meet requirements of extreme event analysis as detailed in section 9.2.01.D.

b. Redevelopment: The existing storm drain (sewer, ditch) shall be evaluated using a 2-Year rainfall event, assuming no development takes place. The storm drain shall then be evaluated for the 2-Year rainfall event design with the development in place.

(1) If the proposed Redevelopment has an equal or lesser amount of Impervious Surface and the existing storm drain (sewer, ditch) meets 2-Year Level of Service, then no modifications to the existing storm drain are required.

(2) If the proposed Redevelopment results in the 2-Year Hydraulic Grade Line of the existing storm drain below the gutter line, no improvements to the existing storm drain are required.

(3) If the analysis of the existing conditions finds that the existing storm drain is deficient (i.e. the 2-Year Hydraulic Grade Line is above the gutter line), the Applicant should check with the City to see if a CIP or a DPC project is proposed that will require a capital contribution.

3. Starting Water Surface and Hydraulic Grade Line

a. Tailwater elevation selections for Hydraulic Grade Line (HGL) analysis:

(1) Capital Improvement Plan (CIP) Projects:

(a) If the storm system being analyzed is part of a Capital Improvements Plan (CIP) project that includes drainage improvements, then the storm system shall be modeled to the receiving channel, and the starting tailwater elevation shall be determined, as noted below.

(b) If the Engineer of Record and the City's project team have determined that modeling to the receiving channel is not necessary (i.e., has minimal impact on the project), then this requirement may be lifted.

[1] For the 2-Year Design Rainfall Event with non-submerged Outfall to the receiving channel, the starting tailwater shall be the top of Outfall pipe.

9.2.01.C.3.a.(1).(b) continued

[2] For the 100-Year extreme rainfall event, the starting tailwater shall be the greater of the 10-Year water surface elevation (WSE) or 2-feet below the top of bank.

(2) Non-Capital Improvement Plan (CIP) Projects:

(a) If the receiving channel is less than 2,000 feet from the project limits, then the storm system shall be modeled to the receiving channel, and the starting tailwater shall be determined, as noted below.

[1] For the 2-Year Design Rainfall Event with non-submerged Outfall to the receiving channel, the starting tailwater elevation shall be the top of Outfall pipe.

[2] For the 100-Year extreme rainfall event, the starting tailwater elevation shall be the greater of the 10-Year water surface elevation (WSE) or 2-feet below the top of bank.

(b) If the receiving channel for the storm system being analyzed is greater than 2,000-feet from the project limits, then the hydraulic model shall include at least 2,000-feet of trunkline downstream of the project limits. The starting tailwater elevation shall be determined at the model truncation point, downstream of the project interconnect limit, as noted below.

[1] For the 2-Year Design Rainfall Event, the starting HGL at the model truncation point shall be the midpoint between the gutter line elevation and the soffit of the receiving pipe (i.e. midpoint elevation). If a starting tailwater elevation at the "midpoint elevation" is not allowed due to agency coordination, the engineer shall model the storm system to the receiving channel, as noted below.

[a] For the 2-Year Design Rainfall Event with non-submerged Outfall to the receiving channel, the starting tailwater elevation shall be the top of Outfall pipe.

9.2.01.C.3.a.(2).(b) continued

[2] For the 100-Year extreme rainfall event, the starting HGL at the model truncation point shall be 1-foot below the gutter line elevation. If a starting tailwater elevation at 1-foot below the gutter line elevation is not allowed due to agency coordination, the engineer shall model the storm system to the receiving channel using the tailwater criterion, as noted below.

[a] For the 100-Year extreme rainfall event the starting tailwater elevation shall be the greater of the 10-Year water surface elevation (WSE) or 2-feet below the top of bank.

(3) If the Engineer of Record has determined that modeling to the receiving channel or 2,000-feet is not necessary (i.e., a critical location is more representative of tailwater), then this requirement may be lifted subject to approval from Office of The City Engineer's Storm Water Review Group.

(4) For the hydraulic impact analysis, a variable tailwater at the downstream end of the model may be used (reference to TP-100). A variable tailwater condition is recommended for use for Detention analyses.

b. At drops in pipe invert, where the top of the upstream pipe is higher than the HGL, then the HGL shall be recalculated assuming the starting water surface to be at the top of pipe at that point.

c. For the Design Rainfall Event, the Hydraulic Grade Line shall at all times be below the Critical Elevation for all newly developed areas. Critical Elevation for 2-Year rainfall event is gutter line. Critical Elevation for 100-Year rainfall event is maximum ponding elevation.

4. Pipe Sizes, Material, and Placement

a. Use storm sewer and inlet leads with at least 24-inches inside diameter or equivalent cross section. Box culverts shall be at least 3-feet by 2-feet. Closed Conduits, circular, elliptical, arch pipe, or box, shall be selected based on hydraulic principles and economy of size and shape.

9.2.01.C.4 continued

b. Design of Outfalls: Unless otherwise allowed in the subsections of this article use storm sewer and inlet leads with at least 24-inches inside diameter or equivalent cross section. Box culverts shall be at least 3-feet by 2-feet. Closed Conduits, circular, elliptical, arch pipe, or box, shall be selected based on hydraulic principles and economy of size and shape. Using multiple pipes smaller than 24-inches is not permitted. A separate OCE plan and profile project is required to be submitted. For submittal requirements see SECTION 7.

(1) For private connection to the back of the curb inlet, a minimum 12-inch inside diameter storm sewer can be used.

(2) Single-family residential projects with Direct Driveway Access that do not share a storm Outfall with others, shall be permitted to use the point of connection through a curb via a 4-inch schedule 40 pipe or to connect to the roadside ditch via a 4-inch to 12-inch schedule 40 pipe within the R.O.W. without a plan and profile drawing submittal. This option is only available if curb or ditch is directly fronting the single-family residential lot. (See Table 9.6 - DETENTION CRITERIA 1).

(a) Single Family Residential projects are allowed to Sheet Flow to a ditch, curb and gutter, or any R.O.W. drainage as long as the tract meets all of the following conditions:

[1] Tract size is less than or equal to 15,000 SF.

[2] Total percent Impervious Area within tract is less than or equal to 65% of tract area.

[3] Tract shall have Direct Driveway Access to the R.O.W.

[4] The site shall have adequate grading in place, the Sheet Flow shall be effectively managed by adequately sloped runoff, and shall promote soil infiltration through gently sloped well drained areas as it flows to the R.O.W.

(3) Single-Family Residential developments with Direct Driveway Access, joint access, shared access, Courtyard Access Drive, and Multi-Unit Residential (MUR) developments (MUR) (See Table 9.7 - DETENTION CRITERIA 2):

9.2.01.C.4.b.(3) continued

(a) Developments that are 15,000 SF or less in tract size shall be permitted to use an alternative point of connection through a curb via a 4-inch schedule 40 pipe or to connect to the roadside ditch via a 4-inch to 12-inch schedule 40 pipe within the R.O.W. without a plan and profile drawing submittal. This option is only allowed if a curb or ditch is directly fronting the development.

[1] Single Family Residential developments are allowed to Sheet Flow to a ditch, curb and gutter, or any R.O.W. drainage as long as the tract meets all the following conditions:

[a] Tract size is less than or equal to 15,000 SF.

[b] Total percent Impervious Area within tract is less than or equal to 65% of tract area.

[c] Tracts shall conform to configurations shown in Figure 9.2 and as described below:

[i] Tracts with any number of lots that have Direct Driveway Access to the R.O.W.

[ii] Tracts with a maximum of two lots that have shared driveway access to the R.O.W.

[d] The site shall have adequate grading in place, the Sheet Flow shall be effectively managed by adequately sloped runoff, and shall promote soil infiltration through gently sloped well drained areas as it flows to the R.O.W.

(b) Unless allowed by exception for sheet flow according to 9.2.01.C.4.b.(3).(a).[1]. Single Family Residential developments with joint access, shared access, Courtyard Access Drive, and Multi-Unit Residential developments (MUR) require a subsurface drainage system.

(4) Single Family Residential tracts that Outfall through a pipe to a ditch shall have an Outfall pipe end that is mitered to match the ditch slope.

9.2.01.C.4 continued

c. Larger pipes upstream should not flow directly (via inlet, junction box, manhole) into smaller pipes downstream unless construction constraints prohibit the use of a larger pipe downstream, or the upstream system is intended for use as Detention. When a larger upstream pipe is proposed, an analysis of the downstream flow capacity is required.

d. Match crowns of pipe at any size change unless severe depth constraints prohibit.

e. Locate public storm sewers in public street R.O.W. or in approved easements.

f. Follow the alignment of the R.O.W. or easement when designing cast-in-place concrete storm sewers.

g. For box manholes, junction boxes and inlets, Conduits shall connect at no greater than 7 degrees normal to the wall. See Figure 9.3.

h. Junction angles: At junctions, acute angles are preferred to reduce head losses and pass debris more easily. See Figure 9.4.

i. Clearance:

(1) Minimum horizontal clearance from the exterior of any storm pipe or box culvert shall be at least 48-inches to the exterior of the existing or proposed public or private utility and other appurtenances (i.e., inlet or manhole).

(2) Minimum vertical clearance from the exterior of any storm pipe or box culvert or other appurtenances (i.e., manhole or inlet) shall be at least 24-inches to exterior of the existing or proposed public or private utility and other appurtenances.

j. Siphon design connection shall not be allowed.

k. Conflict manhole shall not be allowed.

l. Any Conduits with bends shall have a structure such as an inlet, junction box, manhole, or cleanout within 100-feet for maintenance.

9.2.01.C.4 continued

m. Thermoplastic pipe design requirements:

(1) Pipe structural design shall be according to AASHTO LRFD Bridge Design Specifications.

(2) Pipe Cover Requirements:

(a) Do not exceed manufacturer's specifications for maximum cover.

(b) Minimum cover shall not be less than values provided in Table 9.2. In case the values in Table 9.2 are less than the manufacturer's values, the manufacturer's values shall govern.

(3) Engineer of Record shall confirm the project conditions are suitable for use of pipe material and structural adequacy of the pipe system.

(4) When thermoplastic pipes are placed under pavement subject to vehicular traffic loading, interaction between the pavement and pipe shall be a structural design consideration for both pavement and pipe design.

(5) Buoyancy shall be a design consideration when specifying thermoplastic pipes.

(6) For projects where more than one type of backfill is specified, backfill material locations shall be clearly noted in contract documents.

9.2.01.C.4.m continued

Table 9.2 – MINIMUM STORM SEWER AND CULVERT COVER REQUIREMENTS FOR THERMOPLASTIC PIPE

Location	Minimum Cover Based on Pipe Diameter (D) [Note 1]		Notes
	D ≤ 36-in.	D > 36-in.	
Under Paved Roadways (Thoroughfares and Major Collectors)	24-in.	24-in.	1, 2, 3, 9
Under Paved Roadways (Minor Collectors, Local Streets)	18-in.	24-in.	1, 2, 3
Driveways on Roadways with Open Ditches (Commercial Driveways)	18-in.	24-in.	1, 2, 3
Driveways on Roadways with Open Ditches (Residential Driveways)	12-in.	18-in.	1, 2, 3
Under Unpaved Non-Roadway Areas with Potential for Rutting	18-in.	24-in.	1, 4, 7, 11
Under Unpaved Areas	12-in.	12-in.	1, 4, 7, 9

Table Notes:

1. Values in this table are provided based on reference data available at time of publication.
2. For rigid pavement, depth of cover is from top of pipe to top of pavement.
3. For flexible pavement, depth of cover is from top of pipe to bottom of pavement.
4. For unpaved areas, depth of cover is from top of pipe to ground surface.
5. Where rutting due to live loading is a design consideration, the amount of rutting shall not be permitted to reduce the cover less than 12-inches (Note 11).
6. Topsoil and erosion control products are not included in minimum cover depth (Note 11).
7. Where groundwater and fully saturated soil conditions are anticipated, the minimum cover shall be 4-feet (Note 10) unless justified by buoyancy calculations.
8. These requirements are not applicable to construction loads. Minimum cover for construction loads shall conform to requirements in 2017 AASHTO LRFD Bridge Construction Specifications: Section 30.6 Minimum Cover, Table 30.6-1-Minimum Cover for Construction Loads.
9. Requirements have been established using the 2024 AASHTO LRFD Bridge Design Specifications: Section 12.6.6.3 Minimum Cover, Table 12.6.6.3-1 Minimum Cover.
10. Requirements have been established using the 2023 TxDOT's "Structural Design Considerations for Specifying Thermoplastic Pipe".
11. Requirements have been established using the 2022 MnDOT Technical Memorandum No. 22-04-B-02 "Use of Plastic Pipe for Storm Sewer and Culverts on Trunk Highways".

9.2.01.C.4.n continued

n. Pipe materials and installation shall conform to latest City of Houston Standard Specification 02631. See Table 9.3 for a summary of Conduit materials.

Table 9.3 – STORM SEWER CONDUIT MATERIALS

Location[5]	Specification Section	Pipe Material [2][3]	Restrictions[4]
Storm Sewer Pipe in R.O.W.	02505	High Density Polyethylene (HDPE)	a. Only use for local streets[1]. b. Not allowed in augering. c. Multi-barrel installations are not allowed.
	02506	Polyvinyl Chloride (PVC)	a. Not allowed in Potentially Petroleum Contaminated Areas (PPCA). b. Not allowed in augering/jacking c. Not allowed in the City right-of-way and easements, except for the cases outlined in paragraph 9.2.01.C.4.b.(2) & 9.2.01.C.4.b.(3) d. Not allowed on projects handled by Capital Projects Service Line except for the cases outlined in paragraph 9.2.01.C.4.b.(2) & 9.2.01.C.4.b.(3).
	02510	Polypropylene (PP)	a. Not allowed in augering. b. Multi-barrel installations are not allowed.
	02611	Reinforced Concrete	-
	02612	Precast Reinforced Concrete Box Sewer	-
	02642	Corrugated Metal	a. Only use at railroad crossings (not street crossings).
Driveway Culvert Pipe for Streets with Open Ditches	02505	High Density Polyethylene (HDPE)	a. Single Family Residential (SFR) culverts only. b. Multi-barrel installations are not allowed.
	02506	Polyvinyl Chloride (PVC)	a. Not allowed for driveway culverts.
	02510	Polypropylene (PP)	a. Multi-barrel installations are not allowed.
	02611	Reinforced Concrete	-
	02612	Precast Reinforced Concrete Box Sewer	-

(1) Local street is defined as by the City Code of Ordinances 42-1: Local street shall mean a type 1 permanent access easement and a public street that is not a major thoroughfare or collector street.

(2) Pipe shall meet minimum class, dimension ratio, and other criteria indicated in the specifications.

(3) Pipe material other than listed above should not be specified.

(4) Engineer shall refer to Standard Specifications for any other restrictions that may impact design. If there is a discrepancy between this table and the Standard Specifications, the Standard Specifications shall take precedence.

(5) Pipe materials for private developments shall comply with the latest edition of Uniform Plumbing Code and City of Houston amendments[16].

[16]Refer to weblink for City requirements: https://www.houstonpermittingcenter.org/building-code-enforcement/code-development - agency-links-416

Table 9.4 – ALLOWED STORM SEWER PIPE DIAMETERS IN THE R.O.W.

Pipe Material	Pipe Diameter Limitation [1]	Storm Sewers	Driveway Culvert For Streets With Open Ditches
Polyvinyl Chloride (PVC)	4-in SCH. 40 Pipe for SFR Curb Cuts 4-in to 12-in SCH. 40 for SFR Ditch Outfalls	X[2]	
High Density Polyethylene (HDPE)	24-in ≤ Pipe Diameter ≤ 48-in	X	X
Polypropylene (PP)	24-in ≤ Pipe Diameter ≤ 48-in	X	X
Reinforced Concrete	Pipe Diameter ≥ 24-in	X	X
Precast Reinforced Concrete Box Sewer	3-ft × 2-ft ≤ W × H ≤ 12-ft × 12-ft	X	X
Corrugated Metal	Pipe Diameter ≥ 24-in	X	

(1) Values provided in this table are approved for design and construction. Where there is a conflict between the IDM and construction specifications, the material specifications in City's Standard Construction Specifications shall govern.

(2) Allowed only for Single Family Residential Outfalls.

5. Manhole Locations

   a. Use manholes at the following locations:

      (1) Size or cross section changes.

      (2) Inlet lead and Conduit intersections.

      (3) Changes in pipe grade.

      (4) A maximum spacing of 700-feet measured along the Conduit run.

9.2.01.C.5 continued

b. Use manholes for existing monolithic-concrete storm sewers at the same locations as above except for intersections of inlet leads unless a manhole is needed to provide maintenance access at those intersections.

c. Do not place manholes in driveways or in the street in front of or immediately adjacent to a driveway.

6. Inlets

a. Locate inlets at low points in the gutter.

b. Valley gutters across intersections are not permitted.

c. Inlet spacing is a function of gutter slope. The minimum gutter slope shall comply with Chapter 10, Street Paving Design Requirements.

(1) For minimum gutter slopes, the maximum spacing of inlets shall result from a gutter run of 700-feet from high point in pavement or the adjacent inlet on a continuously graded street section, with a maximum of 1,400-feet of pavement draining towards any one inlet location.

(2) Inlet location should be spaced to ensure that Spread does not exceed one lane of the roadway for the Design Rainfall Event.

(3) Residential development: Maximum spacing of inlets shall result from a gutter run of 700-feet from high point in pavement to the adjacent inlet on a continuously graded street section, with a maximum of 1,400-feet of pavement draining towards any one inlet location.

(4) Commercial development: Maximum spacing of inlets shall result from a gutter run of 400-feet from high point in pavement to the adjacent inlet on a continuously graded street section with a maximum of 600-feet of pavement draining towards any one inlet location.

9.2.01.C.6.c
continued

(5) Spread: Calculate 2-Year rainfall flow approaching each inlet from each direction. Additional inlets may be required if the Spread exceeds the maximum allowable value. The Spread in a typical prismatic curb-and-gutter street may be calculated using the following relationships:

$Q = (K_g/n)(S_x^{1.67})(S_o^{0.5})(T^{2.67})$, and
$T = y/S_x$

Where:
K_g = 0.56 (US Customary Units)
n = Manning's roughness coefficient
S_x = Transverse slope (or cross slope) (ft/ft),
S_o = Longitudinal pavement slope (gutter slope) (ft/ft)
T = Spread (ft), and
y = Ponded depth (ft)

(6) Allowable Spread:

(a) On a residential street, the Spread shall be no greater than the distance from the curb to the center crown of the roadway.

(b) For a roadway with two or more lanes in each direction, the Spread shall be no greater than the distance from the curb to the inside edge of the outside lane.

(c) The Spread adjacent to an inlet shall be no greater than the point of intersection of the transverse pavement slope with the top of curb elevation (i.e., the maximum Design Ponding Depth).

d. Use only City of Houston standard inlets (See Table 9.5).

9.2.01.C.6.d continued

Table 9.5 – *STANDARD STORM SEWER INLETS

INLET	APPLICATION	NOMINAL CAPACITY CFS	DWG. NOS.
Type A	Driveway, parking lots, small areas (curb and gutter system not available area). Please note inlets shall not allowed on travel lanes.	2.50	02633-01
Type B-B (without extensions, with solid plate or grate)	Curb and gutter system within collector streets (major collector, minor collector), transit corridor street, residential and commercial area.	5.00	02633-02
Type B-B (1) (with one extension; with solid plate or grate)	Curb and gutter system within collector streets (major collector, minor collector), transit corridor street, residential and commercial area.	10.00	02633-02
Type B-B (2) (with two extensions; with solid plate or grate)	Curb and gutter system within collector streets (major collector, minor collector), transit corridor street, residential and commercial area.	15.00	02633-02
Modified B-B (with solid plate or grate)	Driveway, parking lots, small areas (with no curb and gutter system). Please note grates shall not allowed on travel lanes.	N/A	
Type C (without extensions)	Curb and gutter system within collector streets (major collector, minor collector), transit corridor street, residential & commercial area.	5.00	02633-03
Type C-1 (with one extension)	Curb and gutter system within major thoroughfare, collector streets (major collector, minor collector), transit corridor street & commercial area.	10.00	02633-03
Type C-2 (with two extensions)	Curb and gutter system within major thoroughfare & commercial area.	15.00	02633-03
Type D	Driveway, parking lots, small areas (curb and gutter system not available area). Please note inlets shall not be allowed on travel lanes.	2.00	02633-04
Type E	Roadside ditch connect with storm sewer system.	20.00	02632-09, -10
Precast Area Zone Drain (PAZD)	Low profile roadside ditch in residential and commercial area	Varies TBD by Engineer	Styles ‘RG’ and ‘FG’ on TxDOT detail CD-PAZD-20

* The nominal capacity values provided in Table 9.5 are to be used for initial sizing only. The actual inlet size all shall be based on hydraulic analysis of the required inlet capacity. Inlet capacities are calculated using either orifice and or weir equations depending upon their location and a type of inlet openings with or without plates.

9.2.01.C.6 continued

e. Do not use beehive grate inlets or other specialty inlets.

f. Do not use grate top inlets in unlined roadside ditch.

g. Do not place inlets in the circular portion of cul-de-sac streets unless justification based on special conditions can be provided.

h. Place inlets at the end of proposed pavement if drainage will enter or leave pavement.

i. Do not locate inlets adjacent to esplanade openings.

j. For new residential development, locate inlets at the center of lots and drainage system with lot site layout such that inlets are not located within the driveway between the radius end points as defined by the driveway radius intersection with the curb or edge of pavement.

k. Place inlets on side streets intersecting major streets, unless justification based on special conditions can be provided.

l. When connecting to a curb inlet, only one connection to that inlet shall be allowed, and that connection (lead) shall be made to the back of the inlet. The connection is to be designed and constructed in accordance with Section 9.2.01.C.4, Pipe Sizes, Materials and Placement. Connection shall not be made to the front face or to the short sides of the inlet. Design the connection not to exceed the downstream pipe capacity minus either the inlet capacity listed in Table 9.5, Standard Storm Sewer Inlets, or calculated inlet inflow.

m. For all new construction, convey alley drainage to an inlet prior to entering the public street drainage system.

n. For all new connections, the Engineer shall be required to demonstrate that inlets for design storm events have adequate capacity based on ponding and available opening. For New Development, Redevelopment, or Site Modification or connections to curbside inlets, existing B inlets along or immediately downstream of said development shall be enlarged to BB inlets.

o. For inlet calculations reference the TXDOT Hydraulic Design Manual Chapter 10, Section 5, Storm Drain Inlets.

p. Grate inlets shall not be allowed on travel lanes other than the gutter.

q. Do not use inlets without top manhole lip in major streets (i.e. Type BB inlet).

9.2.01.C continued

7. Velocity Considerations

   a. Storm sewers should be constructed to flow in subcritical hydraulic conditions if possible.

   b. Minimum velocities should not be less than 3 feet per second with the pipe flowing full, under the design conditions.

   c. Maximum velocities within storm sewers should not exceed 12-feet per second.

   d. Maximum velocities at the storm sewer system Outfall should not exceed 8 feet per second without use of energy dissipation at the Outfall.

8. Sample Calculation Forms

   a. Figure 9.5, City of Houston Storm Sewer Calculation Form, is a sample calculation form for storm sewer systems.

   b. Figure 9.6, City of Houston Roadside Ditch Worksheet, is a sample calculation form for roadside ditch systems.

9.2.01.D Extreme Event Analysis

1. Design Frequency

   a. The design frequency for consideration of overland Sheet Flow will consider extreme storm events (up to 100-Year storms). These events, which exceed the capacity of the underground storm sewer system and result in ponding and overland Sheet Flow, shall be routed to drain along street R.O.W. or open areas and through the development to a primary outlet.

2. Overland Flow Analysis

   a. An Overland Flow analysis of the proposed drainage system shall be prepared by the design Engineer. The design Engineer shall submit supporting calculations, exhibits, and drawings, which define the conveyance capacity of the roadway, define the flow paths of Overland Sheet Flow and define the ponding depths of Overland Sheet Flow.

9.2.01.D.2 continued

b. Three analysis methods as presented in Technical Paper No. 101 (TP-101), Simplified 100-Year Event Analyses of Storm Sewers and Resultant Water Surface Elevations for Improvement Projects in the City of Houston, Harris County, Texas Region will be acceptable to the City.

(1) Method 1: Hydraulic Grade Line (HGL) Analysis. A simplified approach to analyze and control the 100-Year water surface elevation (WSEL) can be achieved by designing the storm sewer system for the 2-Year Frequency rainfall event; imposing a 100-Year Frequency storm event on the proposed design; calculating the Hydraulic Grade Line for the 100-Year Frequency event for the proposed design; and adjusting the position of the HGL to not exceed the Critical Elevation by increasing the size of the proposed storm sewer for selective reaches.

(2) Method 2: $Qt = Qo + Qc$

Where: Qt is the total flow conveyed;
Qo is the Overland Flow component, and
Qc is the calculated flow in the Conduit for the 2-Year design event.

The Overland Flow component (Qo) is computed by applying Manning's Equation to calculate the flow across the critical street cross-section along the R.O.W. This method accounts for flow in the storm sewer and Overland Flow across the street crest, but does not account for street ponding or storage.

(3) Method 3: $Qt = Qo + Qc + \Delta S/T$

Where: Qt, Qo, and Qc are as defined above; and
$\Delta S/T$ is the change in storage volume relative to time provided in the streets and adjacent area upstream of the point of interest being analyzed.

This method uses a volumetric calculation based on a 100-Year Frequency storm event with a duration of 3-hours for developments less than 200 acre and 6-hours duration for developments over 200 acres. The Soil Conservation Service, TR-20 method is used to set a peak triangular hydrograph shape. This method accounts for flow in the storm sewer, Overland Flow across the street crest, and storage within the street and adjacent area.

9.2.01.D.2.c continued

c. Analysis using the U.S. Environmental Protection Agency's Stormwater Management Model (SWMM) will be acceptable to the City.

3. Design Considerations

a. Relationship of Structures to Street: All structures shall be above the maximum ponding elevation anticipated resulting from the extreme event analysis.

(1) Barring conditions listed in 9.2.01.D.3.a.(1) and 9.2.01.D.3.a.(2), the maximum ponding elevation for the 100-Year event at any point along the street shall not be higher than the natural ground elevation at the R.O.W. line.

(2) For City CIP Projects, the maximum ponding elevations shall be no higher than 12-inches below the finished slab elevations, or, if the finished slab elevations are less than 12-inches above the natural ground elevations at the R.O.W., the ponding elevations shall be no higher than the natural ground elevations at the R.O.W. In instances where the maximum ponding elevation for the 100-Year event is not within the natural ground elevation at the R.O.W. line, the Engineer will add a note on the drawings indicating the Rainfall Frequency event is designed to be conveyed within the R.O.W.

(3) For development or Redevelopment by private entities, the post-project maximum WSE shall be no higher than the pre-project maximum WSE in surrounding areas and proposed finished slab elevation shall be above the post-project maximum WSE. The maximum ponding elevation is determined from the physical characteristics of an area, and may change as a result of the proposed development. Where existing topographic conditions, project location within a special flood hazard area, and/or other site conditions preclude achieving this objective, the City will consider waiver of this requirement upon submittal of documentation and analysis prepared, signed, and sealed by a Professional Engineer, registered in the State of Texas. Analysis shall demonstrate that Structural Flooding will not occur and will identify the Rainfall Frequency event that will be conveyed within the R.O.W. The limiting parameter will depend on project-specific conditions, and the most restrictive condition (the lowest ponded water elevation) shall govern.

9.2.01.D.3 continued

b. Streets shall be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet. If a Detention facility is designed to mitigate peak flows from the extreme event, the Overland Flow path shall carry the extreme event Sheet Flow to the Detention facility. If the extreme event Sheet Flow must enter a receiving channel, the Overland Flow path shall carry the extreme event Sheet Flow to the channel. In the event that there is no Overland Flow path, or the Overland Flow path is insufficient to carry all of the extreme event Sheet Flow, the inlets and storm sewer at the downstream end of the Overland Flow path shall be sized to carry the extreme event Sheet Flow from the end of the Overland Flow path into the Detention facility or receiving channel.

(1) The maximum depth of ponding at high points shall be 6-inches above top of curb.

(2) The maximum depth of ponding at low points shall be 18-inches above top of curb.

(3) Refer to Article 5.2.04.E.3 for easement requirements for Sheet Flow. Fence lines and other improvements shall not be constructed on or across dedicated drainage easements.

(4) A drawing(s) shall be provided to delineate extreme event flow direction through a development and how this flow is discharged to the primary drainage outlet.

(a) The extreme event flow path(s) shall be identified on a plan view drawing(s) such as the Drainage Area Map. There will be multiple extreme event flow paths for most projects. A profile for each path should be shown. Where secondary paths join a primary path, the secondary path profile should extend at least one street high/low point downstream along the major flow path, until the maximum ponding elevation downstream of the confluence is lower than the maximum ponding elevation upstream of the confluence.

9.2.01.D.3.b continued

(5) The drawing for each path shall show a profile of the roadway (or Overland Flow path) from the upper reach of the Drainage Area to the primary drainage outlet. The drawing(s) shall be exaggerated vertical scale and shall include roadway profile at the gutter, ground profile at the R.O.W., all the parameters used to determine the maximum ponding elevations, the maximum ponding elevations, and the hydraulic gradient for the extreme event, or an alternative equivalent drawing accepted by the City. The drawing(s) should be separate from the plan and profile sheets, and should include the entire Overland Flow path on one sheet, if possible. The drawings are not required to include the storm sewer profile.

c. Evacuation Routes and Emergency Service Routes. This standard applies to routes designated by HPW for emergency evacuation and for routes where access by the emergency service vehicles is a public safety need. Ponding of surface runoff is not allowed in the highest travel lane (each direction) for the 100-Year event. Exceptions to this standard based on technical infeasibility or cost limitations will require approval of the Director, Houston Public Works, or the Director's designated representative. This standard may be modified or exempted for locations in the 100-Year floodplain.

9.2.01.E Design of Roadside Ditches.

1. Design Frequency

a. Roadside ditch design is permissible only for single family residential lots or commercial areas equal to or larger than 0.5 acres.

b. The Design Rainfall Event for the roadside ditches shall be a minimum of 2-Year rainfall.

c. Design capacity for a roadside ditch shall be to a minimum of 0.5-feet below the edge of pavement or 0.5-feet below the natural ground at R.O.W. line, whichever is lower, including head loss across the culvert. Hydraulic calculations shall include head loss calculations for driveway and roadway culverts that are placed along the roadside ditch.

d. The design must include an extreme event analysis to indicate that structures will not be flooded, and that maximum ponding elevation for the extreme event complies with article 9.2.01.D.3.a.

2. Velocity Considerations

9.2.01.E.2 continued

a. For grass-lined sections, the maximum design velocity shall be 3.0 feet per second during the design event.

b. Minimum grades for roadside ditches shall be 0.1-foot per 100-feet.

c. Calculation of velocity will use Manning's roughness coefficient (n) of 0.045 for earthen sections and 0.025 for ditches with paved inverts.

d. Use erosion control methods acceptable to the City when design velocities are expected to be greater than 3-feet per second.

3. Driveway and Roadway Crossings

a. Culverts will be placed at all driveway and roadway crossings, and other locations where appropriate.

b. Culverts shall be evaluated for inlet and outlet control, as well as normal depth. The highest of the three shall be designated as the computed headwater for design of the culvert section.

c. Roadside culverts are to be sized based on hydraulic analysis. The minimum culvert size shall be 24-inches inside diameter or equivalent 'cross section'. For example, if the ditch is deeper than or equal to 29-inches, the elliptical pipe with inside diameter of 19-inches x 30-inches can be used. Calculations shall be provided for review. In the ETJ, the Regulations for Harris County, Texas for the Construction of Driveways and/or Culverts on County Easements and R.O.W. shall govern.

d. When spacing of driveways results in a roadside ditch that is less than 8-feet long (e.g., less than 8-feet between culverts), options shall be considered to address maintenance challenges and may include replacement of the short roadside ditch with a Long Run Culvert.

e. For culverts that are 40-feet in length or longer (i.e., Long Run Culverts), provide a grated inlet, junction box or manhole (with grated manhole cover). Engineer to coordinate with the City the spacing of inlets, junction boxes or manholes for Long Run Culverts.

f. Design capacity calculations shall include head loss calculations for driveway and roadway culverts that are placed along the roadside ditch.

9.2.01.E.3 continued

g. Stormwater discharging from a ditch into a storm sewer system must be received by an appropriate structure (i.e., stubs with ring grates or Type E inlets).

h. Install appropriate measures (e.g., headwalls, safety end treatments, riprap, sloped paving, earthen slope protection, etc.) at both sides of inlet and outlet of a culvert to prevent erosion and increase public safety.

(1) End treatment/appropriate measure details shall be provided in the Drawings.

(2) Headwall or safety end treatment shall be provided for commercial driveways.

(3) Riprap, sloped paving and earthen slope protection are only allowed for single family residential driveway culverts located along Local Streets.

(4) Where earthen slope protection is specified, factors such as erosion control, soil and pipe strength to carry errant vehicle loads shall be design considerations.

(5) Where earthen slopes are specified, the slope shall not be steeper than 3H:1V. The pipe end shall extend 2-feet minimum beyond the edge of driveway pavement on each side of the driveway culvert.

i. Proposed street parking pads over an existing ditch are not allowed.

j. Partially replacing roadside ditches with a subsurface drainage system is not allowed unless the Engineer can demonstrate that there is no adverse impact to drainage.

4. Invert Protection

a. Ditch invert protection shall be used when velocities exceed 3-feet per second.

b. Ditch invert protection will be used at the upstream and downstream ends of all culverts.

5. Depth and Size Limitations (Figure 9.7)

a. Maximum depth shall not exceed 4-feet from adjacent edge of pavement.

9.2.01.E.5 continued

b. Roadside ditch bottoms shall be at least 2-feet wide, unless design analysis will support a narrower width.

c. Ditches in adjoining and parallel easements shall have top of bank not less than 2-feet from the outside easement line.

d. The top of bank shall not encroach beyond the City R.O.W. or within 2-feet of the edge of pavement.

e. A grass-lined or unimproved roadside ditch shall have side slopes no steeper than three horizontal to one vertical (3:1), or as soil conditions will permit.

9.2.01.F Design of Open Channels

1. Design Requirements and General Criteria.

a. Open channels shall be designed according to methods described in the Harris County Flood Control District Interim PCPM 2019: Policy Criteria and Procedures Manual for approval and acceptance and shall convey 100-Year event.

b. Design standards for channel construction shall follow the requirements specified in the Harris County Flood Control District Interim PCPM 2019: Policy Criteria and Procedures Manual for approval and acceptance.

c. Design standards for Outfalls into channels shall conform to those in the Harris County Flood Control District Interim PCPM 2019: Policy Criteria and Procedures Manual for approval and acceptance.

2. Determination of Water Surface Elevation (WSE)

a. WSE shall be calculated using Manning's Equation and the Continuity Equation.

b. For the Design Rainfall Event, the water surface shall be calculated to remain 1-foot below the top of banks.

3. Design of Culverts

a. Head losses in culverts shall conform to TxDOT Hydraulics Manual.

b. Corrugated metal pipe will be approved only for railroad crossings.

9.2.01.G Outfalls that directly discharge to other jurisdictions see 9.1.02.G.

9.2.01.H Stormwater Detention

1. Detention volume requirements are based on the proposed Development area. Detention volumes are calculated at the minimum rates set forth in article 9.2.01.H.3.

2. Application of Detention

   a. The use of Detention is required for all developments within the City and for new or expanding utility districts within the City's ETJ. Detention may not be required if the City has developed Detention capacity for a drainage watershed, and/or infrastructure improvements, to serve the drainage watershed in compliance with the requirements of this chapter. Under these conditions, the City will consider a funding contribution in lieu of on-site Detention volume constructed by the owner.

   b. Drainage and storm designs are still required to collect and convey site run off for projects that are exempt from providing Detention.

   c. Stormwater Detention requirements are invoked for New Developments and Redevelopments that contain Impervious Areas.

   d. Stormwater Detention requirements are not invoked for the following conditions:

      (1) Where existing Impervious Cover exists, Detention is not required for the addition of a feature or improvement on top of the existing Impervious Cover. This is only in scenarios where existing Impervious Cover is not redeveloped (e.g. a charging station equipment without proposed pavement is added to an existing parking lot, awnings, canopies, table umbrellas, shade structures, a covered patio added to a deck, etc.).

      (2) Addition of floors to existing buildings that do not change the footprint of the building or the storm drainage pattern of the building.

      (3) Building roof repair that does not change the storm drainage pattern of the building.

      (4) Change in use of existing roof areas that do not change the storm drainage pattern of the building.

      (5) Maintenance Activities as defined in article 9.1.04.JJ.

9.2.01.H.2.d continued

(6) New development or Redevelopment projects that result in an increase in Impervious Area within the Right-of-Way due to construction of sidewalks, monuments, travel/left-turn lanes, among other facilities on the condition that the following can be established:

(a) Provide a hydraulic computations for the 2-Year storm event showing that both:

[1] The proposed total surface flow resulting from the increased Impervious Area will not exceed the allowable capacity of the receiving public storm sewer inlet or open drainage system in the street; and

[2] The proposed additional Impervious Area within the Right-of-Way will not exceed the impervious coverage reflected in the 'C' value for the Right-of-Way area used in the design of the storm sewer draining into the Right-of-way.

(b) If 9.2.01.H.2.d.(6).(a) cannot be met, the conditions in the following article shall apply:

[1] Perform a Hydraulic Grade Line (HGL) analysis for the receiving public drainage system to demonstrate that the 2-Year HGL does not exceed the Critical Elevations (e.g., gutter line) and that the 100-Year HGL remains below the Maximum Ponding Elevation (MPE) or the existing 100-Year HGL.

(7) Developments on parcels immediately adjacent to Lake Houston which outfall directly into Lake Houston. This exemption does not apply to portions of the development that are located outside of the Lake Houston watershed.

(a) However, for developments within the Lake Houston watershed not governed by 9.2.01.H.2.d.(7), provide a hydraulic analysis that shows No Adverse Impact (NAI) to channels, gullies, tributaries, parcels downstream and surrounding developments. The analysis shall extend to Lake Houston.

(8) Proposed underground utility lines that meet both of the following criteria:

9.2.01.H.2.d.(8) continued

(a) Utility line installation does not create new Impervious Areas; and

(b) Construction site restoration due to utility installation does not alter the site's existing drainage pattern.

e. Existing Impervious Cover Detention Credit for Redevelopment: Applicant must present a valid survey that is signed and sealed by a Registered Professional Land Surveyor licensed in the state of Texas. To claim existing Impervious Area, the survey shall be signed and sealed within five years of the project submittal date and shall include supporting pictures taken within the same period to validate site conditions.

(1) Detention storage credit for Redevelopment shall apply only to developments that are subject to Detention criteria 3.

(2) Detention storage credit is allowed at a rate of 0.4 acre-foot/acre for Redevelopment of existing Impervious Cover area.

(3) The Detention volume required including the credit shall be calculated as follows:

$$\text{Detention Volume Required} = \left(A_p \times r_d\right) - \left(A_e \times 0.4 \text{ acre-ft/acre}\right)$$

Where:

A_p = Proposed Impervious Area (SF)

A_e = Existing Impervious Area (SF) onsite to be removed with Redevelopment

r_d = Detention rate (acre-foot/acre) required by Table 9.8

(4) When a tract has existing Detention volume provided onsite prior to Redevelopment, the Detention volume determined according to article 9.2.01.H.2.e.(3) shall not be less than the existing Detention volume provided for the tract.

(5) If existing Impervious Cover on a Redevelopment site will remain and not be redeveloped, no additional Detention will be required for the area not being redeveloped.

9.2.01.H.2.e continued

(6) Credit can be applied for all Impervious Cover removed with Redevelopment.

f. Detention credit for dry-grass-lined Detention basins may be considered when justified by Infiltration report of soil testing and by hydraulic analysis.

g. Master Drainage Plan:

(1) A master drainage plan establishes the current and future drainage plan for a development. A master drainage plan generally consists of drainage, grading, Detention, and other applicable site plans. These site plans contain detailed calculations for Impervious Area, Detention, restrictors, flow rate, etc. All master drainage plans shall follow Detention requirements in Table 9.6, Table 9.7, or Table 9.8 and other applicable criteria in this chapter shall be utilized.

(2) Developments will be recognized as legacy projects where the Detention system and storm sewers have been fully constructed for the entire Development based on a master drainage plan approved after the year 2002. Legacy projects will be allowed to build out the remainder of the project under the approved drainage plan without additional requirements.

(a) Minimum Requirements for Legacy Projects:

[1] Applicants claiming to be a legacy project shall provide documents that show the proposed design matches the original approved design.

[2] Impervious Area for proposed tracts should match the total Impervious Area based on the estimated amount in the original design. If this information is not available, the amount shown on the plat should be applied.

(b) Qualification: Proposed New Development or Redevelopment of tracts do not require Detention when all of the following criteria are met:

[1] Detention has been provided on the master plan (regardless of current Detention rates).

[2] Detention has been permitted and constructed.

9.2.01.H.2.g.(2).(b) continued

[3] Associated public infrastructure has been permitted and constructed.

h. Plat, replat, change the use of, or subdividing any tract to reduce stormwater Detention requirements will not be permitted. Original tract size on plat or replat, change the use of, subdividing, HCAD and survey will be used to determine stormwater Detention requirements. Replating subdivisions that result in increased Impervious Cover and differs from the regional master plan design originally approved does not reduce Detention requirements.

i. Project site that discharges directly into the Harris County, HCFCD, Fort Bend County, Montgomery County or other jurisdictions requires their review and approval prior to City's approval.

j. Detention basins that directly discharge to other jurisdictions see 9.1.02.G.

k. City no longer allows timing analysis to avoid Detention requirements.

l. De Minimis Impact Credit:

(1) De minimis impact projects will be considered where the increase in Impervious Area will have minimal impact on the City's drainage system. De minimis impact projects include but are not limited to adding charging stations to existing parking lots (equipment and proposed pavement), adding a deck or pool to a home, and adding additional parking area to an existing parking lot.

(2) Drainage and storm designs are still required even when Detention requirement is not applicable due to de minimis impact.

(3) De minimis impact credit will only apply to existing Single Family Residential developments or existing commercial developments where improvements are added.

(a) For existing single family residential developments that fall under criteria 1 (See article 9.2.01.H.3.b) and criteria 2 (See article 9.2.01.H.3.c) where improvements are added.

9.2.01.H.2.l.(3).(a) continued

[1] Tracts less than 15,000 square feet in size: De minimis credit will be allowed up to 5% of the lot size area for increased Impervious Cover improvements. This credit is for additions that exceed the 65% Impervious Cover allowance for single family residential tracts. Total Impervious Area for the tract shall not exceed 70% of the tract area for this credit allowance.

[2] Tracts greater than 15,000 square feet in size: De minimis credit will be allowed up to 5% of the lot size area for increased Impervious Cover improvements. This credit is for additions that exceed the greater of 9,750 square feet or 40% Impervious Cover allowance for single family residential tracts. Total Impervious Area for the tract shall not exceed 750 square feet for this credit allowance.

[3] Repetitive submittals to claim de minimis impact credit will be accepted as long as the summation of all historical submittals requested for the tract does not exceed the maximum credit allowance.

(b) For existing developments that fall under criteria 3 as defined in article 9.2.01.H.3.d where improvements are added.

[1] Tracts 20 acres and less in size: De minimis impact credit will be given for an improvement of an existing development up to 1% of the total tract area. Credit will only be allowed once. Repetitive submittals to claim de minimis credits will not be accepted and tract will be subject to Detention requirements.

[2] Tracts greater than 20 acres in size: A drainage study will be required to determine the total impact. The City Engineer will determine whether the impact(s) can be considered a de minimis impact.

9.2.01.H continued

3. Calculation of Detention Volume

   a. Detention volume requirements are based on the proposed Development area.

   b. Detention Criteria 1: For a tract containing only one single family residential (SFR) home, follow Table 9.6.

Table 9.6 - DETENTION CRITERIA 1

SFR Tract Size	Percentage/Total Impervious Area[i]	Detention Required (Y/N)	Detention Volume	Notes
One SFR tract ≤ 15,000 SF	Total Impervious Area ≤ 65% of tract	N	N/A	1-3
One SFR tract ≤ 15,000 SF	Total Impervious Area > 65% of tract	Y	0.75 ac-ft/ac rate × Impervious Area in excess of 65% of tract	1-3
One SFR tract >15,000 SF	Total Impervious Area ≤ the greater of 9,750 SF or 40% of tract	N	N/A	1-3
One SFR tract >15,000 SF	Total Impervious Area > the greater of 9,750 SF or 40% of the tract	Y	0.75 ac-ft/ac rate × Impervious Area in excess of the greater of 9,750 SF or 40% of tract	1-3

(1) For a tract with multiple lots, the Detention exemption shown in this table is not applicable. Refer to Table 9.7 for Detention volume requirements.

(2) No Sheet Flow shall be permitted to an alley, neighboring properties, R.O.W. or a ditch unless allowed according to 9.2.01.C.4.b.(2).(a). The point of connection shall be as described in 9.2.01.C.4.b.(2).

(3) See article 9.2.01.H.2. Application of Detention for criteria for acceptable Detention credits.

i Total impervious area = (existing + proposed) impervious area.

9.2.01.H.3 continued

c. Detention Criteria 2: For tracts with SFR developments with Direct Driveway Access, joint access, shared access, Courtyard Access Drive or Multi-Unit Residential (MUR) development, follow Table 9.7.

Table 9.7 - DETENTION CRITERIA 2

Tract Size	Percentage/Total Impervious Area[i]	Detention required (Y/N)	Detention Volume	Notes
Tract ≤ 15,000 SF	Total % Impervious Area within tract ≤ 65% of tract	N	N/A	1-6
Tract ≤ 15,000 SF	Total % Impervious Area within tract > 65% of tract	Y	0.75 ac-ft/ac rate × Impervious Area in excess of 65% of the tract	1-6
15,000 SF < Tract < 1 acre	Total Impervious Area within tract ≤ the greater of 9,750 SF or 40% of tract	N	N/A	1-6
15,000 SF < Tract < 1 acre	Total Impervious Area within tract > the greater of 9,750 SF or 40% of tract	Y	0.75 ac-ft/ac rate × Impervious Area in excess of the greater of 9,750 SF or 40% of tract	1-6
Tract ≥ 1 acre	All proposed Impervious Area	Y	Refer to requirements in Table 9.8	1-6

(1) When a tract of one acre or more is divided into multiple lots, Detention is required for all proposed Impervious Area within the lot. No residential exemption will be granted for the individual lot within this subdivision tract.

(2) No Sheet Flow shall be permitted to an alley, neighboring properties, R.O.W. or a ditch unless allowed according to 9.2.01.C.4.b.(3).(a).[1]. The point of connection shall be through a pipe as described in 9.2.01.C.4.b.(3).

(3) The Detention exemption for Impervious Area should be proportionate among all the lots within the tract; this also includes any Direct Driveway Access, shared access, joint access, Courtyard Access Drive and Multi-Unit Residential (MUR). A breakdown of impervious area calculation for each lot shall be submitted to take the Detention exemption.

(4) An alley created with recorded plat prior to January 1st, 2023, is exempt from detention requirements.

(5) Proposed permanent access easement (28’ PAE), alley, or similar accessway by any other name requires Detention; no Detention exemption will be allowed.

(6) See article 9.2.01.H.2. Application of Detention for criteria for acceptable Detention credits.

i Total Impervious Area = (existing + proposed) Impervious Area also including Direct Driveway Access, joint access, shared access, Courtyard Access Drive or Multi-Unit Residential (MUR) developments.

9.2.01.H.3 continued

d. Detention Criteria 3: For other projects not subject to 9.2.01.H.3.b or 9.2.01.H.3.c follow Table 9.8.

Table 9.8 - DETENTION CRITERIA 3

Tract Size	Proposed Impervious Area	Detention Required (Y/N)	Detention Volume	Notes
Tract ≤ 20 acre	All proposed Impervious Area	Y	0.8 ac-ft/ac rate × proposed Impervious Area of the tract	1-2
Tract > 20 acre	All proposed Impervious Area	Y	Follow the most current version of the HCFCD PCPM; Minimum rate is 0.75ac-ft/ac	1-2

(1) No Sheet Flow shall be permitted to an alley, neighboring properties, R.O.W., or a ditch. For projects using this table, a subsurface drainage system is required. The point of connection shall be designed as described in article 9.2.01.C.4.b.

(2) Tract size greater than 20 acres: Detention calculation will be per the most current version of the HCFCD Policy, Criteria and Procedures Manual (PCPM). When project Outfalls within City limits, the maximum Detention credit due to existing impervious area shall be as defined in article 9.2.01.H.2.e.

(3) See article 9.2.01.H.2. Application of Detention for criteria for other acceptable Detention credits.

e. In private parking areas, and private streets, provide Detention or portion of Detention utilizing underground system or Detention pond, whenever possible. If the existing conditions do not allow for underground Detention or Detention pond, Detention through ponding in private parking areas, private transport truck only parking areas will be considered. Engineer shall provide calculations and analysis to the Office of the City Engineer for approval of design method prior to plan submittal.

f. If approved for Detention through ponding in private parking areas, the maximum depth of ponding cannot exceed 9-inches directly over the inlet and paved parking areas must provide signage stating that the area is subject to flooding during rainfall events.

9.2.01.H.3.f continued

If approved for Detention through ponding in private transport truck only parking, the maximum depth of flooding cannot exceed 15-inches directly above the inlet, and signage must be provided stating that the area is subject to flooding during rainfall events.

g. All Detention facilities shall be located within or adjacent to the project area except for roadway projects or projects where impacts are mitigated in a regional stormwater Detention facility. Engineer shall provide calculations indicating receiving stormwater system was designed to have conveyance capacity to non-adjacent Detention facilities.

h. Overflow from the Detention facility shall be directed away from adjacent properties and building structures. Where possible, reroute overflow within the development away from sidewalks and into swales or ditches to return the overflow to the development's Detention basin.

i. Sheet Flow across sidewalks is allowed in cases where criteria in Article 9.2.01.H.2.d.(6) is met.

j. Low Impact Development (LID) techniques that are considered acceptable for achieving Detention are listed in Table 9.11. See SECTION 6 for LID design guidelines.

(1) Review and approval of engineering calculations demonstrating the volume of Detention achieved for each LID technique will be required.

(2) If LID techniques are considered for achieving Detention, review and approval of a maintenance and life cycle plan are required per this section and section 9.2.01.H of this chapter. Review and approval of engineering calculations demonstrating the volume of Detention achieved for each LID technique will be required. This plan shall be signed and sealed by a registered Professional Engineer and included as part of the review and approval process.

(3) For project implementing GSI (Green Stormwater Infrastructure)/LID technique, refer to Section 9.2.01.H for Detention requirements.

9.2.01.H.3 continued

k. Detention requirement for projects dealing with natural disasters (e.g. hurricanes, tornados, flood, and unintentional damages such as fire damages to the structures, chemical leaking, chemical explosion): Detention criteria will be determined on a case-by-case basis. Supporting reports showing proof of damages will be required to be submitted for the projects.

l. The Detention requirement for projects within the Central Business District, approved locations within the Medical Center and Lower Buffalo Bayou: In lieu of the required Detention, these developments or Redevelopments shall consider the application of LID techniques to significantly reduce the runoff prior to discharging into the R.O.W. See Table 9.11 for LID techniques. For Buffalo Bayou, this provision is only valid if runoff from the development is routed directly to the bayou. For Central Business District, Texas Medical Center and Buffalo Bayou boundaries, see Figure 9.8, Figure 9.9 and Figure 9.10.

m. Safety should be given careful consideration in Detention basin designs. Embankment slopes, railings, fences, grates, and other features should be incorporated into the design of the facility wherever appropriate. Appropriate warning signs should be placed around the perimeter of the facility.

    (1) Vehicular access gate for the Detention fence shall be designed for vehicles of various types and sizes for routine maintenance visits.

n. Requirements for projects with Maintenance Activity:

    (1) For maintenance of existing parking lots, the use of different materials may be permissible while keeping the same grading and drainage pattern.

    (2) Maintenance of an existing roof requires the original roof area, slope of the roof, downspout, drainage, and Outfall to be shown in civil plan.

    (3) Maintaining or repairing underground utilities/pipe systems is allowed without requiring Detention given the existing condition is maintained.

    (4) All Maintenance Activity requires a survey or site plan showing the existing condition to be submitted to the City.

9.2.01.H.3.n continued

(5) A separate plan and profile permit is required for maintenance projects of a commercial driveway approach that is required to upgrade the culvert size to current standards.

(6) For SFR projects only, when repairing or replacing driveways, and walkways, the use of different materials may be permissible while keeping the same grading and drainage pattern.

4. Underground Detention Requirements: Underground Detention systems are comprised of the use of underground pipes, tanks, vaults, inlets, manholes, and other engineered underground structures for Detention purposes.

a. Site requirements: Sites that are allowed to use underground Detention are grouped as follows:

(1) All residential projects

(2) Commercial projects up to 10-acres.

(3) Commercial projects above 10-acres may be approved using underground Detention systems on a case-by-case basis.

(4) Public projects where approved by City.

b. Inlet/Outlet and Structural Requirements:

(1) Underground Detention systems require an overflow design for extreme flood events in accordance with section 9.2.01.D. See to article 9.2.01.H.3.h.

(2) Include energy dissipaters (i.e., riprap or plunge pools) at the end of the outlet pipe if the pipe discharges onto a pervious surface.

(3) Provide a storm water quality BMP to remove trash/sediment/debris at all direct inflow points of the storage chamber.

(4) Follow the current maximum drainage rule of 48-hours or less.

(5) Follow pump requirements in the event a pump is being used to discharge stormwater.

(6) A minimum of 12-inches of cover on top of the Detention structure is required.

9.2.01.H.4.b continued

(7) A cross-section of the underground Detention system with manufacturer's recommendations is required to be submitted with the plans.

(8) A Texas Licensed Professional Engineer shall be responsible for design of underground Detention systems and shall verify if the underground Detention system is structurally adequate to support any imposed loads (vertical and lateral).

(9) The Drawings shall be signed and sealed by a Texas Licensed Professional Engineer.

(10) Use manufacturer's recommendation for access locations over the inlet pipe and outflow structure. Additional access locations may be needed depending on system size. Access points should be bolted or locked.

(11) Note that confined space entry may be required in certain systems.

(12) Add notes in the plan stating:

(a) Underground Detention systems shall be installed and maintained based on the manufacturer's recommendation.

c. Maintenance Requirements: Active maintenance is required for all underground Detention systems. Sediment removal and trash collection are necessary to upkeep the Detention system.

(1) The following maintenance requirements supplied by the manufacturer shall be included in plans:

(a) Trash and debris removal schedule.

(b) Sediment removal schedule.

(c) Inspections schedule.

(2) Include the following notes on plans:

(a) Inspections shall include:

[1] Pre-treatment screening, sediment capture devices and outlet control devices.

[2] Investigation of any leaks (sinkholes or other indications of a failing system).

9.2.01.H.4.c.(2) continued

(b) Repair inlets and outlets when damage occurs.

(c) If media is utilized, replace if the drawdown time exceeds 48-hours.

(3) If the system is used as a stormwater quality feature, the design requirements shall be meet article 9.5.01.

d. If the underground system is approved in the R.O.W., an agreement between the private development and the City of Houston must be in place to clearly define ownership and maintenance responsibilities.

5. Calculation of Outlet Size

a. Detention pond discharge pipe into an existing storm sewer line or existing City of Houston ditch:

(1) If the maximum pool elevation is at or below the design Hydraulic Grade Line (HGL) at the drainage system Outfall, the discharge line shall be sized for the design rainfall with the discharge pipe flowing full. The pond will float on the drainage system to provide maximum benefit.

(2) If the maximum pool elevation is above the design Hydraulic Grade Line (HGL) at the drainage system Outfall, provide a reducer or restrictor pipe to be constructed inside the discharge line. The discharge line shall be sized for the design rainfall with the discharge pipe flowing full.

b. Reducer or restrictor pipes shall be sized as follows:

(1) Allowable Discharge Rate - Use the lowest of the discharge rates described below:

9.2.01.H.5.b.(1) continued

(a) Restrictor pipes will provide a combination of low level and high level controlled release from the Detention basin. The low level restrictor pipe (primary orifice) shall be sized to provide a release rate of 0.5 CFS/acre when the Detention basin water depth is 25% of capacity. The low level restrictor pipe (primary orifice) shall be located at the bottom of the basin to provide complete drainage of the pond. The high level restrictor pipe (secondary orifice) shall be sized to provide a combined release rate (from the primary orifice and secondary orifice) of 2.0 CFS/acre at full basin depth. The high level restrictor secondary orifice) shall begin releasing flow when Detention basin water depth reaches 75% of capacity. The combined rate of 2.0 CFS/acre is the approximate discharge from an undeveloped tract for the 100-Year storm. The basin is considered 100% full when it reaches its maximum volume during the 100-Year storm. See Figure 9.11.

(b) Flow discharged to the storm drain shall not exceed the proportional amount of pipe capacity allocated to the development. The proportional amount of pipe capacity allocated to the development shall be determined by the ratio of the area (acres) of the development (in storm drain watershed) divided by the total Drainage Area (acres) of the storm drain multiplied by the capacity of the storm drain.

(2) Use the following equations to calculate the required outflow orifice (see Figure 9.12):

$$Q = CA\sqrt{2g}\ \sqrt{h}$$

$$D = Q^{½} / (2.25h^{1/4})$$

Where:

Q	=	outflow discharge (cfs)
C	=	coefficient of discharge
	=	0.8 for short segment of pipe
	=	0.6 for opening in plates, standpipes, or concrete walls
A	=	orifice area (square feet)
g	=	gravitational factor (32.2)
h	=	head, water surface differential (feet)
D	=	orifice diameter (feet)

9.2.01.H.5.b continued

(3) For rectangular weir flow calculation (see Figure 9.13):

$$Q = CLH^{3/2}$$

Where:

Q = weir discharge (cfs)
C = weir coefficient
L = horizontal length (ft)
H = head on weir (ft)

The value of the weir coefficient, C, depends on the weir shape (i.e., broad crested or sharp crested) and if the weir is submerged or not. See Brater and King's Handbook of Hydraulics or other applicable references.

(4) Restrictor shall be either of the required diameter or of the equivalent cross-sectional area. The orifice diameter D shall be a minimum of 0.5-feet.

c. In addition to a pipe outlet, the Detention basin shall be provided with a gravity spillway that will protect structures from flooding should the Detention basin be overtopped.

6. Ownership and Easements

a. Private Facilities:

(1) Pump discharges into a roadside ditch or storm sewer system must comply with the following:

(a) Submittal of pump specifications, including capacity (GPM) of the pump, on the design drawings.

(b) Provide a backup pump in the event of a pump failure.

(c) Provide emergency power from a second source or install a quick connect for a mobile generator.

(d) Provide a stilling basin to dissipate the energy from the pump outlet prior to gravity flow into the ditch or storm sewer.

(e) HCFCD projects with tracts above 20 acres utilizing pumps require pumped volume to be less than 50% of the Detention basin capacity.

9.2.01.H.6.a continued

(2) The City reserves the right to prohibit the use of pump discharges where their use may aggravate flooding in the public R.O.W.

(3) Responsibility for maintenance of the Detention facility must be confirmed by letter submitted to the City as part of the design review and shall also be stated on the drawings.

(4) All private properties being served have drainage access to the pond. Dedicated easements may be required.

(5) No public properties may drain into the Detention area.

(6) A private maintenance agreement must be provided when multiple tracts are being served.

(7) All Detention facilities must completely drain out of property within 48-hours with exception to facilities that are intended to maintain a static water level (e.g. wet bottom detention basins). Where applicable Drawings shall state that the facility shall completely drain out of the property within 48-hours.

(8) All inflow pipes to the detention basin cannot be submerged.

(9) For swales and detention ponds, a minimum of 2-feet set-back from the property line or boundary is required. Set-back shall be measured from the top of bank whichever is closest to the property line or boundary.

(10) All storm sewer within a Type 2 Permanent Access Easement (PAE) must be designed to public storm standards outlined in this chapter of the Infrastructure Design Manual except when it is indicated that the PAE will not be dedicated to the City. Refer to Chapter 42 of the Code of Ordinances. A separate plan and profile shall be submitted.

b. Public Facilities:

(1) Facilities will only be accepted for maintenance by the City within the City limits in cases if public drainage is being provided.

9.2.01.H.6.b continued

(2) The City requires a maintenance work area of 20-foot width surrounding the extent of the Detention area. Public R.O.W. or permanent access easements may be included as a portion of this 20- foot width. See Table 9.9 below from the HCFCD PCPM for minimum berm widths around a Detention basin.

Table 9.9 – MINIMUM BERM WIDTH AROUND A DETENTION BASIN

Detention Basins That Are	The Minimum Berm Width Is
Grass-lined with a depth > 7-ft	30-ft
Grass-lined with a depth < 7-ft	20-ft[1]
Grass-lined where side slopes are 8(horizontal):1(vertical) or flatter	10-ft[2]
Grass-lined with the 20-ft maintenance access on a bench	10-ft
Lined with riprap or articulated concrete blocks or partially concrete-lined	Same as grass-lined channel
Fully concrete-lined	20-ft[1]

[1]Backslope swale system not needed.
[2]Maintenance access is on the side slope.

(3) A dedication of easement shall be provided by plat or by separate instrument.

(4) Proper dedication of public access to the Detention pond must be shown on the plat or by separate instrument. This includes permanent access easements with overlapping public utility easements.

(5) Backslope drainage systems are required where the natural ground slopes towards the drainage basin. A basin that is within 30-feet of a parking lot or roadway with berms that drain away from the basin does not require a backslope swale. Comply with criteria provided in HCFCD Policy Criteria and Procedure Manual (PCPM).

9.2.02 STORM STRUCTURAL DESIGN REQUIREMENTS

9.2.02.A Structural Design Requirements

1. The Engineer of Record is responsible for the design of all structural components within the proposed storm water design. This includes but is not limited to pipe, box sewers, manholes and junction boxes.

2. Cast-in-place and precast structural elements are both allowed given that each design is signed and sealed by a Professional Engineer.

SECTION 3 – EASEMENTS AND RIGHTS-OF-WAY

9.3.01 EASEMENTS AND RIGHTS-OF-WAY

9.3.01.A Storm sewer easement and R.O.W. requirements are described in Chapter 5 Easement Requirements.

SECTION 4 – SURVEY REQUIREMENTS

9.4.01 SURVEY REQUIREMENTS

9.4.01.A Projects shall be tied to National Geodetic Survey (NGS) datum adjustment which matches the Federal Emergency Management Agency (FEMA) rate maps or the most current NGS datum which matches the FEMA rate maps. In the event GPS surveying is used to establish benchmarks, at least two references to benchmarks relating to the rate maps shall be identified. Equations may be used to translate other datum adjustments to the required adjustment.

9.4.01.B Refer to Chapter 2 – Survey Requirements for additional requirements.

SECTION 5 – STORMWATER QUALITY DESIGN REQUIREMENTS

9.5.01 STORMWATER QUALITY DESIGN REQUIREMENTS

9.5.01.A Stormwater quality design requirements shall be integrated to meet the standards in all chapters of the IDM. Stormwater quality measures must work to meet or exceed the drainage requirements of this chapter.

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

9.5.01.C For individual BMPs the Water Quality Volume is calculated using the Rational Method runoff coefficients in Section 9.2.01.B.1 and minimum storm depth of 1.00-inches [preferably 1.72–inches (90^{th} percentile) for New Development or 1.39-inches (85^{th} percentile) for Redevelopment]. The BMP shall be preferably designed to remove 80% (minimum of 50%) of TSS and 60 percent of best achievable practice for bacteria removal (i.e. indicated by E. coli and Enterococci). See LID section for additional bacterial removal requirements for LID techniques. For BMPs requiring a flow rate, the calculation shall be based on the rational method using a minimum design intensity of 1.00 inches per hour with the ultimate goal of a design of an Atlas 14, 2-year, 1-hour storm event (See section 9.2.01.B.1).

9.5.01.D Regulated Construction Activity:

1. SWPPPs and BMPs will be developed in accordance with the Stormwater Management Handbook for Construction Activities (9.1.03.Y), for all construction in the City limits. A site-specific SWPPP (e.g., erosion control plan) is required and must include the Stormwater Pollution Prevention Plan Detail (DWG No. 01570-01).

2. Construction plans will include a note requiring contractor to comply with the construction stormwater general permit including preparation of a SWPPP and to provide a copy of the Site Notice, NOI, and maintenance checklist to City Engineer or Building Official five (5) workdays prior to commencement of any construction activity.

9.5.01.D continued

3. For post-construction permanent BMPs, designs and construction activities should be consistent with the guidance given in the Harris County's "Minimum Design Criteria for Implementation of Certain Best Management Practices for Storm Water Runoff Treatment Options"[17].

9.5.01.E New Development and Significant Redevelopment:

1. All designs must be consistent with the Stormwater Quality Guidance Manual[18] (SWQGM) and the Minimum Design Criteria for Certain Stormwater Runoff Treatment Options[19] (MDC), 2001 edition.

2. Pollutants expected from the site (e.g. floatables, sediments, hydrocarbon, bacteria, etc.) must be identified in the SWQMP. BMPs must be designed and selected to remove the pollutants identified.

3. At a minimum, the system must be designed to be in accordance with 9.5.01.C.

4. BMPs listed in the SWQGM but not in the MDC may be acceptable for implementation pending review of design calculations and site applicability. BMPs not listed in the SWQGM may be considered on a case-by-case basis. Acceptance of these BMPs will require not only review of design calculations and site applicability, but also review of case studies or other data provided by an uninterested third party indicating the effectiveness of the BMP. All calculations and literature must be provided as part of the plan submittal.

5. In addition to meeting the stormwater quality requirements of this section, the stormwater system must also meet the requirements of the rest of this chapter.

9.5.01.F Demonstration of Soil Permeability

1. Representative soil sampling of the in-situ soil shall be conducted by qualified personnel to determine if Underdrain system is required, to be in accordance with applicable requirements in 9.6.02.

[17] https://www.eng.hctx.net/Portals/23/Publications/criteria_2001_edition.pdf
[18] The Stormwater Quality Management Guidance Manual developed jointly by City of Houston, Harris County, and Harris County Flood Control District can be found at https://www.cleanwaterways.org/Portals/73/downloads/professional/guidance_manual_full.pdf
[19] The Minimum Design Criteria (MDC) Manual developed jointly by City of Houston, Harris County, and Harris County Flood Control District can be found at https://www.eng.hctx.net/Portals/23/Publications/criteria_2001_edition.pdf

9.5.01.G The minimum design criteria for conventional SWQ features shall be applied in accordance with Table 9.10.

Table 9.10 – MINIMUM DESIGN CRITERIA FOR CONVENTIONAL TECHNOLOGIES

SWQ Conventional Type	SWQ Treatment Technology	General Design Criteria	SWQ Application Example
Hydrodynamic Separator	Sedimentation and Separation	• Capture 90-micron particles, or an equivalent. • Access for cleaning/accessible to cleaning equipment.	• Small or large development. • For retrofit or existing storm systems.
Inlet Filter Basket	Filtration and sedimentation	• Have coarse and fine filter screens. • Be able to capture floatable and coarse/fine sediments. • Corrosion resistant.	• Small development or # of inlets less than 10. • Retrofits for existing urban areas.
Dry Detention Pond	Sedimentation and Separation	• Vegetated. • Side slope is 3H:1V or flatter. • Have trash rack or perforated riser pipe. • Capture floatables larger than 1.5-in wide and capture settleable materials < 90microns.	• Larger developments • Where other stormwater BMPs do not apply.
Wet Detention Pond	Sedimentation and Separation	• Vegetated. • Side slope is 3H:1V or flatter. • Have trash rack or perforated riser pipe. • Forebay 3-ft min. depth • Capture floatables larger than 1.5-in wide and capture settleable solids < 90micron.	• Larger developments • Where other stormwater BMPs do not apply.

9.5.02 SWQ PERMIT APPLICATION REQUIREMENTS

9.5.02.A Refer to section 9.7.01.E for SWQ Permit application submittal requirements.

SECTION 6 – LOW IMPACT DEVELOPMENT (LID) DESIGN REQUIREMENTS

9.6.01 LID OVERVIEW

9.6.01.A The City of Houston is promoting GSI, which encourages the use of natural features within a development. See 9.6.02 for design requirements. For additional LID information refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston."

9.6.01.B LID is considered as an alternative to conventional Detention and conveyance systems. All LID projects must provide supporting engineering calculations to prove that the introduction or proposal of GSI or LID in the project will equal or exceed current capacity and the minimum capacity criteria set by SECTION 2. In applicable cases, conventional Detention shall be coupled with LID to meet the Level of Service.

9.6.01.C This section provides an overview of suitable Best Management Practices (BMPs) that are preferred LID techniques to minimize downstream impacts of development and mimic how rainfall behaves when it falls on an undeveloped green landscape.

9.6.01.D LID based practices are used to reduce stormwater runoff volume and pollutant loading from developed sites. For effective Infiltration, Detention, and maintenance, SWQ Permit is required for LID techniques.

9.6.01.E LID practices use natural features to slow and filter stormwater runoff. Project characteristics will define which LID BMPs are applicable. When determining the appropriate LID requirements, Engineers shall consider characteristics such as site location, existing topography and soils, and planning elements. These characteristics and their impacts on design are important because LID BMPs are permanent features that can affect other project elements; therefore, it is critical to conduct thorough site assessments to avoid the need for redesign later. Incorporating LID early in the site design stage can reduce the need for and cost of traditional drainage infrastructure by reducing the amount of stormwater to be conveyed off-site.

9.6.01.F Siting and selecting appropriate LID practices is an iterative process that requires comprehensive site planning. A site planner, landscape architect, or Engineer can review the existing and proposed site layout when developing final site plans. Consideration to LID practices should be given during all of the design phases of a project (site assessment, preliminary design, and final design).

9.6.01.F continued

1. A thorough site assessment is needed initially to identify the development envelope and minimize site alterations. The primary objective of the site assessment process is to identify limitations and development opportunities specific to LID. For example, development opportunities include available space, use of right-of-way as appropriate, and maximizing opportunities for Infiltration through soil and Underdrains. Constraints or limitations that need to be factored into site planning when implementing LID practices include but are not limited to:

    a. Slow-infiltrating soils (typically clays)

    b. Soil contamination

    c. Steep slopes

    d. Adjacent foundations of structures

    e. Wells

    f. High seasonal water table

2. For both New Development and Redevelopment, in the preliminary site plan, the development envelope (site boundary) is delineated. To make the best and most optimal use of LID techniques on a site, a comprehensive site assessment must be completed that includes an evaluation of existing site topography, soils, vegetation, and hydrology (surface water and ground water features). High quality ecological resources (e.g., wildlife habitat, mature trees) should also be identified for conservation or protection. With such considerations, the site assessment phase provides the foundation for consideration of and proper planning around existing natural features and to retain or mimic the site's natural hydrologic functions.

9.6.02 LID DESIGN REQUIREMENTS

9.6.02.A When design approaches included in this section are incorporated in designs requiring City Engineer approval, the standards of this section will apply.

9.6.02.B The minimum design criteria for LID techniques shall be applied in accordance with this section. See Table 9.11 for a list of LID techniques. For applying any LID technique, a SWQMP is required. For facilities requiring a Forebay, see Figure 9.14 and Figure 9.15.

9.6.02.B continued

Table 9.11 – LID TECHNIQUES

LID Type	Runoff Reduction/ Detention	SWQ Treatment Feature	Application Example
Bioretention (9.6.02.C.1)	Yes	Filtration, Sorption, Nutrient Uptake	• Residential, commercial • Roadway • Streetscaping projects • Parks and trailways
Tree Box (9.6.02.C.2)	No	Filtration, Sorption, Nutrient Uptake	• Dense urban areas • Residential, commercial and suburban areas • Streetscaping projects
Infiltration Trenches (9.6.02.C.3)	Yes	Filtration	• Urban area • Arid regions (recharging groundwater) • Retrofit • Roadway and R.O.W.
Porous Paver Systems and Porous Pavement (9.6.02.C.4)	Yes	Filtration	• Residential, commercial • Urban areas
Vegetated Swales (9.6.02.C.5)	Yes	Filtration	• Driveways • Parking lot (perimeter, island median) • Along local roads • Highway medians
Green Roof (9.6.02.C.6)	Yes	Filtration	• Commercial, industrial, and residential structures
Blue Roof (9.6.02.C.7)	Yes	Capture	• Commercial, industrial and residential structures
Rain Barrel (9.6.02.C.8)	Yes	Capture, Settling	• Commercial, industrial, and residential structures
Cisterns/Above Ground Systems (9.6.02.C.9)	Yes	Capture, Settling	• Commercial, industrial, and residential structures
Constructed Wetland Basins (9.6.02.C.10)	Yes	Filtration, Settling, Nutrient Uptake	• Parks and trailways • Suburban areas
Underground Storage Tanks (9.6.02.C.11)	Yes	Capture, Settling	• Parking lots • Commercial, industrial, and residential structures

9.6.02.C Low Impact Development (LID) Techniques:

1. Bioretention

a. Overview

9.6.02.C.1.a continued

(1) Bioretention is a terrestrial-based (up-land as opposed to wetland), water quality and water quantity control practice using the chemical, biological and physical properties of plants, microbes and soils for removal of pollutants from Stormwater runoff. Some of the processes that may take place in a Bioretention facility include: sedimentation, adsorption, filtration, volatilization, ion exchange, decomposition, phytoremediation, bioremediation, and storage capacity. Bioretention may also be designed to mimic predevelopment hydrology. Native plants are preferred to be used for Bioretention as they are best adapted to the region. A recommended list of plants is available from the Native Plant Society of Texas Houston Chapter Native Plant Guide[20]. Non-native plants shall be reviewed by the Engineer for functionality and applicability.

b. Design Criteria

(1) The design detail for a typical Bioretention basin is shown in Figure 9.16.

(2) Determine volume of Bioretention area below maximum design water surface. Depth of ponding above the Bioretention soil media (BSM) is limited to a maximum of 9-inches in the R.O.W. or where there is public access and 18-inches where access is restricted.

(3) Demonstrate that sufficient area contributes stormwater runoff to the Bioretention area to fill the area to its maximum design water surface for the design storm under consideration. Location of Bioretention systems should be at relative low points in the overall site grading plan. The size (area) of Bioretention system is directly proportional to the contributing Drainage Area flowing to it.

(4) Protect systems vulnerable to damage from vehicle and pedestrian traffic. Systems are not designed to accommodate any surface loads and compaction from surface loads will harm system function.

[20] https://www.houstontx.gov/police/cpted/planting_information/Houston_native_plant_guide.pdf

9.6.02.C.1.b continued

(5) Using in-situ, Engineered Soils, or new soils, design the Bioretention area to empty within 24-hours to prevent insect breeding and bacteria or algae formation. This may be accomplished through Infiltration, evapotranspiration, and/or the design of a subsurface drainage system. The maximum Infiltration Rate of designed Bioretention media shall be 2-inches per hour.

(6) Each LID technique shall have a service area of no more than 5 acres.

(7) Runoff from commercial areas and parking lots require pretreatment; grass buffer strip, Vegetated Swales, or other feature to capture sediment and debris prior to draining into Bioretention area.

(8) For LID techniques without subsurface drainage system, in-situ subsoil shall have a minimum Infiltration Rate of 0.5-inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm Infiltration Rate. Otherwise, Infiltration Rates less than 0.5-inches per hour or where the project is constructed on fill soils will require a subsurface drainage system. When the capacity of the Bioretention system's reservoir is exceeded, an overflow bypass graded towards existing drainage system to convey the required flow rate from the inlet to a suitable storm sewer, channel, or bayou may be allowed on a case-by-case basis.

(9) Include an observation port to provide an opening to below grade portions of the system so that water level monitoring can be conducted during drawdown tests. In case of bigger techniques (e.g. multiple techniques in series, large area), observation ports should be typically placed every 300-feet. If the Underdrain system has branches, add ports at the end of every branch lateral.

(10) Soil media must be a minimum of 24-inches deep.

c. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

9.6.02.C.1.c continued

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

2. Tree Box

a. Overview

(1) Tree boxes are containment systems usually installed along public R.O.W. as a form of Bioretention and beautification. Boxes are usually made with an Engineered Soil mix, an Underdrain, an overflow and may connect to the storm sewer system. The trees act as mini reservoirs to divert, absorb and purify stormwater runoff on site before it enters the stormwater drainage system. Trees help to reduce the amount of stormwater entering the system and increase Infiltration into the soil.

b. Design Criteria

(1) There are a few different strategies for incorporating tree boxes into public R.O.W., along streets, plazas, parking areas and medians.

(a) Engineer tree boxes to accept water and tie into the stormwater management system.

(b) Suspended pavement techniques can be used to extend tree rooting volume under HS-20 load bearing surfaces. This technique suspends pavement above the soil to provide ample room for larger tree roots to grow. The pavement can be suspended using soil cells between the soil and pavement, which reduces compaction on the soil and increases filtration and holding capacity.

(c) Other options are rock-based structural soils that are gap graded Engineered Soils. This technique provides load bearing capacity while also protecting soil in its void spaces from compaction. These types of designs drain very quickly and tree species tolerant of well drained soils should be selected.

9.6.02.C.2.b.(1) continued

(d) Holes for the tree should be excavated two feet greater in width than the diameter of the soil ball. Care should be taken not to compact the soil immediately around the tree as this will restrict root growth.

(e) Tree boxes with Engineered Soils have the capacity for larger shrubs and trees with a radius of around 5-feet.

(f) Tree selection should reference the street trees list in Houston's ordinances and consideration of height is important. For the site, take note of obstructing views and presence of overhead power and utility lines.

(g) Diversity of species is important to reduce risk of disease and pests threatening health of trees. More than one variety of species should be planted in an area.

c. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

3. Infiltration Trenches

a. Overview

(1) Trenches or basins that temporarily detain a design Water Quality Volume while allowing Infiltration to occur over a prescribed period of time. Trenches are applicable for both water quality and water quantity control practices. Infiltration Trenches consist of a long, narrow excavation ranging from 3 to 12-feet in depth (depending on stormwater volume, soil and water table conditions) which is backfilled with stone Aggregate, allowing for the temporary storage of stormwater in the voids between the Aggregate material. Stored runoff then infiltrates into the surrounding soil.

9.6.02.C.3 continued

b. Design Criteria

(1) A design detail for a typical Infiltration Trench is shown in Figure 9.17.

(2) For LID techniques without subsurface drainage system, in-situ subsoil shall have a minimum Infiltration Rate of 0.5-inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm Infiltration Rate. Otherwise, Infiltration Rates less than 0.5-inches per hour or where the project is constructed on fill soils will require a subsurface drainage system. When the capacity of the Infiltration Trench system's reservoir is exceeded, an overflow bypass graded towards existing drainage system to convey the required flow rate from the inlet to a suitable storm sewer, channel, or bayou may be allowed on a case-by-case basis.

(3) Vegetation tolerant to temporary inundation should be used in the facility. Root penetration and thatch formation maintains and often enhances Infiltration capacity of the basin floor. In addition, vegetation can trap stormwater constituents by growing through accumulated sediments and preventing re-suspension. Vegetation also provides nutrient uptake in the shallow root zone and a substructure for microbial residence.

(4) The site should be graded to maximize the trench Sheet Flow distance avoiding placement on slopes greater than 15% in fill areas.

(5) Design of the trench area to empty within 48-hours.

(6) Include energy dissipation in the inlet design for the basins.

(7) Backfill using Aggregate made up of ASTM 8 or 89 crushed stone surrounded by nonwoven geotextile filter fabric.

(8) Provide overflow structure, splitter structure, or channel to accommodate larger runoff events.

(9) Provide 4-inches PVC observation well into subgrade.

(10) Runoff from commercial areas and parking lots require pretreatment; grass buffer strip or Vegetated Swales, or other feature to capture sediment and debris prior to draining into Infiltration Trench.

9.6.02.C.3.b continued

(11) Locate bottom of facility at least 4-feet above seasonal high water table elevation to prevent groundwater contamination.

(12) Locate at least 100-feet from any water supply well.

(13) Maximum contributing Drainage Area is 5 acres. Runoff contributing to the Drainage Area directed to the LID technique must be completely stabilized before construction to prevent pollutants, debris and sediments to enter the system.

(14) The volume of the basin should be sized to retain at least the volume of runoff from a 1.5-inch rainfall event. Maximum water depth in the basin should not exceed 2-feet.

(15) Mitigating Detention volume can be reduced by the amount of Infiltration into the subsoil and the volume of voids within the trench area.

c. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

4. Porous Paver Systems and Porous Pavement

a. Overview

Porous Pavement consists of a permeable surface course (typically, but not limited to, pavers, asphalt or concrete) that allows Infiltration of stormwater runoff into a permeable layer of uniformly graded stone bed. The underlying permeable layer serves as a storage reservoir for runoff and/or Infiltration. Porous pavement is applicable for both water quality and water quantity control practices.

9.6.02.C.4 continued

b. Design Criteria: Minimum requirements for porous system

(1) Design details for Porous Paver Systems are shown in Figure 9.18, Figure 9.19, Figure 9.20, and Figure 9.22. Porous Pavement Systems are shown in Figure 9.21.

(2) For LID techniques without subsurface drainage system, in-situ subsoil shall have a minimum Infiltration Rate of 0.5-inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm Infiltration Rate. Otherwise, Infiltration Rates less than 0.5-inches per hour or where the project is constructed on fill soils will require a subsurface drainage system. When the capacity of the Porous Pavement System's reservoir is exceeded, an overflow bypass graded towards existing drainage system to convey the required flow rate from the inlet to a suitable storm sewer, channel, or bayou may be allowed on a case-by-case basis.

(3) Subsurface drainage systems are required to be drained in 48-hours.

(4) The top of the in-situ soil within the pavement system should be at least 2-feet above the groundwater table.

(5) Porous paving systems should be located at a relative high point and should be placed to avoid accepting runoff from adjacent impermeable Drainage Areas. If this is unavoidable, the ratio of contributing Drainage Area to the porous pavement should be less than 2 to 1, to avoid excessive loading and maintenance requirements. The contributing Drainage Area should be 100% impervious and should not include any significant pollutant loadings.

(7) Soft porous pavement area (use of organic materials such as wood chips, crushed seashells or mulch along pathways to help water infiltrate) shall be considered undeveloped.

(8) The cross-section typically consists of four layers, as shown in Figure 9.20. A fifth layer is added for an optional stormwater quality component. The Aggregate reservoir can sometimes be avoided or minimized if the sub-grade is sandy and there is adequate time to infiltrate the necessary runoff volume into the sandy soil without by-passing the Water Quality Volume. Descriptions of each of the layers are presented below:

9.6.02.C.4.b.(8) continued

(a) Porous Pavement Layer - The porous pavement layer consists of an open graded pavement mixture, concrete or asphalt, specifically designed to be porous with binding agents that create a cohesive wearing surface. The thickness of this layer is based on the design of the pavement section and the loading requirements associated with the intended use. It is important to note that porous asphalt is not to be confused with Open Graded Friction Course (OGFC) that is used as a driving surface on highways which should not be used in this particular application except as an overlay wearing course over the porous concrete or asphalt. Porous pavement may be considered to contain 18% voids (typical range is 16% to 22%). Technical reference for porous concrete is FHWA-HIF-13-006. Technical reference for porous asphalt is FHWA-HIF-15-009.

(b) Top Stabilization Layer -Consists of Crushed Aggregate. Grading shall comply with ASTM No.8 or No.89 as stated in ASTM C33 to a depth of 2-inches. This layer serves to stabilize the porous pavement layer and can be combined with reservoir layer using suitable stone.

(9) Reservoir Layer – The reservoir layer consists of two components. The structural layer and the storage layer. The structural layer consists of ASTM No. 57 stone to a minimum depth of 4-inches. The reservoir gravel base course (storage layer) consists of washed gravel, 1.5 to 2.5-inches in diameter with a void space of about 40 %. Typically, ASTM No. 2, 3 or 4 stone is used for this layer. The depth of this layer depends on the desired storage volume, which is a function of the soil Infiltration Rate and void spaces, but typically ranges from 2 to 4-feet. The layer must have a minimum depth of nine inches. The layer shall be designed to drain completely in 48-hours. The layer shall be designed to store at a minimum the Water Quality Volume (WQV). Aggregate contaminated with soil shall not be used. A void space value (void space/total volume) of 40% shall be used in calculations unless Aggregate specific data exist.

(10) Storm Water Quality Layer (Optional) – For designs that are treating stormwater quality, an additional layer is added between the reservoir and bottom stabilization layers. The stormwater quality layer consists of 3-inches of sand on top of 2-inches of choking stone (ASTM No. 8). The choking stone layer helps prevent the sand from infiltrating the bottom layers.

9.6.02.C.4.b continued

(11) Bottom Stabilization Layer – The surface of the subgrade shall be a 6-inch layer of No. 57 stone, and be completely flat to promote Infiltration across the entire surface. This layer serves to stabilize the reservoir layer and Underdrain, to protect the underlying soil from compaction, and act as the interface between the reservoir layer and the filter fabric covering the underlying soil.

(12) Filter Fabric and Liner - It is very important to line the entire trench area, including the sides, with filter fabric prior to placement of the Aggregate. The filter fabric serves as a very important function by inhibiting soil from migrating into the reservoir layer and reducing storage capacity. Fabric shall be MIRAFI 140 N or equivalent. Above the filter fabric, a liner may be required for conditions where Infiltration Rates are too low, or Infiltration will cause damage to surrounding infrastructure. The liner should be overlapped and seamed and shall be 30 mil PVC or HDPE. The fabric and liner help prevent punctures during construction and improve performance of the system.

(13) Underlying Soil - The underlying soil shall have an Infiltration capacity of at least 0.5 inches per hour, but preferably greater than 0.50 inches per hour. as initially determined from Natural Resources Conservation Services (NRCS) soil textural classification, and subsequently confirmed by field geotechnical tests. The minimum geotechnical testing is one test hole per 5,000 square feet, with a minimum of two borings per facility (taken within the proposed limits of the facility). Infiltration Trenches cannot be used in fill soils. Soils at the lower end of this range may not be suited for a full Infiltration system. Test borings are recommended to determine the soil classification, seasonal high ground water table elevation, and impervious substrata, and an initial estimate of permeability. Often a double-ring infiltrometer test is done at subgrade elevation to determine the impermeable layer, and for safety, one-half the measured value is allowed for Infiltration calculations.

c. Inspection and Maintenance Requirements

(1) Refer to “A Guide to Developing and Maintaining Low Impact Development Techniques in Houston” for inspection and maintenance requirements.

9.6.02.C.4.c continued

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

5. Vegetated Swales

a. Overview

(1) Vegetated Swales (dry or wet) are earthen, planted stormwater conveyances designed to filter a shallow depth of runoff (<4-inches) for water quality improvement and to infiltrate stormwater. There are two types, dry or wet. Dry swales include an Underdrain system. Wet swales do not. Swales are typically designed to convey runoff from larger storm events; however, treatment and Infiltration is reduced during high flows. Infiltrative soils or an engineered porous subgrade is required for Infiltration use. Vegetated Swales are applicable for both water quality and water quantity control practices.

b. Design Criteria for Dry Swale

(1) A design detail for a typical dry swale is shown in Figure 9.23.

(2) Soil Infiltration Rate of 0.27 to 0.50 inches per hour.

(3) Trapezoidal or parabolic cross section.

(4) Bottom width shall be 2-feet wide minimum or 6-feet wide max.

(5) Longitudinal slope shall range from 1% to 6%.

(6) Flow depth shall be less than 4-inches for water quality treatment.

(7) Flow velocity shall be less than 1 foot per second for water quality, less than 5 feet per second for 2-Year storm (non-erosive velocities for grass and soils).

(8) Length shall yield a 10-minute Residence Time.

(9) Side slopes shall be flatter than 3H:1V.

9.6.02.C.5.b continued

(10) Maximum ponding time shall be 48-hours.

(11) Use proper vegetation (grass or wetland plants) consistent with climate, ecoregion, soils, and hydric conditions.

(12) Provide at least 3-inches of free-board during design storm.

(13) Provide pretreatment of runoff into the swale.

(14) Swale outlet or Outfall shall be designed to protect bed and banks receiving channel or bayou considering tailwater conditions during hydrology and hydraulic analysis.

c. Design Criteria for Wet Swale

(1) Design details are shown in Figure 9.24 and Figure 9.25.

(2) Soil Infiltration Rate of 0.27 to 0.50 inches per hour.

(3) Trapezoidal or parabolic cross section.

(4) Bottom width shall be 2 feet wide minimum or 8-feet wide max, to avoid gullying or channel braiding.

(5) Longitudinal slope shall range from 1% to 6%.

(6) Flow depth shall be less than 4-inches for water quality treatment.

(7) Flow velocity shall be less than 1 foot per second for water quality, less than 5 feet per second for 2-Year storm (non-erosive velocities for grass and soils).

(8) Length shall yield a 10-minute Residence Time.

(9) Side slopes shall be flatter than 3H:1V.

(10) Maximum ponding time shall be < 48-hours.

(11) Use proper vegetation (grass or wetland plants) consistent with climate, ecoregion, soils, and hydric conditions.

(12) Provide at least 3-inches of free-board during design storm.

(13) Provide pretreatment of runoff into the swale.

9.6.02.C.5.c continued

(14) Swale outlet or Outfall shall be designed to protect bed and banks receiving channel or bayou considering tailwater conditions during hydrology and hydraulic analysis.

d. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

6. Green Roof

a. Overview

(1) In the simplest terms, a Green Roof is a vegetated roof. The vegetation varies, but must be suitable to the local climate and be drought tolerant unless a method of irrigation is also installed.

(2) Green Roofs have been shown to effectively retain pollutants. Green Roofs with a lightweight media should be connected in a treatment train with a downstream BMP that can treat the runoff for pollutants especially bacteria and hydrocarbons (from roofing materials).

(3) If a modular system is selected, the drainage system may already be incorporated into the design, along with the soil and vegetation, depending on the manufacturer.

(4) The substrate material and depth are also factors that influence the efficiency of the Green Roof to store and/or treat stormwater.

(5) There are three basic categories of Green Roof infrastructure, extensive, semi-intensive, and intensive. Roofs consisting of relatively thin soil layers, called extensive roofs, are not as heavy as the intensive roofs, which are covered with thicker soil layers that provide better water quality benefits.

9.6.02.C.6.a continued

(6) Additional considerations of a Green Roof are how they may: offset the need for an underground storm water Detention vault, how it may reduce the size of the receiving drainage system, and how the growing media can be used to filter contaminants to improve the water quality coming off the roof.

b. Design Criteria

(1) A design detail for typical Green Roof is shown in Figure 9.26.

(2) Plants suitable to the roof micro-climate shall be installed. Plants should be selected to remain healthy and minimize maintenance for the long term. The following factors should be considered:

(a) Roofs are typically hotter and drier than the surrounding city, thus drought tolerant plants are necessary, unless a method of irrigation is provided.

(b) Wind velocities are typically higher on rooftops. The effect of wind on the vegetation shall also be considered when selecting the plants.

(c) Roof shading or heat/solar reflection from surrounding buildings should be considered when selecting plants.

(3) The design must consider the additional structural loads (gravity and lateral) that the system will impose on the building structure. The additional loading includes, but is not limited to, the water weight, soil weight and the weight of the other elements of the system such as pipes, drainage mats, modular systems, and any dead and live loads that may be on the roof for recreational use or routine maintenance of the system.

(a) Structural calculations shall be submitted that demonstrate the structure's ability to sustain the additional loading of the Green Roof appurtenances plus the maximum water weight that could be stored.

(4) The roof must consist of a medium designed as a filter to remove the anticipated contaminants identified in the Stormwater Quality Permit such as bacteria, wind borne contaminants, fertilizers, etc.

(5) The functional part of a Green Roof will typically contain four sections.

9.6.02.C.6.b.(5) continued

(a) Vegetation Layer: The vegetation layer is the plant material on the exposed surface of the Green Roof.

(b) Growing Medium: The vegetation layer and the soil growing medium work together to filter and remove contaminants from the stormwater runoff. There are two types of growing medium depths shown in Table 9.12.

Table 9.12 – GROWING MEDIUM

Roof Type	Minimum Growing Medium Depth	Purpose
Extensive	6"	Vegetation
Intensive	12"	Vegetation and Water Quality Control

(c) Filter Layer: The filter layer is below the growing medium to hold the growing medium in place and let the water pass through to the drainage layer.

(d) Drainage Layer: The drainage layer captures the water and routes it to the roof drain.

(6) When used as Detention, the vegetation layer, the growing medium, the filter fabric and the drainage layer all contribute to the attenuation of flow of the rainfall through the system and provide the storage of water. Further attenuation may be required through a restrictor at the roof drain depending on the design of the system.

(7) Attenuation approach with the calculated hydrograph is required to mitigate proposed runoff (Detention) from the proposed building roof.

(a) Captured Drainage Area is only for the Green Roof.

(b) Underdrain system is required to capture water draining through the growing and drainage layers. In addition, an emergency outflow is required to provide the emergency overflow required by plumbing code.

(c) Develop inflow and outflow hydrograph to calculate Detention volume as stated below:

9.6.02.C.6.b.(7).(c) continued

[1] Since the time of concentration on a building roof will be nearly instantaneous, and the land use can be assumed to be impervious, it may be assumed that the runoff hydrograph will follow the typical design rainfall pattern.

[2] If the design storm is assumed, for example, to be a 24-hour 100-Year Atlas 14 for City of Houston rainfall (16.9 inches), the rainfall pattern would be multiplied by the area of the roof (for this example, a typical downtown roof might be 250-feet x 250-feet, or 1.43 acres).

[3] If the design storm is broken into hourly increments, the conversion of the rainfall in inches per hour is a direct conversion to cubic feet per second (the factor is actually 1.000 acre-in/hour = 1.008 cfs).

[4] Once the outflow is determined from the above analysis, evaporation can be separated out to determine the remaining detained/attenuated outflow from the medium.

[5] This entire routing procedure can be set up in a spreadsheet to simplify the analysis.

(8) The credit value given for the stored rainfall volume shall be as prescribed by the manufacturer for a modular system.

(9) The credit value given for the stored rainfall volume for non-modular systems shall be calculated for the Engineered Soil Media.

(a) The rate shall be derived by in-situ porosity testing. The porosity test shall be performed four times with the first time results being discarded and the three remaining results averaged.

(b) The test shall require the first sample remain wet a minimum of 1-hour.

(c) The subsequent porosity tests shall be performed the same day.

9.6.02.C.6.b.(9) continued

(d) In no case shall the storage volume be credited more than 33% of total volume, as that is the assumed volume of clean graded washed gravel.

(10) The roof membrane must be sufficiently designed and installed to pond a minimum of 1 inch of water at the most shallow point on the roof for 24-hours without leaks. This shall be tested in the same manner as shower pans are tested under the building code. Additionally, special consideration shall be given for the plant root structure and prevention of soil migration during membrane selection. A root barrier may also be required to protect the waterproof membrane integrity.

(11) The underdrain drainage system shall be designed for the selected plant's tolerance for drought and varying soil moisture contents by maintaining the proper balance of moisture and aerobic conditions within the soil media for optimum vegetation sustainability. Design provisions shall address higher volume rainfall events to keep excessive amounts of water from ponding on top of the soil, to prevent erosion, and to prevent soil media saturation for extended periods.

(12) Installation generally consists of a waterproof membrane installed over a suitably constructed roof deck.

(13) For in-situ installations, an under-drain drainage system is installed over the membrane. A lightweight Engineered Soil is installed on top of the underdrain, as fill dirt or topsoil is typically too heavy to use in rooftop applications. The Engineered Soil is then planted with select vegetation.

c. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

9.6.02.C continued

7. Blue Roof

a. Overview

(1) Horizontal roof surfaces can be used to attenuate peak runoff associated with rainfall and effectively detain flow resulting from smaller rain events. The Detention volume can be controlled in several ways, but typically a simple drain ring is placed around the roof drains. As stormwater begins to pond on the roof, flow into the roof drains is controlled by orifices or slits in the drain ring. Extreme flows can be designed to overflow the ring and drain directly to the roof drains or be directed to openings in the parapet walls to prevent structural and flood damage to the roof. The roof deck must be designed to withstand the live load and be properly waterproofed.

b. Design Criteria

(1) A design detail for typical Blue Roof is shown on Figure 9.27.

(2) The structural capability of the roof system must be considered when designing a temporary rooftop storage system. For example, a 3-inch water depth is equivalent to a load of 15.6 pounds per square foot, which is less than most current building code requirements for live loads. The design must consider the additional structural loads (gravity and lateral) that the system will impose on the building structure. The additional loading includes, but is not limited to, the water weight, the weight of the other elements of the system such as pipes, drainage mats, modular systems, and any dead and live loads that may be on the roof for recreational use or routine maintenance of the system.

(3) Consideration must be given to the placement of electrical devices on the roof, such as air conditioning or ventilation systems and lights, and proper measures shall be taken to protect the electrical devices from the collected water.

(4) Overflow mechanisms shall be provided so that there is no danger of overloading the roof storage system during major storms. Additionally, roof slopes shall be designed to drain positively toward the roof drains to help minimize localized roof ponding or ‘bird bath’ formation after the detained water volume is released.

9.6.02.C.7.b continued

(5) Refer to Chapter 16 of the International Building Code, Current Edition for additional structural criteria along with ASCE Standard Reference Number 7, Minimum Design Loads for Buildings and Other Structures.

(6) The amount of credit given for Detention volume for rooftop storage shall take into account that many flat roofs already pond significant amounts of water, although not by design. Therefore, when measuring credit given for Blue Roof Detention volume, it is recommended that only credit be given for the total rooftop storage volume less the rooftop storage volume associated with the first inch of rain. Typically, rooftop storage volumes are only effective during the smaller, more frequent rainfall events as the larger, less frequent storms typically exceed the rooftop storage capacity.

c. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

8. Rain Barrels

a. Overview

(1) A rain barrel, ranging from 55-gallons to several hundred gallons in capacity, is placed near the down spout of a house and is used to collect rainwater runoff from the roof of the house. The captured water is then typically used as a pure water source for plants and lawns.

b. Design Criteria

(1) Gutters and downspouts carry water from the rooftops to rain barrels as shown on Figure 9.28 and/or connect directly to subsurface drainage system.

(2) Screens are required on gutters to prevent clogging.

9.6.02.C.8.b continued

(3) Rain barrels shall be equipped with a restrictor (ex. Valve) or low-flow outlet.

(4) Overflow outlet must be provided to bypass rain barrel from large rainfall events.

(5) Rain barrel must be designed with removable, child resistant covers marked “Danger-Confined Space” and mosquito screening.

(6) Minimum rain barrel capacity equal to 1 inch of runoff from roof top surface area.

c. Inspection and Maintenance Requirements

(1) Refer to “A Guide to Developing and Maintaining Low Impact Development Techniques in Houston” for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

9. Cisterns/Above Ground Systems

a. Overview

(1) A cistern/above-ground system is placed near the down spout of a building structure and is used to collect rainwater runoff from the roof of the building structure. The captured water is to be released to the subsurface drainage system onsite. When used for Detention, this feature should be used in conjunction with other subsurface Detention system for proper flood mitigation.

b. Design Criteria

(1) Gutters and downspouts carry water from the rooftops to cisterns as shown on Figure 9.29 and/or connect directly to the subsurface drainage system.

9.6.02.C.9.b continued

(2) Screens are required on gutters to prevent clogging. All inlets, overflows, and other openings should be protected with mosquito screens.

(3) Cisterns/above-ground systems must be designed with removable, child-resistant covers marked “Danger-Confined Space”.

(4) Overflow outlet must be provided to bypass the cisterns/above-ground systems from large rainfall events. Overflow pipe should convey overflow to point of discharge.

(5) Low flow outlet should be always clear.

(6) Restrictor should be placed at the connection of cisterns/above-ground systems to the subsurface drainage system. Cisterns shall have a drainage valve to empty within 24 to 48 hours after each rain event.

(7) Cisterns/above-ground systems shall be designed by a State of Texas Professional Engineer.

c. Inspection and Maintenance Requirements

(1) Refer to “A Guide to Developing and Maintaining Low Impact Development Techniques in Houston” for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

10. Constructed Wetlands Basins

a. Overview

9.6.02.C.10.a continued

(1) Storm water treatment wetlands are constructed shallow ponds designed often based on the ecological function of natural wetlands. Natural wetlands are more or less self-maintaining systems; whereas, constructed wetlands for storm water treatment purposes require active management. Wetlands are constructed in development and Redevelopment activity for two main purposes. The first purpose is to mitigate lost, impacted or filled wetlands due to development or construction activity, and the second purpose is to treat storm water runoff (storm water treatment wetlands). Newly Constructed Wetland Basins should be evaluated for exemption listed in 40 CFR 122.2 that provides an exemption to classification as "Waters of the U.S." for treatment pond systems or lagoons designed to meet the requirements of the Clean Water Act. However, if a Constructed Wetland Basin is exempted by being defined as a treatment facility, it cannot be used for wetlands mitigation for losses due to construction. Modification of an existing wetland area to serve for storm water treatment function is potentially subject to 404 permitting. The need for section 404 permits should be evaluated on a case-by-case basis.

b. Design Criteria

(1) A design detail for a typical Constructed Wetland Basin is shown in Figure 9.30.

(2) Constructed Wetland Basins should be designed with an armored sediment Forebay that captures initial sediment depositions and reduces stormwater inflow velocities that will lengthen the life of the project and reduce erosion.

(3) They should be designed to maximize the hydraulic retention time to store water and slowly release it, reducing risk of flooding.

(4) Reduce hydraulic short-circuiting to avoid creating dead zones in the system and giving sediment time to filter out.

(5) Water quality treatment volume and permanent pool volume should be calculated based on requirements in 9.5.01.C for runoff from the Drainage Area.

(6) Depth of sediment Forebay (Pre-treatment) is 4 to 6-feet.

9.6.02.C.10.b continued

(7) Volume of pre-settling basin or Forebay should be 20% of permanent pool volume with inlets that convey stormwater runoff entering the Forebay first or pre-treatment before wetland.

(8) Length to width ratio is 3:1 or more. Design of layout should avoid dead storage area and minimize short-circuiting.

(9) Side slope is 3H:1V or flatter.

(10) Surface-area-to-pool-depth relationship:

(a) 50% area: 0.5-feet deep

(b) 15% of the area: 0.5 to 2-feet deep

(c) 15% of the area: 3 to 4-feet deep

(d) 20% of the area: greater than 3-feet deep with max of 6-feet in Forebay section.

(11) Wetland Vegetation should be a mix of floating, emergent, and submergent plants that are native to the SE region of Texas. Depending on location in the city, wetland plants may need to be salt tolerant. Consult a wetland specialist for specific species. The site should be frequently monitored for invasive species.

c. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

9.6.02.C continued

11. Underground Storage Tanks

a. Overview

(1) Underground Storage Tanks (UST) are containment systems that are installed under the ground to hold and slow down stormwater runoff and mitigate risk of flooding. USTs are buried under parking lots or open green spaces, and help to collect runoff from shopping malls, medical centers, universities, or other similar type development. The storage tank will be connected to runoff through the stormwater piping system and have specially designed valves so it can temporarily hold and slowly release water into the groundwater after a major rain event. The goal is to reduce the amount of runoff on the roads and in the built environment while also encouraging Infiltration. The soil medium surrounding the tank needs to have permeability for the water to release back into the groundwater. Underground Storage Tanks are ideal for urban areas with high population densities and limited space.

b. Design Criteria

(1) Water storage structures (vaults) or large diameter, rigid pipes or arches with capped ends and made of metal, reinforced concrete, plastic, steel, or aluminum.

(2) Pipes and floors of vaults should be designed with a maximum of two percent slopes to facilitate drainage of water.

(3) Consider incorporating sufficient number of access points (manholes) for personnel to facilitate easy maintenance.

(4) This type of BMP can be combined with other techniques such as porous pavers above or installing filtration devices at inlets and outlets to enhance water quality.

(5) Stone backfill around perimeter and a layer of crushed stone between the surface and the stormwater storage systems.

(6) When any storage volume of USTs are proposed to be used for Detention, USTs shall meet the underground Detention requirements in 9.2.01.H.3.

(7) When storage volume of USTS is used primarily for any purpose other than Detention:

9.6.02.C.11.b.(7) continued

(a) In-situ subsoil shall have a minimum Infiltration Rate of 0.5-inches per hour. Geotechnical testing including one boring per 5,000 square feet or two per project is required to confirm Infiltration Rate. Otherwise, Infiltration Rates less than 0.5-inches per hour or where the project is constructed on fill soils will require a subsurface drainage system. When the capacity of the UST is exceeded, an overflow bypass graded towards existing drainage system to convey the required flow rate from the inlet to a suitable storm sewer, channel, or bayou may be allowed on a case-by-case basis.

c. Inspection and Maintenance Requirements

(1) Refer to "A Guide to Developing and Maintaining Low Impact Development Techniques in Houston" for inspection and maintenance requirements.

(2) For any LID technique that requires a SWQ Permit, the Engineer shall provide a checklist for required inspection and maintenance and include it in the SWQMP that will be submitted as a part of the package for obtaining SWQ Permit for LID. The inspection and Maintenance Activities shall be scheduled as per SWQMP (after any heavy rains, annually, etc.).

9.6.03 LID INCENTIVES

9.6.03.A Detention Reduction

1. A preliminary meeting is required to demonstrate a conceptual design to show the pre-development and post-development Hydrology-and-Hydraulic of the stormwater runoff for the proposed LID techniques.

9.6.03.B Plan Review

1. To expedite the plan review, the Applicant shall label the plan set as "Green Stormwater Infrastructure."

9.6.03.C Incentives for using LID techniques as a part of the stormwater Detention system can be applied (Table 9.11):

1. Per the GSI initiative, projects utilizing one or more of the LID techniques can receive a detention reduction of up to a maximum of 0.15 acre-foot per acre from the required Detention rate, as applicable. The minimum Detention requirement will be reduced as long as calculations are provided to justify that the detention supplied by LID techniques sufficiently mitigate storm runoff.

2. Tax Abatement: Qualified Applicants are also encouraged to apply for the City's Green Stormwater Infrastructure Tax Abatement program that will provide an abatement to offset the incremental cost of constructing GSI as an incentive to increase green infrastructure within the city. For more information, please refer to https://www.houstontx.gov/ecodev/tax_abatements.html.

SECTION 7 – SUBMITTALS

9.7.01 SUBMITTALS

9.7.01.A For Building Code Enforcement (BCE) projects inside property, submit the following:

1. Stormwater Information Form and supporting documents (survey and recorded plat, tax account information, and recorded deed/title in owner's name) See Figure 9.31[21].

2. Comments and responses sheet is required for resubmittal projects only. A narrative is required for revision projects.

3. Grading Permit for Excavation and Fill Worksheet (not required where there will be no excavation or fill proposed).

4. Floodplain information, including floodplain boundary, if any; FEMA map number, effective map date and zone.

5. Copies of any documents which show approval of exceptions/variances to the City design criteria.

6. Where applicable, copies of any documents which show approval of other jurisdictions where approval is required (i.e., TXDOT, HCFCD, USACE, etc.).

7. Site plan showing all surveying and topographic data including property legal description, lot, block, subdivision name, property lines, building lines, and utility easements (i.e., surface and underground utility easements).

8. Grading plan with elevations across lot and within 2-feet of adjoining lots along subject property lines, showing no Sheet Flow to unapproved locations.

9. Drainage Area Map showing the existing contour map, existing and proposed Drainage Area and sub-Drainage Area boundaries, existing and proposed Drainage Area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from storm structure (i.e., manhole, inlet, catch basin, etc.) to storm structure; and the extreme event (100-Year) Sheet Flow direction, existing condition, and proposed condition Sheet Flow direction for the surrounding properties.

[21] https://www.houstonpermittingcenter.org/media/7636/download?inline

9.7.01.A continued

10. Drainage Plan showing all internal site drainage. Also provide the following using current Atlas 14 rainfall intensity:

    a. Design calculations for time of concentration, storm line sizes and grades, and for Detention facilities, if any.

    b. Design calculations for the Hydraulic Grade Line of each storm line or ditch, and for Detention facilities, if any, for 2-Year and 100-Year rainfall events.

11. Where applicable, Detention plan with calculations for required volume and designed volume, restrictor calculations and detail(s), calculations and details for all storage areas and overflow structure design. See Figure 9.11.

12. If off-site Detention has been provided by other projects, a memorandum should be provided to explain how the existing Detention facility serves this proposed project. Include a Detention breakdown, see Figure 9.32 as an example.

13. Where applicable, a Stormwater Quality (SWQ) Permit will be required per article 9.1.04.GGG or when any Low Impact Development (LID) technique is proposed. Submit copies of approved SWQ Permit and SWQ ILMS number to be called out in the Drainage plan.

9.7.01.B For Office of the City Engineer (OCE) plan and profiles, submit the following:

1. Approximate definition of lots and street patterns.

2. Stormwater Information Form. See Figure 9.31[22].

3. Show any existing and proposed drainage easements on drawings and provide recorded easement documents.

4. Floodplain information, including floodplain boundary, if any, FEMA map number, effective map date and zone. Projects located within a floodplain boundary or within a floodplain management area shall:

    a. Show the floodplain boundary or floodplain area, as appropriate, on the Drainage Area Map.

    b. Comply with all applicable submittal requirements of Chapter 19, Code of Ordinances.

[22] https://www.houstonpermittingcenter.org/media/7636/download?inline

9.7.01.B.4 continued

c. Be reviewed and obtain approval from the City of Houston Floodplain Management Office (FMO).

5. Drainage Area Map with the following information:

   a. Existing contour map.

   b. Existing and proposed Drainage Area and sub-Drainage Area boundaries.

   c. Existing and proposed Drainage Area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from storm structure (i.e. manhole, inlet, catch basin, etc.) to storm structure.

   d. Extreme event (100-Year) Sheet Flow direction.

   e. Existing and proposed Sheet Flow direction for the proposed and surrounding properties.

   f. A note referencing the BCE project number for proposed Detention and restrictor calculations on site, if applicable.

6. Design calculations for time of concentration, rainfall intensity, stormwater runoff, flow capacity and velocity in both existing and proposed conditions for each proposed storm sewer line or ditch. Refer to Figure 9.5, Figure 9.6 and Figure 9.7.

7. If replacing roadside ditch with culverts, show the flow capacity and storage volume of both existing and proposed condition.

8. Design calculations for Detention facilities providing Detention for public infrastructure, if applicable.

9. If the off-site Detention has been provided by other projects, a memorandum should be provided to explain how the existing Detention facility serves this proposed project. Include a Detention breakdown, See Figure 9.32 as an example.

10. Cover sheet

    a. Provide Stormwater Information Form log number on the cover sheet.

    b. Provide reference note for FEMA map number, effective map date and zone.

9.7.01.B.10 continued

c. Reference BCE project number for private onsite development, if applicable.

11. Plan and profile sheets showing proposed public storm infrastructure design with 2-Year and 100-Year Hydraulic Grade Lines.

12. Profile drawing of roadway (or Overland Flow path) with exaggerated vertical scale from the upper reach of Drainage Area to the primary drainage outlet. Show roadway profile at gutter, ground profile at the public R.O.W., and Hydraulic Grade Lines for the 2-Year and 100-Year extreme event; or an alternative equivalent drawing accepted by the City.

13. Conditions for approval.

    a. All comments are addressed according to requirements listed in SECTION 7.

    b. Stormwater Detention maintenance agreement letters, if any.

    c. All required permits from other agencies (i.e., HCFCD approval, TXDOT approval, USACE approval, etc.)

    d. Copies of any documents which show approval of exceptions to the City design criteria (i.e. approved variances, etc.).

    e. Stormwater Quality Permit, if applicable. See article 9.1.04.GGG for requirements.

14. Revisions

    a. For approved projects that require revisions:

        (1) Provide a separate narrative describing the scope of proposed revisions.

        (2) Cloud and label changes with a numbered triangle corresponding to the iteration of revision per Chapter 3 – Graphic Requirements.

9.7.01.C For Capital Projects, submit the following:

1. Approximate definition of lots and street patterns.

2. Show any existing and proposed drainage easements with dimensions on drawings.

9.7.01.C continued

3. Floodplain information, including floodplain boundary, if any, FEMA map number, effective map date and zone. Projects located within a floodplain boundary or within a floodplain management area shall:

    a. Show the floodplain boundary or floodplain area, as appropriate, on the Drainage Area Map.

    b. Comply with all applicable submittal requirements of Chapter 19, Code of Ordinances.

    c. Be reviewed and obtain approval from the City of Houston Floodplain Management Office (FMO).

4. Engineer of Record to coordinate with Office of the City Engineer Stormwater Quality group for review and approval of plans that requires a SWQ Permit.

5. Drainage Area Map with the following information:

    a. Existing contour map.

    b. Existing and proposed Drainage Area and sub-Drainage Area boundaries.

    c. Existing and proposed Drainage Area (acres) and flow quantity (cfs) draining to each inlet and each pipe segment from storm structure (i.e. manhole, inlet, catch basin, etc.) to storm structure.

    d. Extreme event (100-Year) Sheet Flow direction.

    e. Existing and proposed Sheet Flow direction for the proposed and surrounding properties.

6. Design calculations for time of concentration, rainfall intensity, stormwater runoff, flow capacity and velocity in both existing and proposed conditions for each proposed storm sewer line or ditch. Refer to Figure 9.5, Figure 9.6 and Figure 9.7.

7. Design calculations for Detention facilities providing Detention for public infrastructure. If the Detention has been provided by other projects, a memorandum with supporting documents shall be provided to explain how the existing Detention facility serves the proposed project.

8. Plan and profile sheets showing proposed public storm infrastructure design with 2-Year and 100-Year Hydraulic Grade Lines.

9.7.01.C continued

9. Profile drawing of roadway (or Overland Flow path) with exaggerated vertical scale from the upper reach of Drainage Area to the primary drainage outlet. Show roadway profile at gutter, ground profile at the public R.O.W., and Hydraulic Grade Lines for the 2-Year and 100-Year extreme event; or an alternative equivalent drawing accepted by the City.

10. Calculation for proportional amount of pipe capacity allocated to the development along with the Drainage Area Map used for these calculations.

11. Signature Stage - Submit the following for approval:

    a. Review files with all comments.

    b. Original drawings: Provide all information requested in section 9.7.01.C.

    c. Stormwater Detention maintenance agreement letters.

    d. All required permits/approvals from other agencies or departments (i.e., HCFCD approval, Floodplain Management Office (FMO) approval, TXDOT approval, USACE approval, etc.).

    e. Copies of any documents which show approval of exceptions to the City design criteria (i.e. approved variances, etc.).

9.7.01.D For drainage impact analysis, submit the following:

1. Submit an electronic copy of the completed analysis that follows City issued Drainage Impact Analysis Guidelines.

2. The desired format is an indexed Portable Document Format (PDF) with a minimum of 400 dpi. If drawings are included, flatten the PDF as required in article 3.1.04.B of Chapter 3 – Graphic Requirements.

3. Large files shall be sent through a City of Houston approved downloadable link.

4. The analysis must be completed, sealed, signed, and dated by the licensed Professional Engineer in the State of Texas responsible for its completion.

5. Do not attach any information unrelated to the analysis (i.e. storm water quality plans, etc.).

6. Provide a summary of any model export files; do not send full exported file, unless requested by the City.

9.7.01.D continued

7. Provide a separate response sheet describing changes made to the analysis in response to review comments.

8. Incomplete submittals will not be accepted and will be rejected immediately.

9. Provide all required approvals from other agencies (i.e., HCFCD, FBCDD, etc.).

10. Plan submittal requirements:

    a. Reference approved drainage impact analysis on the coversheet. This should include the name of the analysis, the engineering firm and the responsible Professional Engineer.

    b. A drainage memo should be provided for each section. For drainage memo guidelines, contact the Office of the City Engineer's Stormwater Section.

    c. Provide an overall Drainage Area Map for entire development.

    d. Provide a Drainage Area Map for proposed section.

    e. Provide design calculations for time of concentration, rainfall intensity and stormwater runoff for proposed conditions.

    f. Provide design calculations for the flow capacity, velocity and Hydraulic Grade Line of each proposed storm sewer line or ditch.

    g. Provide plan and profile sheets showing proposed public storm infrastructure design with Hydraulic Grade Lines based on design storm event.

    h. Provide a table summarizing the applied Detention for developed sections of the development. See Figure 9.32 as an example.

9.7.01.E For Storm Water Quality (SWQ) application, submit the following:

1. Administrative documents:

    a. Owner's Affidavit must be signed by the owner.

    b. Engineer's Certification certified by a Professional Engineer stating that the prepared Stormwater Quality Management Plan (SWQMP) complies with the City's requirements.

9.7.01.E.1 continued

c. Notice of Stormwater Quality Requirements and its Exhibit A (Metes and Bounds Legal Description or Survey). The notice must be signed and notarized, then the notice and Exhibit A (preferably property boundary survey) must be recorded at the county courthouse. The submittal shall be official (i.e., no unofficial watermark on the document) and legible.

d. Cost estimate for the stormwater quality feature and its installation. The estimate is to determine the amount of the SWQ Structural Control Bond that is required. The bond does not have to be submitted with the SWQMP; the owner can attach a letter stating that the bond will be provided prior to construction.

2. The SWQ Management Plan (SWQMP).

9.7.01.F Geospatial Data Deliverables: Provide GIS datasets in accordance with Chapter 13 – Geospatial Data Deliverables for projects that are proposing or modifying assets identified in Chapter 13 that are or will be operated and/or maintained by the City.

SECTION 8 - QUALITY ASSURANCE

9.8.01 QUALITY ASSURANCE

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

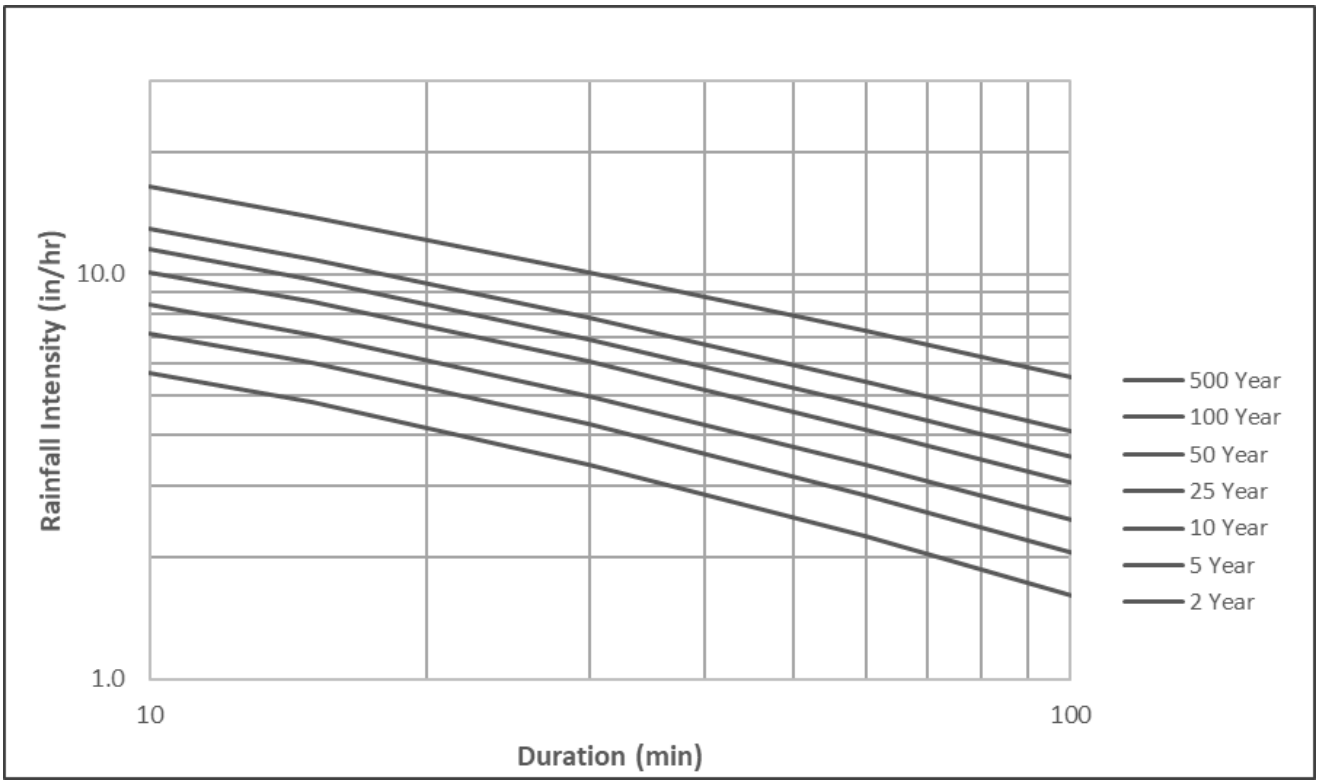


Figure 9.1 – IDF CURVES
Intensity vs Time of Concentration vs Rainfall Frequency
Source: Atlas 14

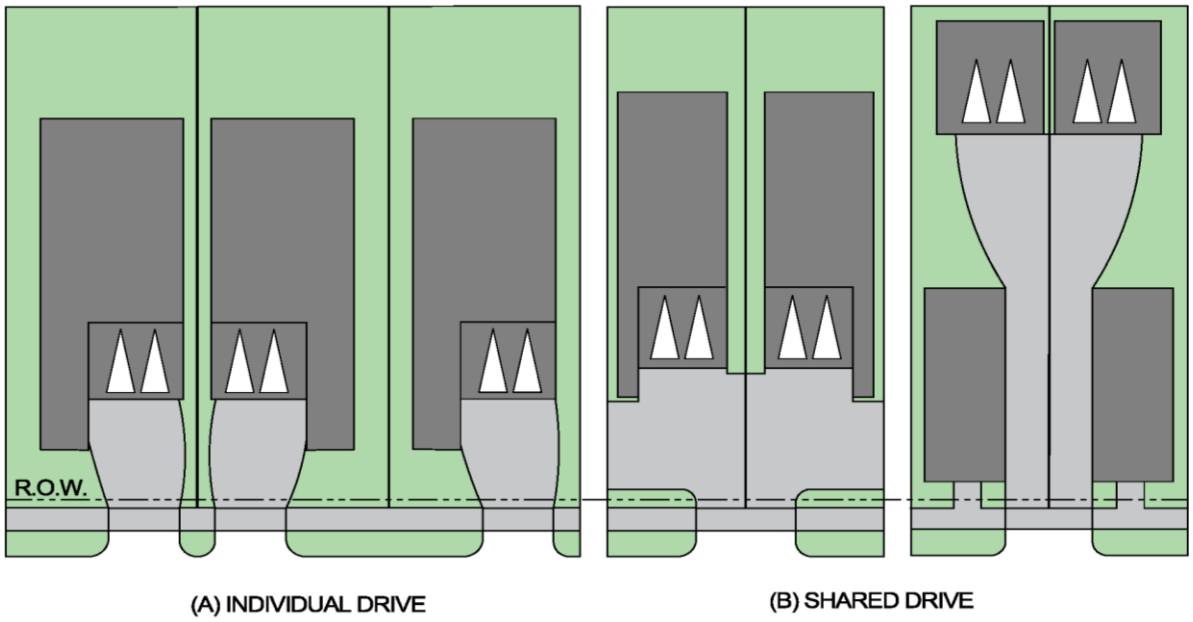
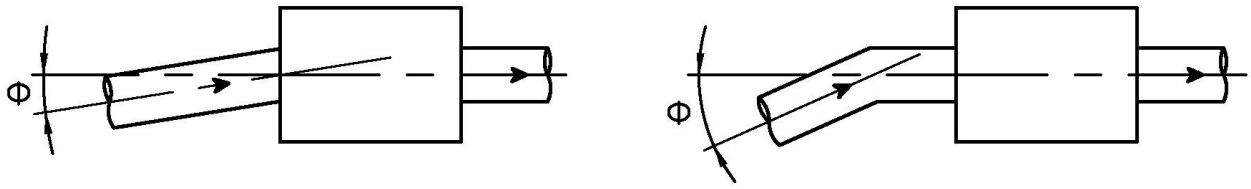


Figure 9.2 – INDIVIDUAL DRIVE AND SHARED DRIVE PROPERTIES



(A) ANGLE OF ENTRY IS LESS THAN OR EQUAL TO 7°

(B) ANGLE OF ENTRY IS GREATER THAN 7°

CONNECT PIPES WITHIN 7° OF NORMAL TO PRECAST BASE WALL. IF NECESSARY, USE PIPE ELBOW OR CURVED APPROACH ALIGNMENT TO STAY WITHIN THIS LIMIT.

Figure 9.3 – PIPE CONNECTION TO BOX STRUCTURES

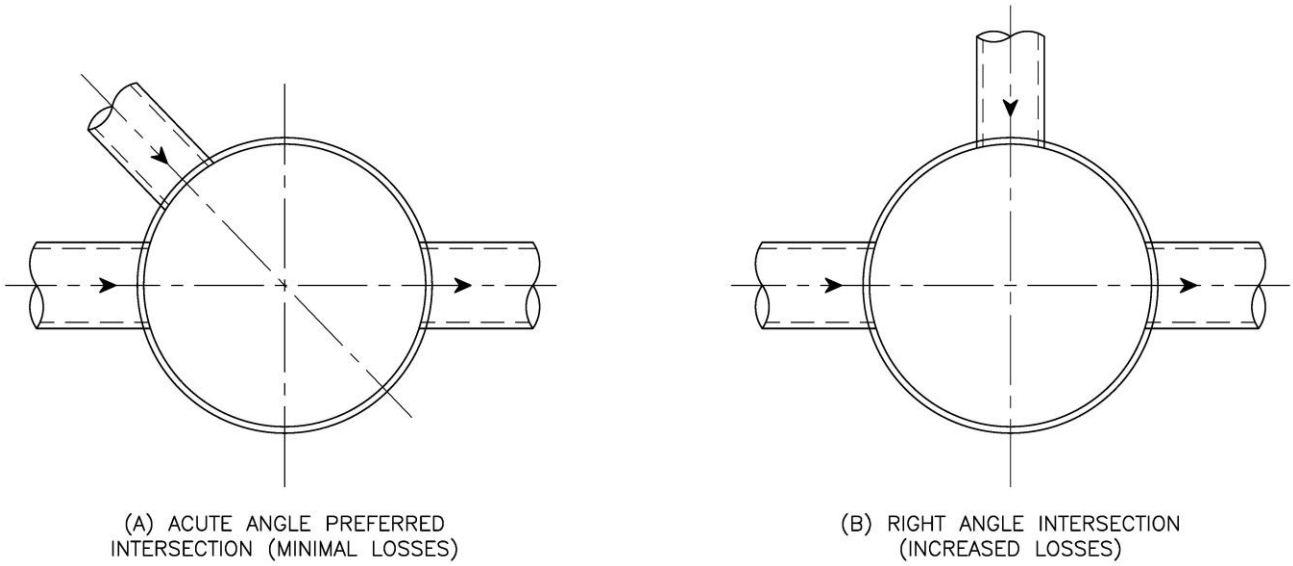


Figure 9.4 – ANGLES AT JUNCTIONS

City of Houston Storm Sewer Calculation Form

Project: _____ HGL Starting Elevation = _____

Job No: _____ Design Storm = _____

System: _____ b = _____

By: _____ Date: _____ d = _____

Checked By: _____ Date: _____ e = _____

MH From	HM To	Area (acres)	Cumulative Area	Runoff Coefficient, C	Sum of C*A	Time of Conc. (min)	Intensity, I (in/hr)	Sum of Flows (cfs)	Reach Length (ft)	Dia. or Rise (in)	Span (ft)	Slope (%)	Manning's "n"	Design Capacity (cfs)	Design Velocity, V (fps)	Fall (ft)	Manhole Drop (ft)	Flowline Elevation Upstream (ft)	Flowline Elevation Downstream (ft)	Actual Velocity, V (fps)	Hydraulic Grade (%)	Change in Head (ft)	Elevation of Hyd. Grade Upstream (ft)	Elevation of Hyd. Grade Downstream (ft)	Natural Ground Upstream (ft)	Natural Ground Downstream (ft)	Maximum Ponding Elevation (ft)

Figure 9.5 – STORM SEWER CALCULATION FORM

City of Houston Roadside Ditch Worksheet

Project: _____ HGL Starting Elevation = _____
Job No: _____ Design Storm = _____
System: _____ b = _____
By: _____ Date: _____ d = _____
Checked By: _____ Date: _____ e = _____

STATION TO STATION	SIDE	SLOPE, %	DRAINAGE AREA	"C"	T_C (minutes)	I (inches/hr)	Q (CFS)	DITCH SECT			"n"	"d"	VELOCITY (fps)	DITCH LINING	SIDE DRAIN PIPE DIA	REMARKS
								FS	BW	BS						
								.								

Figure 9.6 – ROADSIDE DITCH WORKSHEET

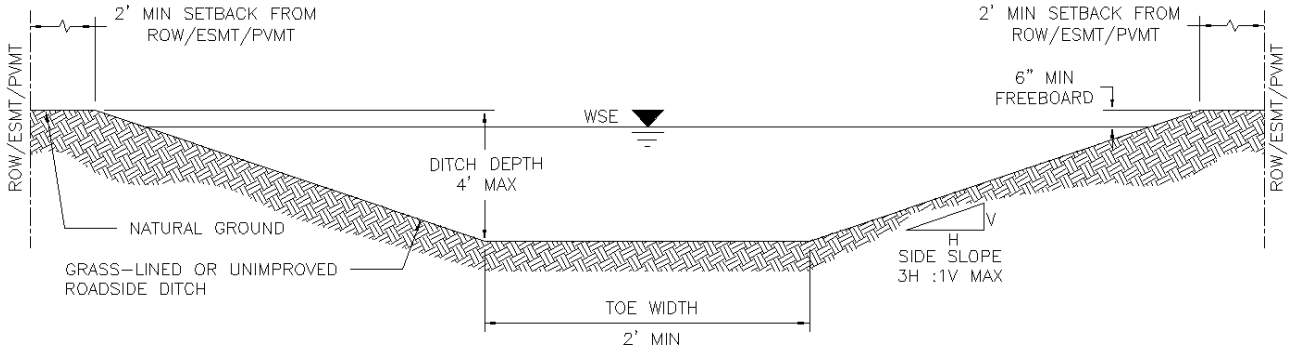


Figure 9.7 – GRASS-LINED/UNIMPROVED ROADSIDE DITCH CROSS SECTION

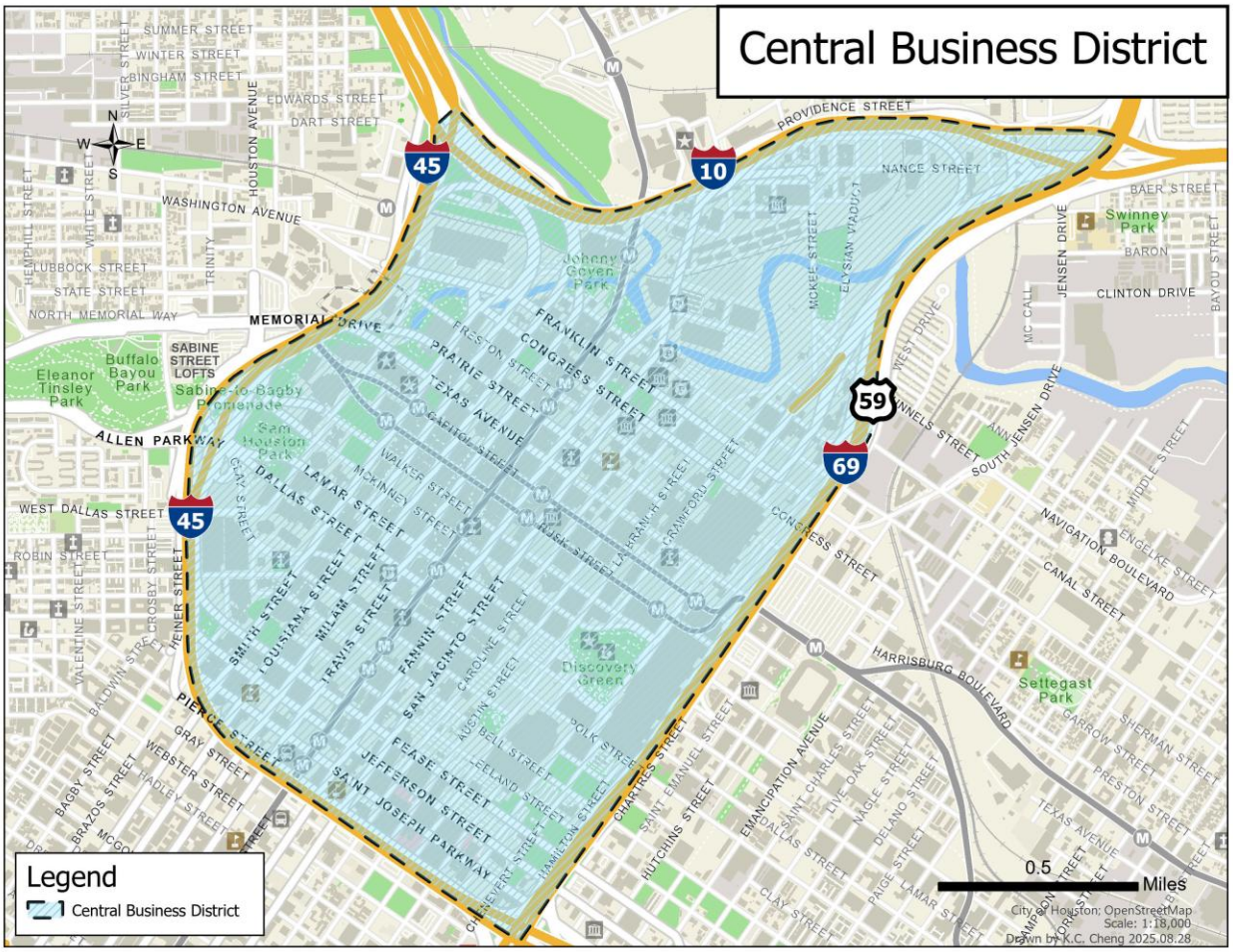


Figure 9.8 – CENTRAL BUSINESS DISTRICT

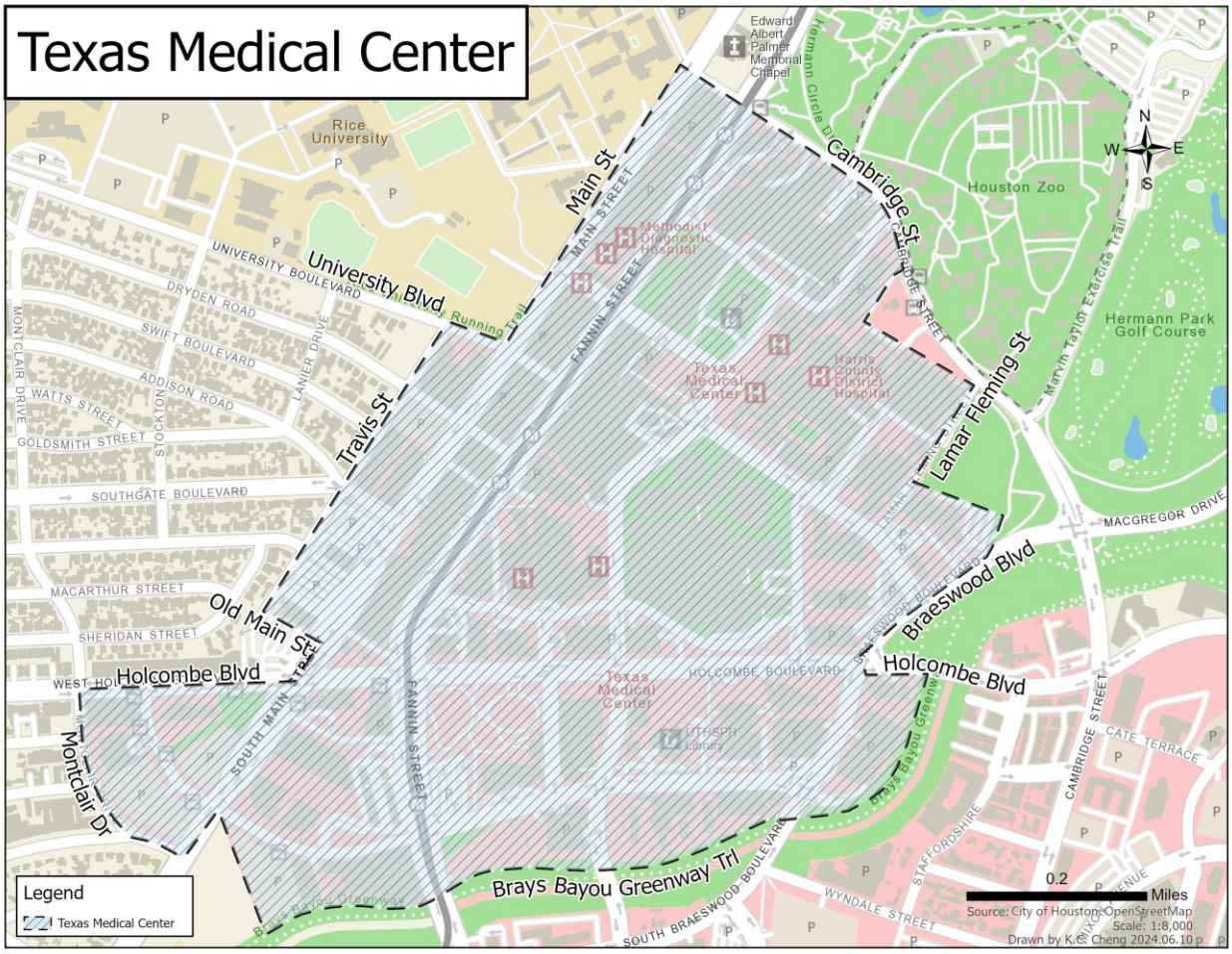


Figure 9.9 – TEXAS MEDICAL CENTER

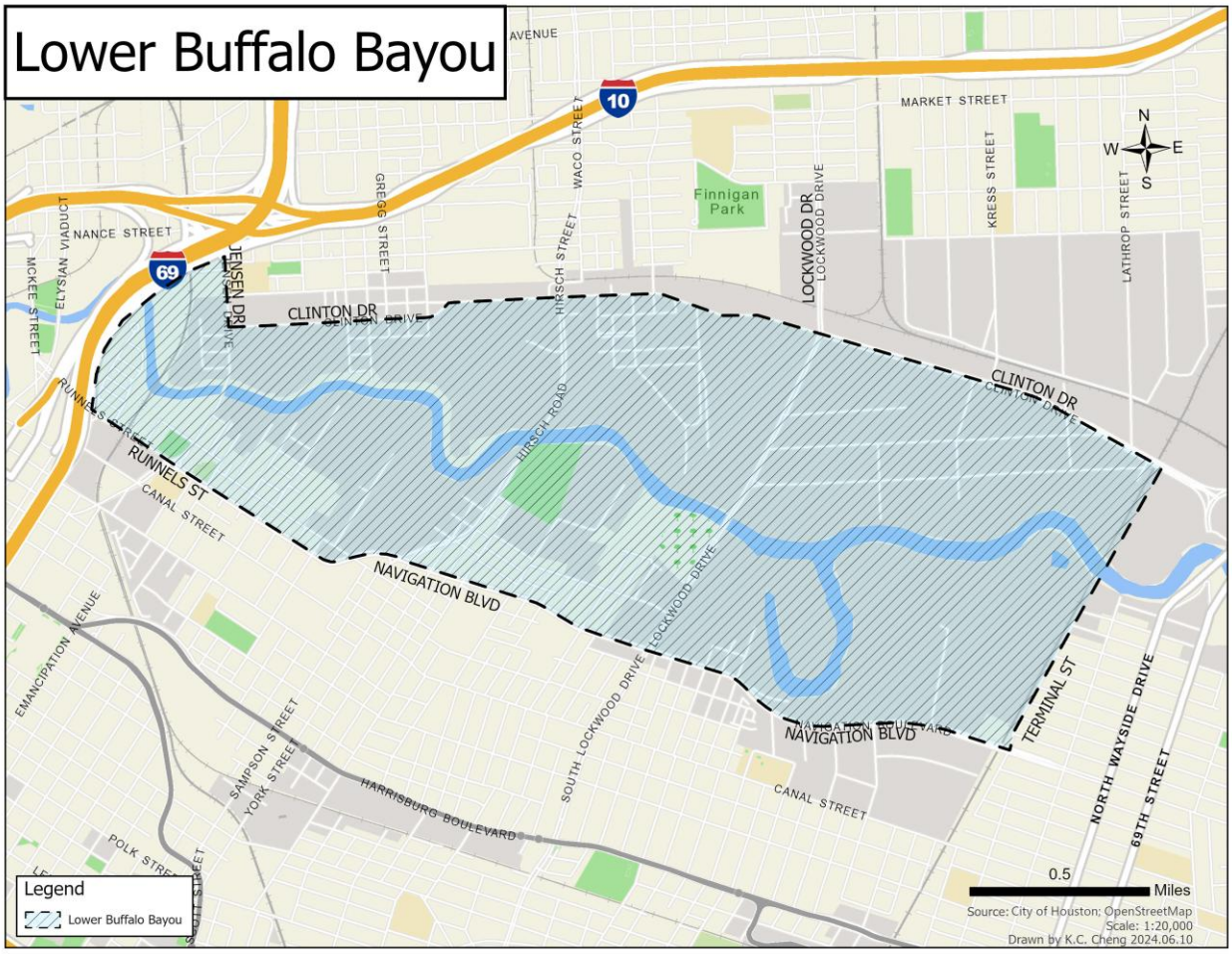


Figure 9.10 – LOWER BUFFALO BAYOU

RESTRICTORS:

Low Level Restrictor (25% flow):
Total Drainage Area =…….....acres
Outflow Rate Allowed for Low Flow QL1 =…… ……cfs (based on 0.5 cfs/ac)
Head HL1 (water surface differential based on 25% water surface and centroid of the primary restrictor) for Low Flow =…...……ft
Calculated Low Level Restrictor Size DL =……..... inches
Provided/Designed Low Level Restrictor Size DL1 =…….....…...inches (min. 6 inches)

High Level Restrictor (75% flow):
(Secondary restrictor should be placed at the 75% WSE, if any)
Total Drainage Area =…….....acres
Total Outflow Rate Allowed (100%) Q =……..cfs (based on 2 cfs/ac)
Re-calculated Head HL2 (water surface differential based on 100% water surface and centroid of the primary restrictor) for Low Level Restrictor =…….ft
Re-calculated Low Flow Q L2 for Low Level Restrictor =……cfs (based on DL1 and HL2)

Outflow Rate Allowed for High Flow Qh1 (75%) =……cfs (based Q and Q L2)
Head Hh2 (water surface differential based on 100% water surface and centroid of the secondary restrictor) for High Level Restrictor =…….....ft
Calculated High Level Restrictor Size Dh =……...inches
Provided/Designed High Level Restrictor Size Dh1 (75%) =……inches
Outflow Rate Provided for High Flow Qh2 =……cfs (based on Dh1, must < Qh1)

To explain your design above, please provide information below to the plan:

The location of the restrictor(s) on the plan(s)
The cross section for the restrictor(s) with the water surface elevations for 25%, 75%, and full detention capacity.
The location and elevation of the overflow structure (should be placed at 100% WSE).
HL1: Low-level Head
HL2: Low-level Head
HH2: High-level Head
WSE: Water Surface Elevation
FL: Flow Line
CL: Center Line

Figure 9.11 – RESTRICTOR CALCULATION SAMPLE

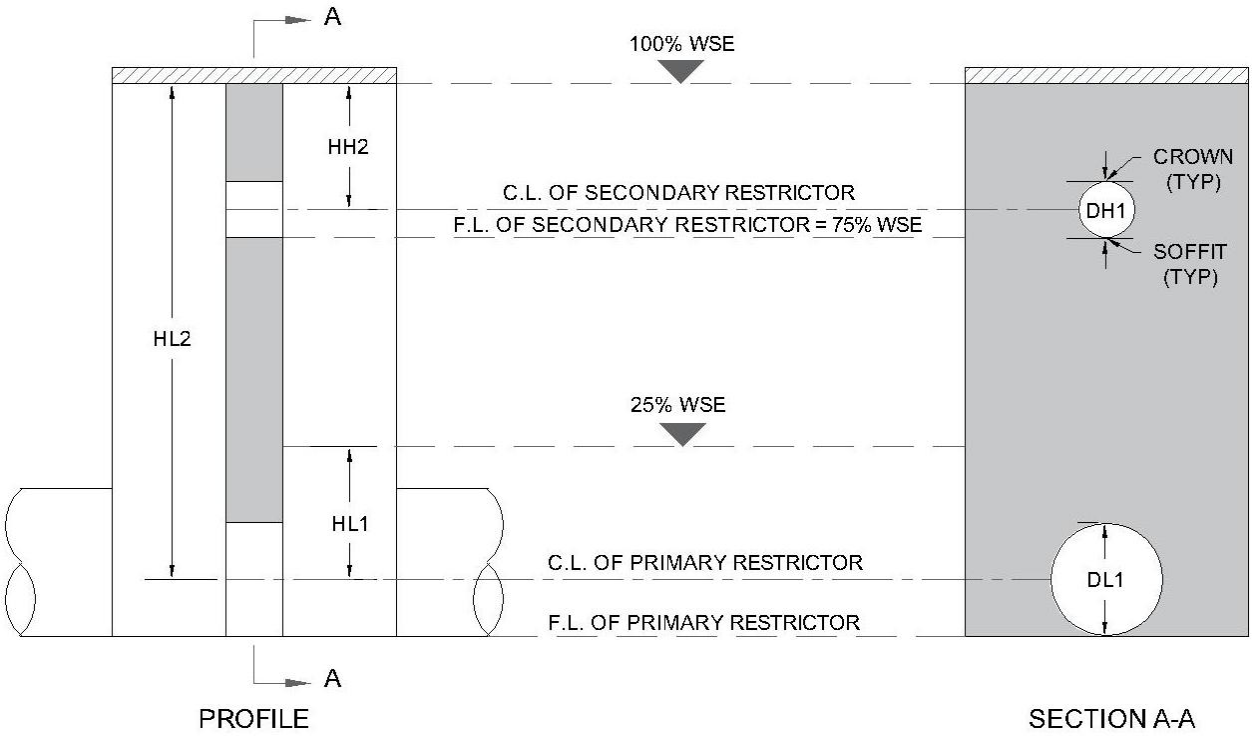


Figure 9.12 – ORIFICE RESTRICTOR SAMPLE

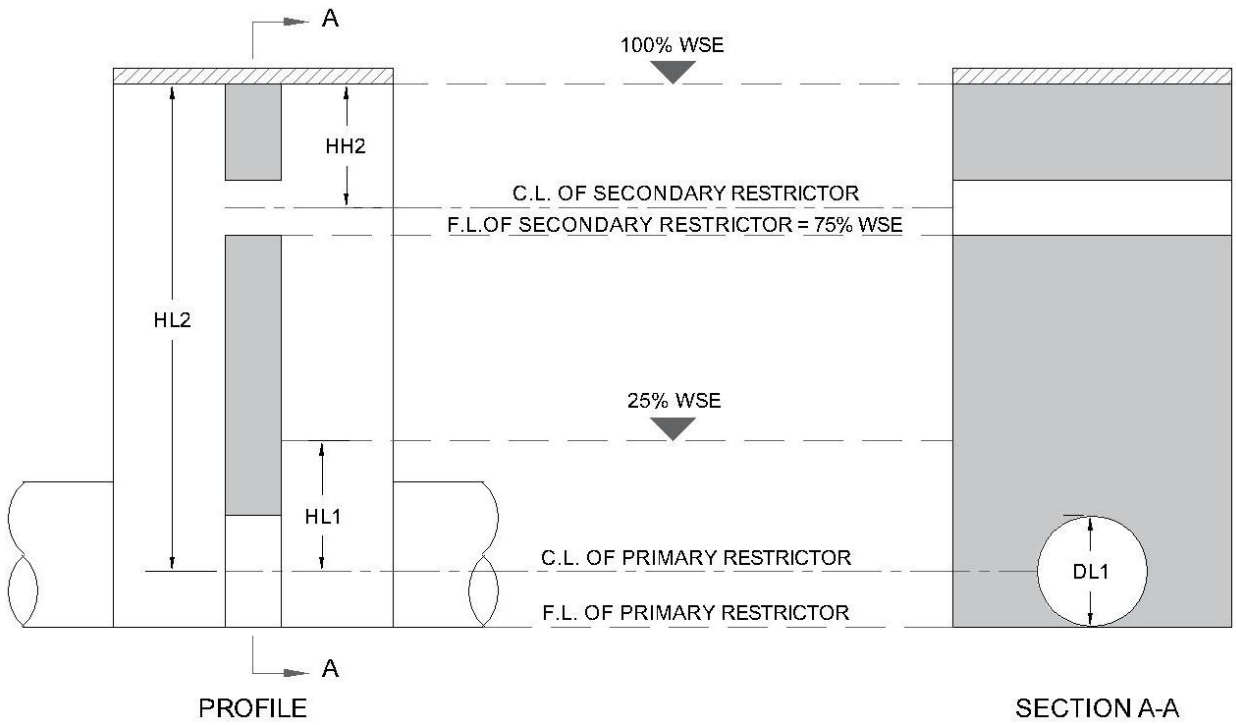


Figure 9.13 – WEIR RESTRICTOR SAMPLE

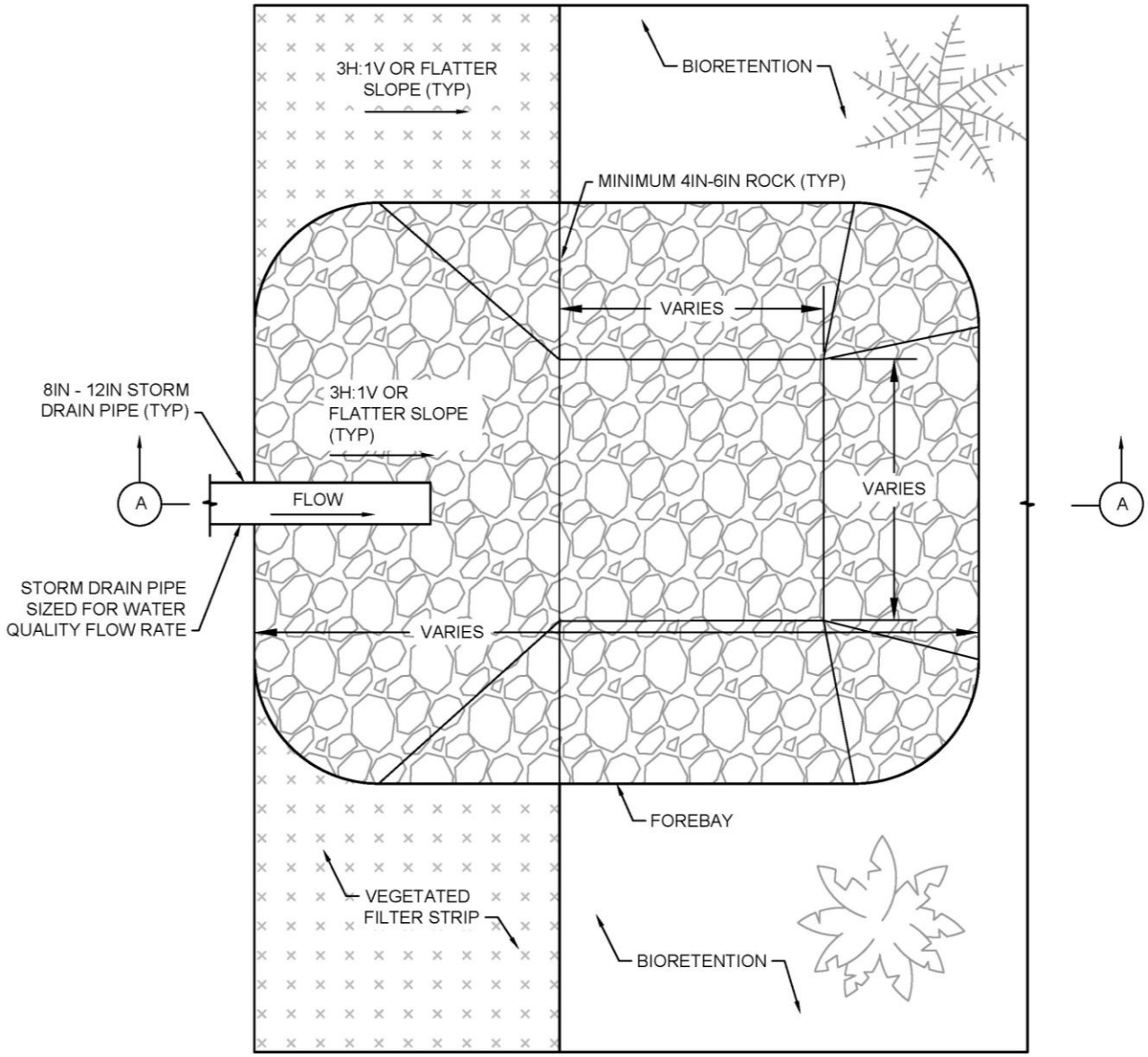


Figure 9.14 – BIORETENTION WITH FOREBAY PLAN VIEW

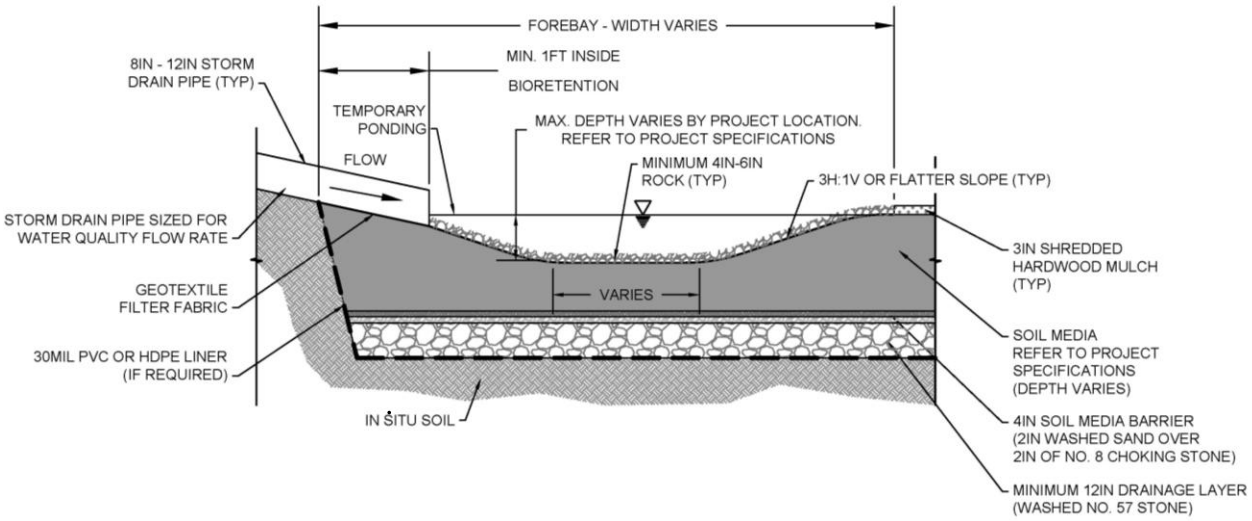


Figure 9.15 – BIORETENTION WITH FOREBAY SECTION A

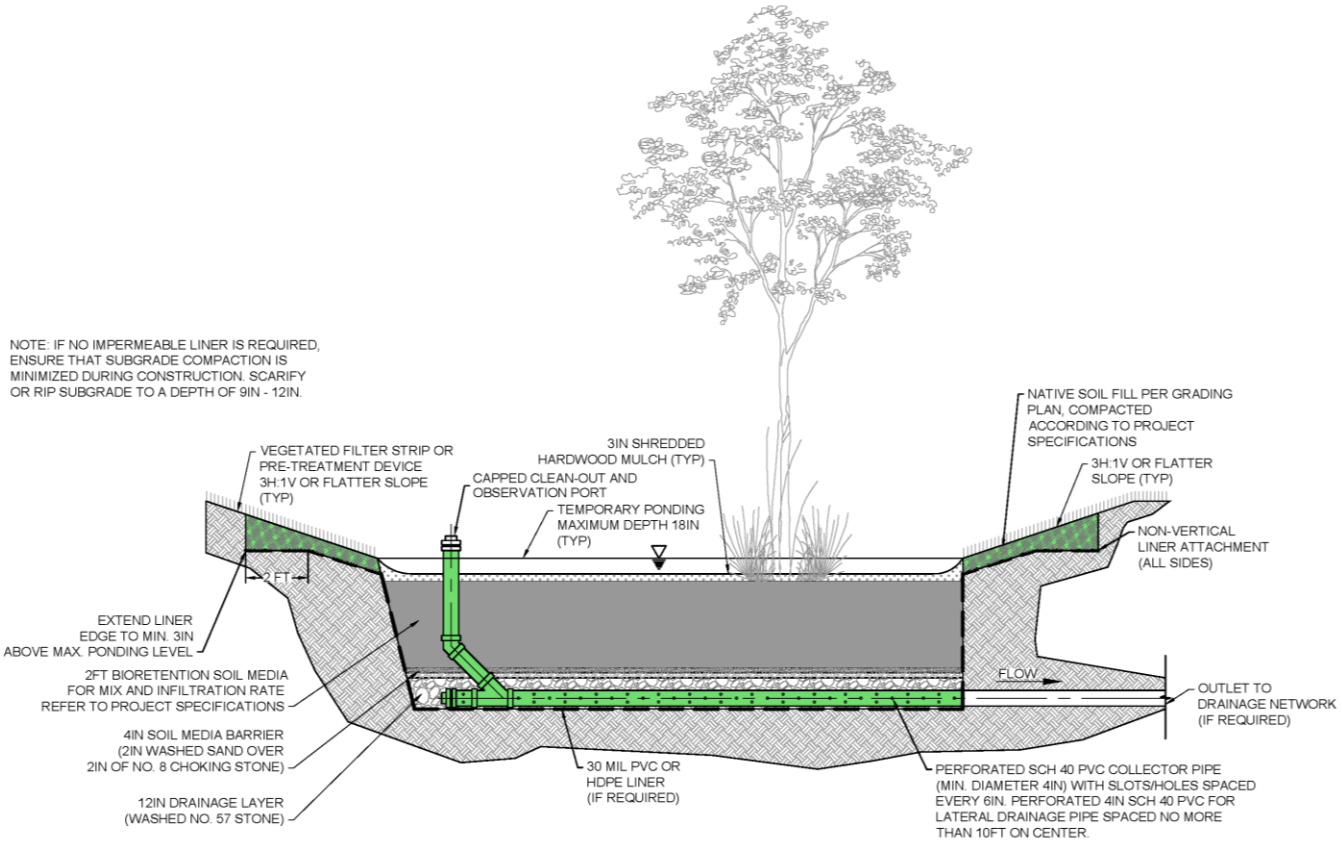


Figure 9.16 – BIORETENTION BASIN

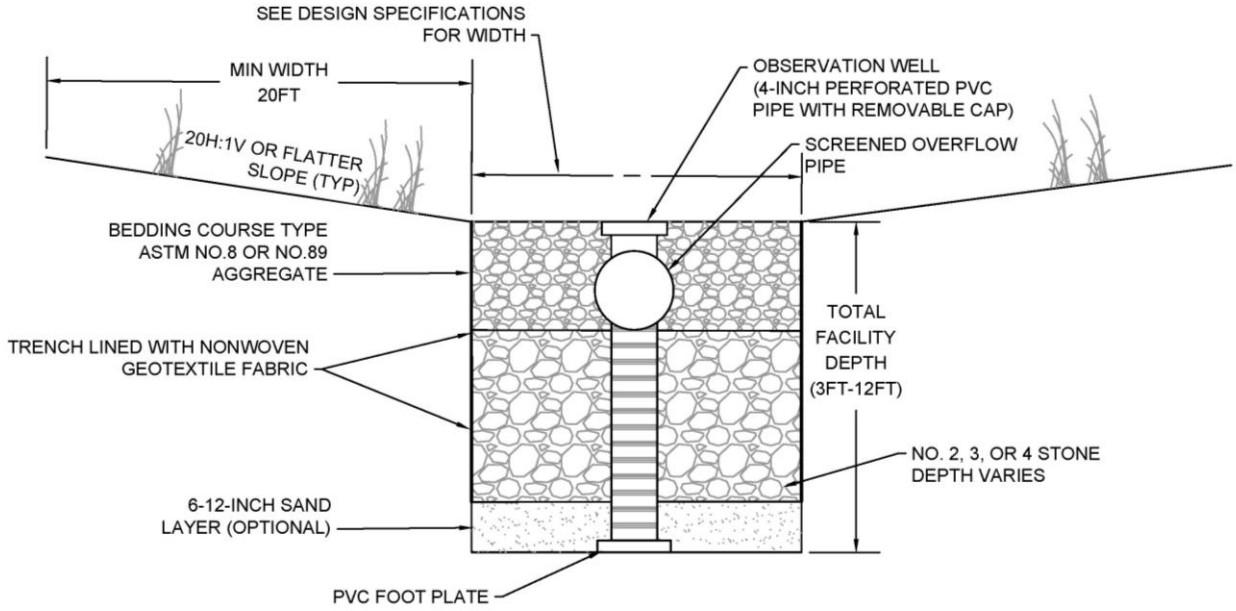


Figure 9.17 – INFILTRATION TRENCH

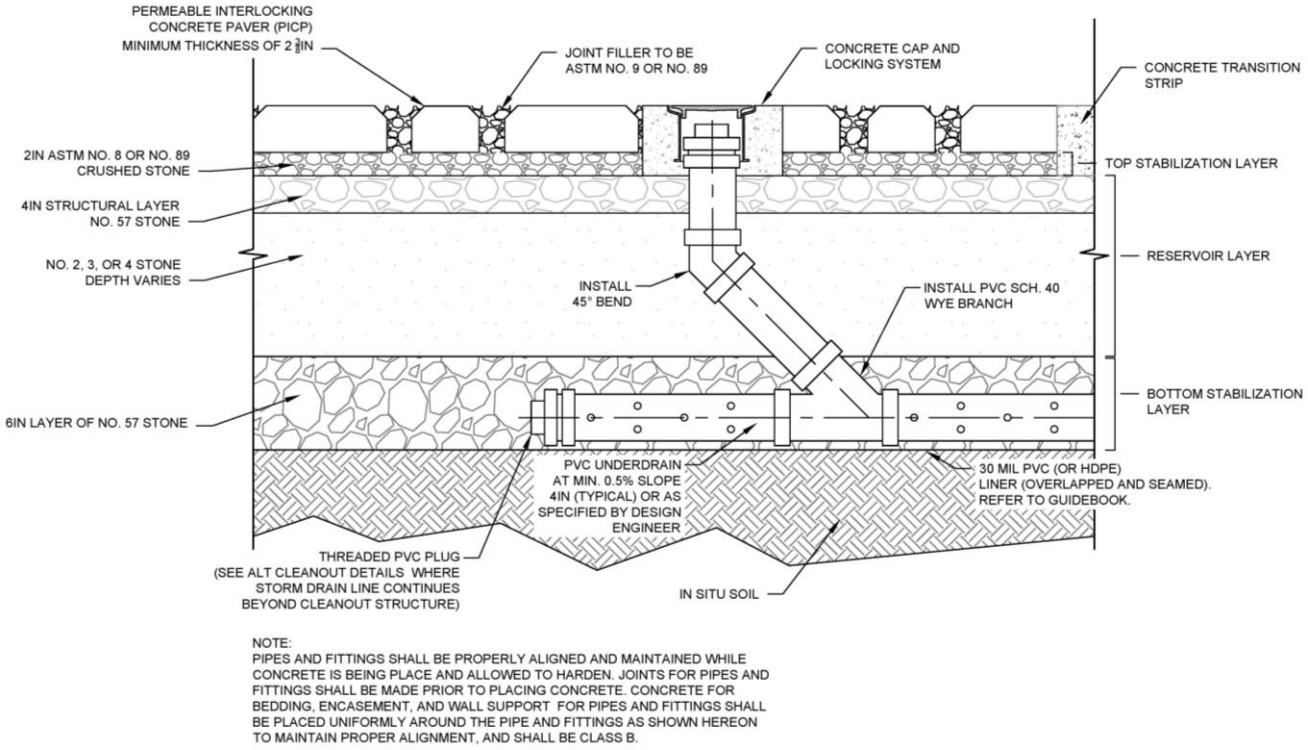


Figure 9.18 – SINGLE FAMILY POROUS PAVER TYPICAL SECTION (WITH UNDERDRAIN)

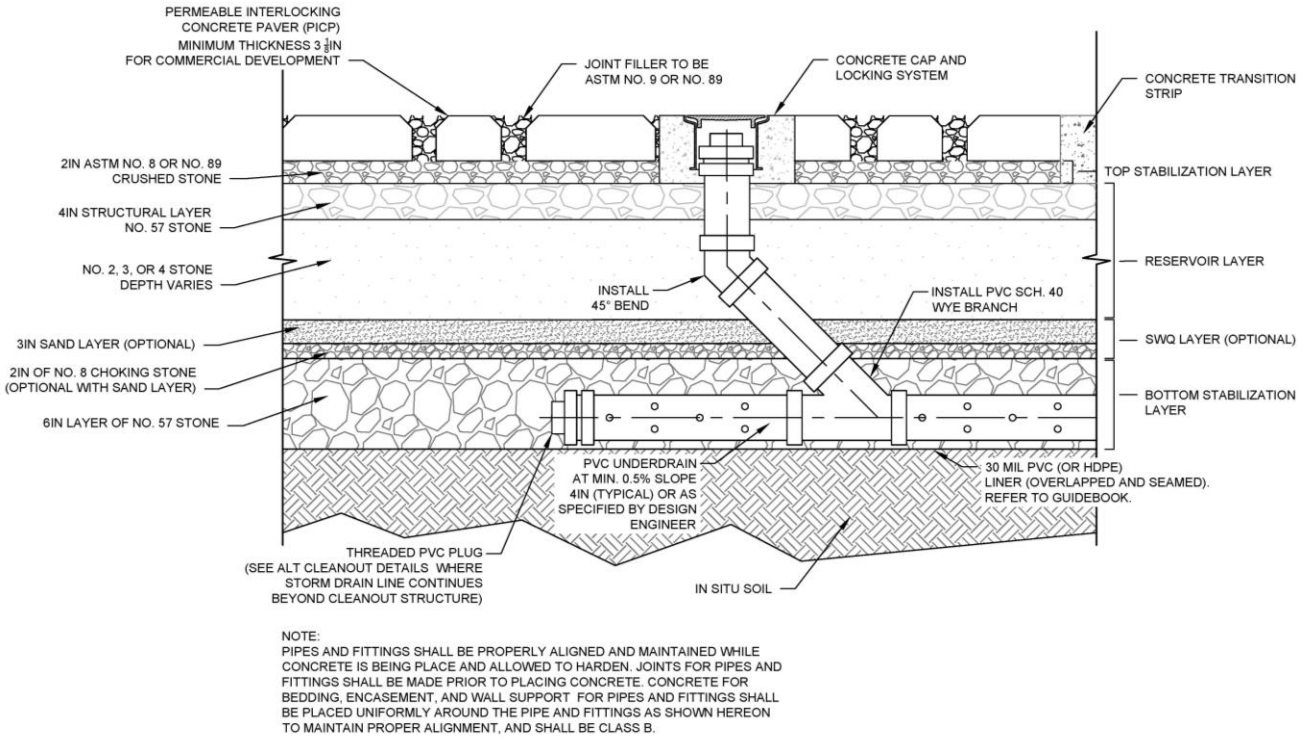


Figure 9.19 – COMMERCIAL/MULTI-FAMILY POROUS PAVER TYPICAL SECTION (WITH UNDERDRAIN)

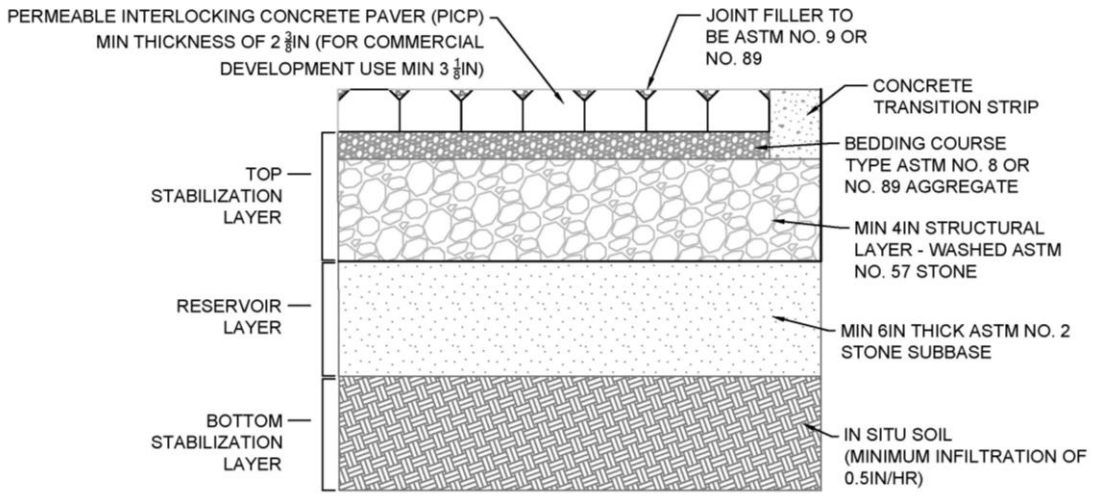


Figure 9.20 – POROUS PAVER TYPICAL SECTION

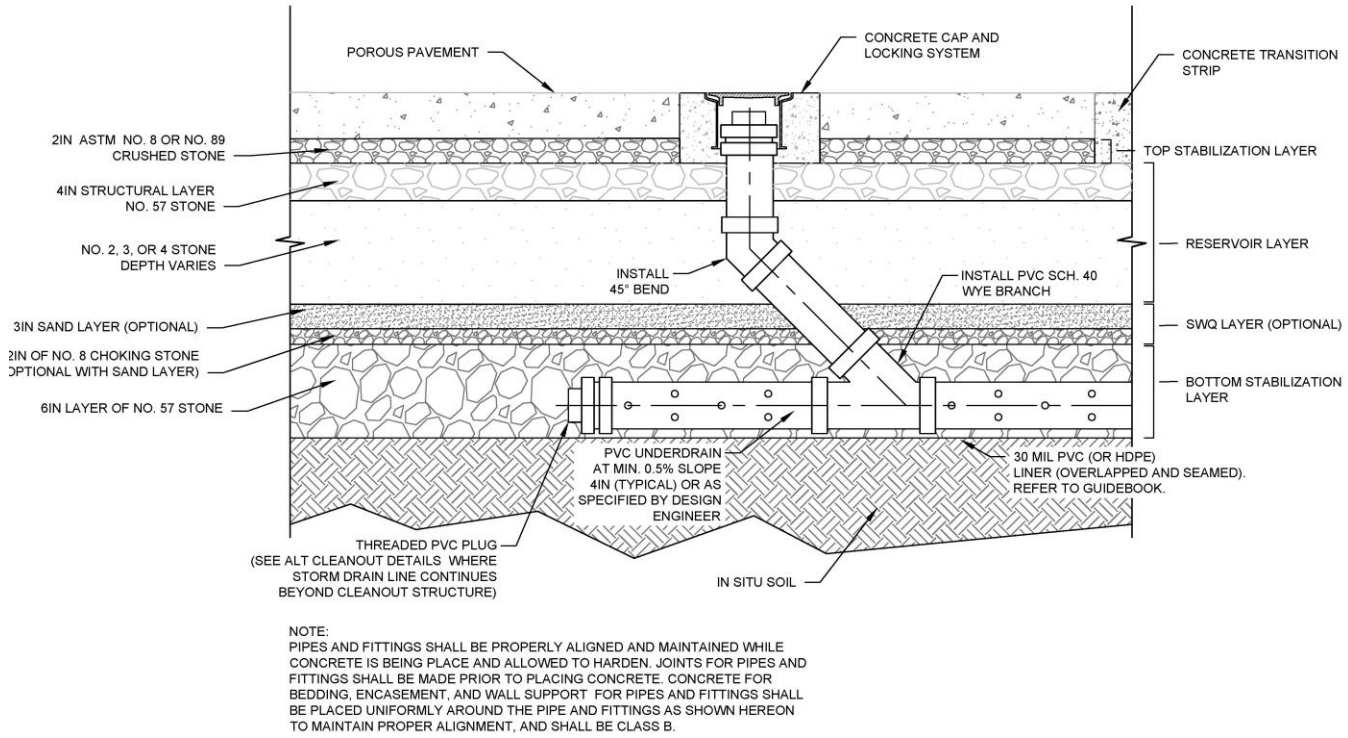


Figure 9.21 – POROUS PAVEMENT TYPICAL SECTION (WITH UNDERDRAIN)

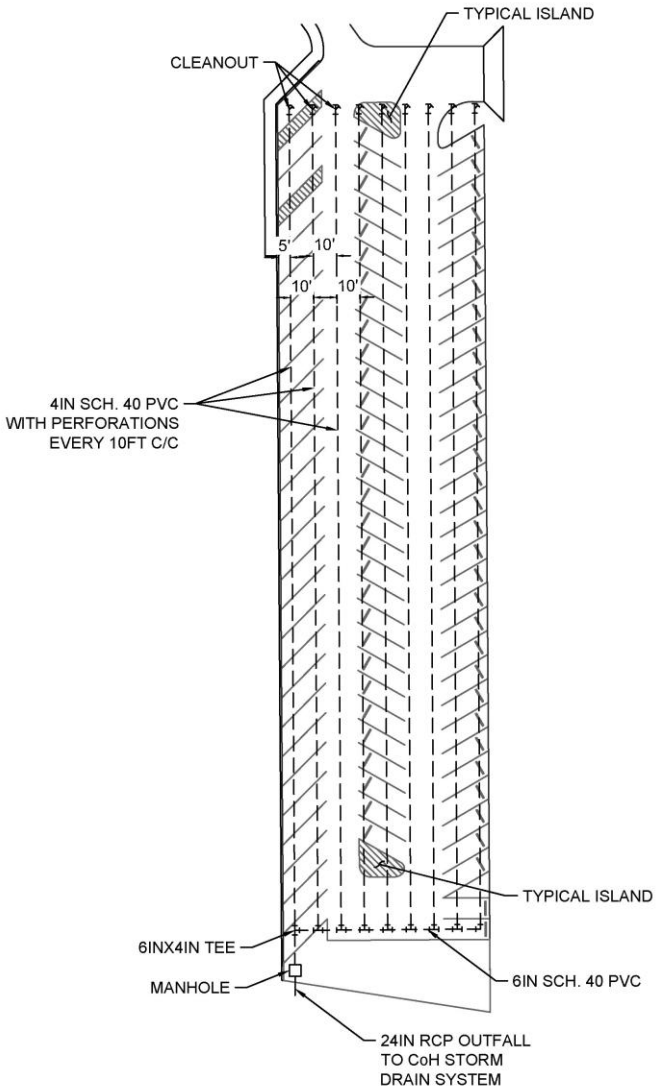


Figure 9.22 – POROUS PAVER PLAN VIEW

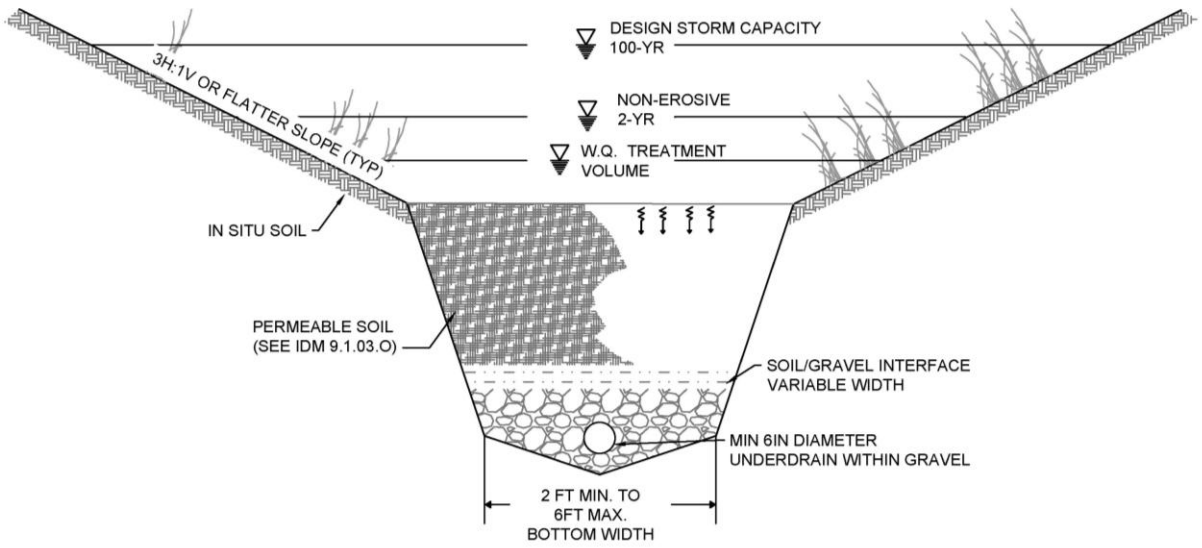


Figure 9.23 – DRY SWALE SECTION

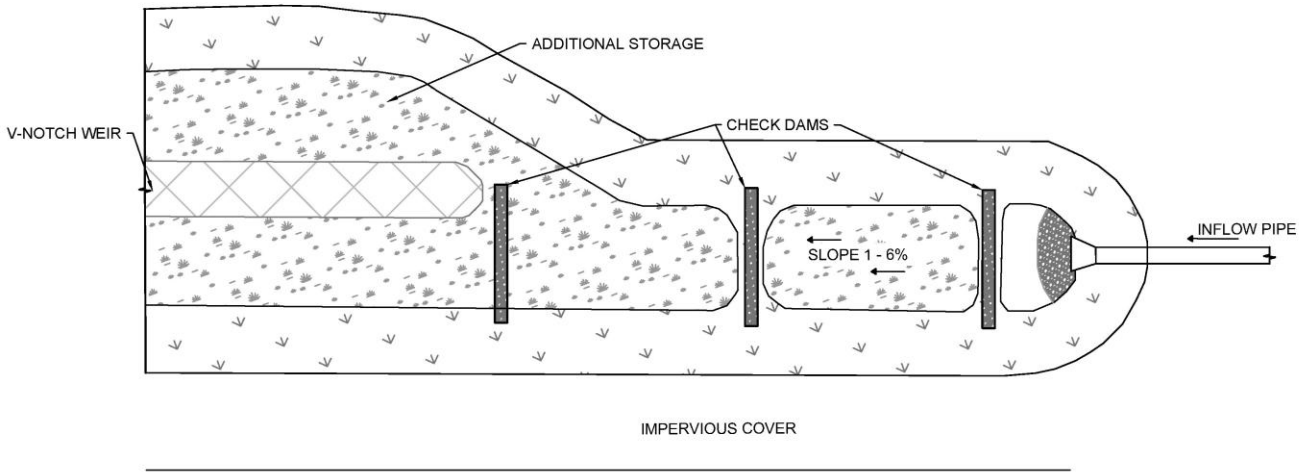


Figure 9.24 – WET SWALE PLAN VIEW

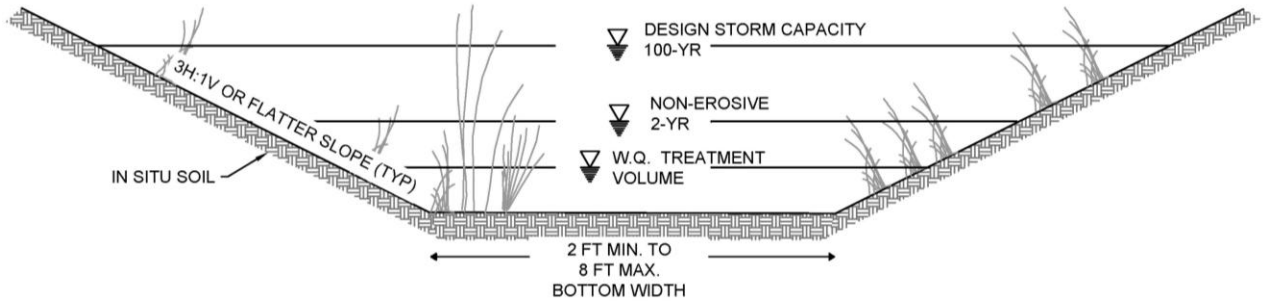


Figure 9.25 – WET SWALE CROSS SECTION

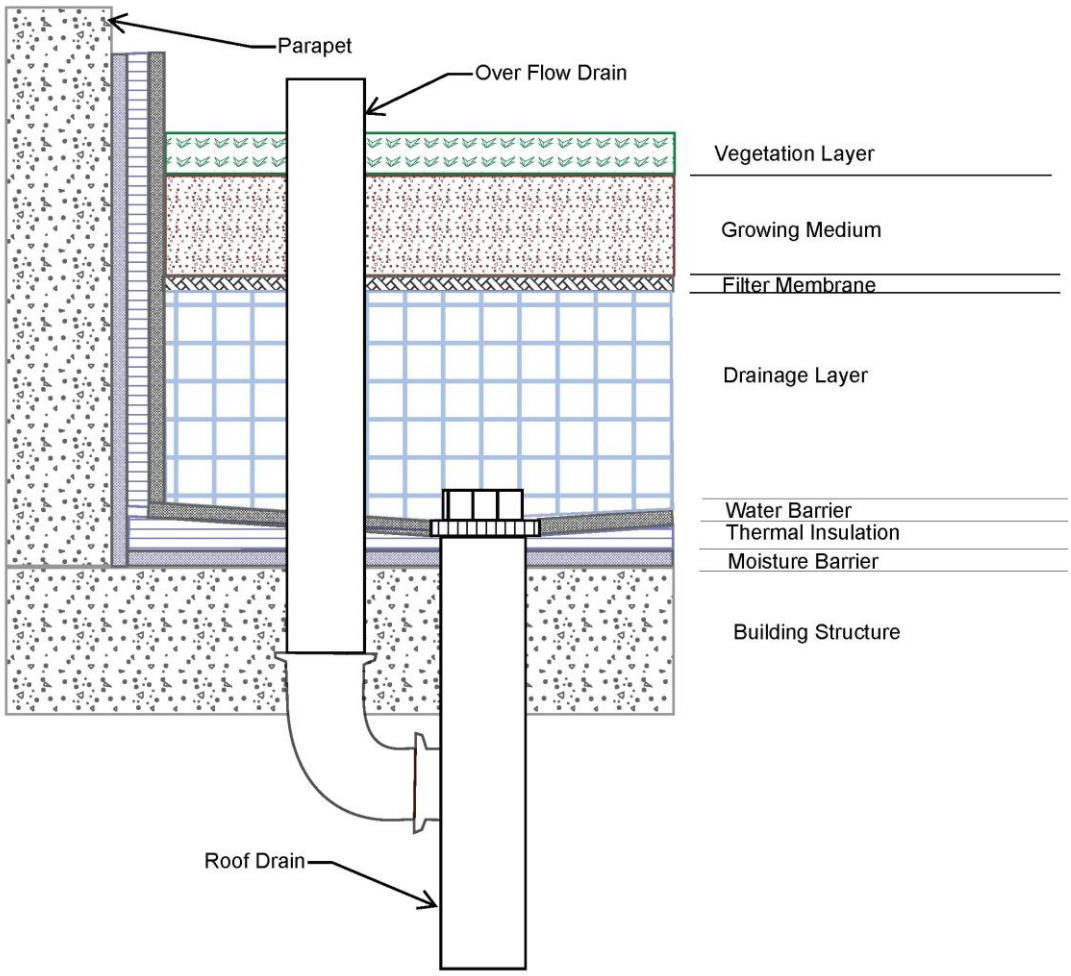


Figure 9.26 – GREEN ROOF CROSS SECTION

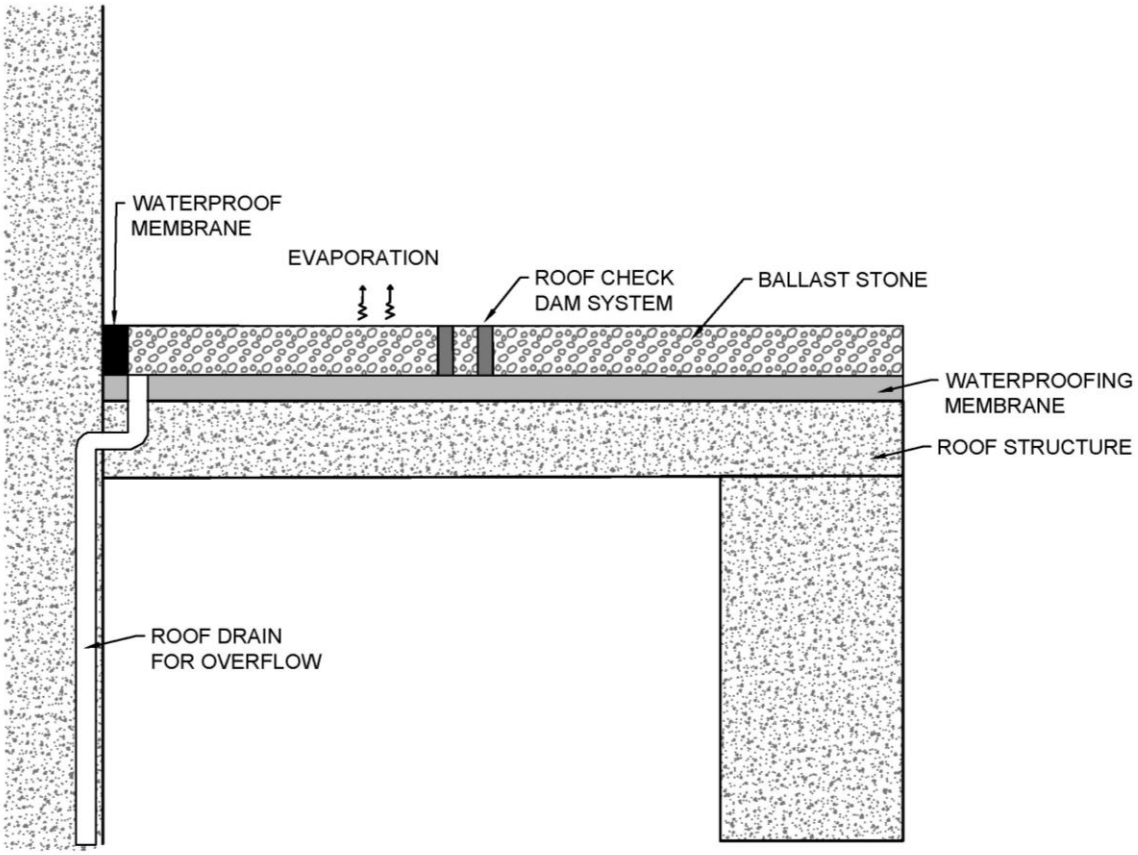


Figure 9.27 – BLUE ROOF CROSS SECTION

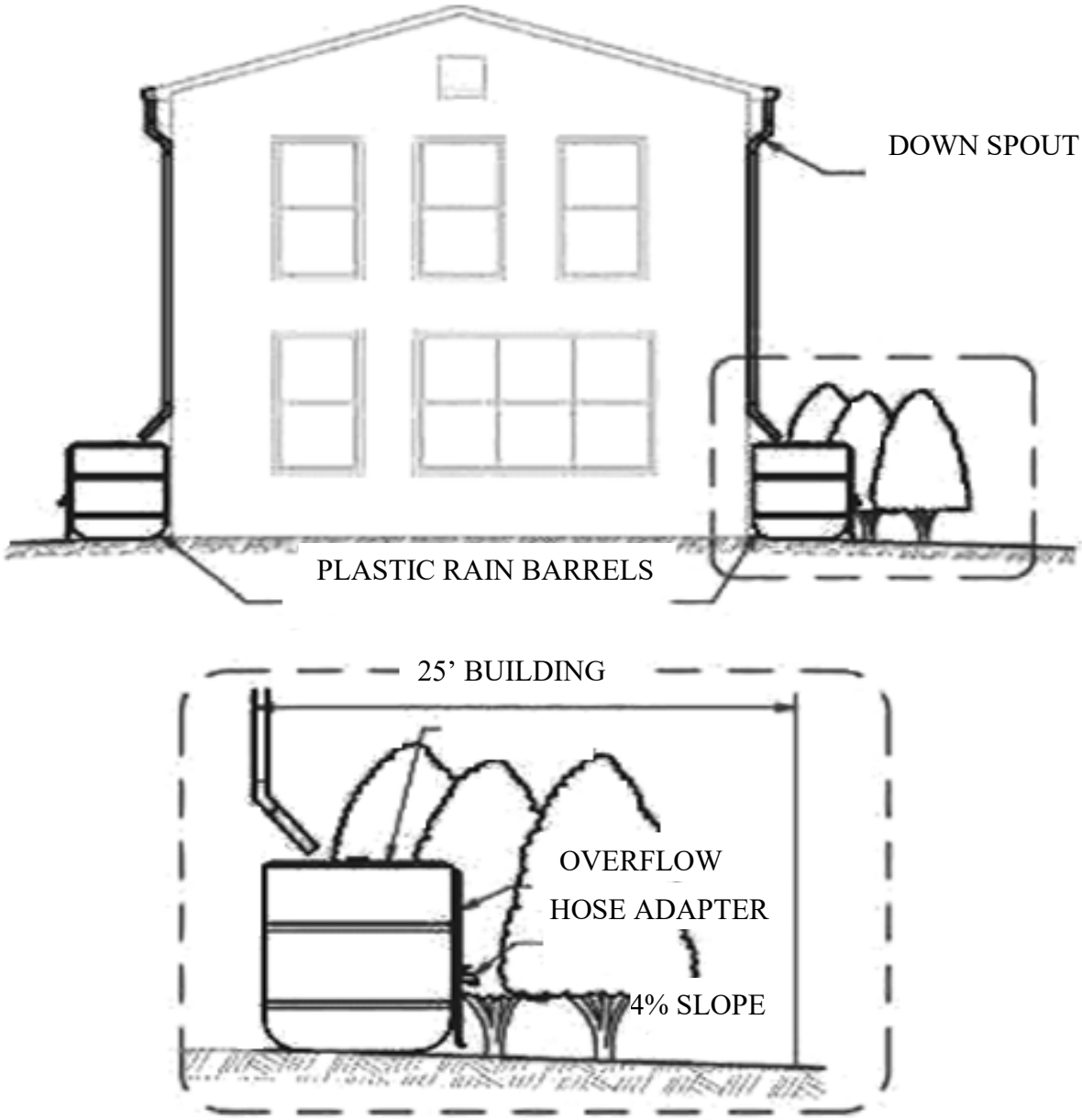


Figure 9.28 – TYPICAL RAIN BARREL

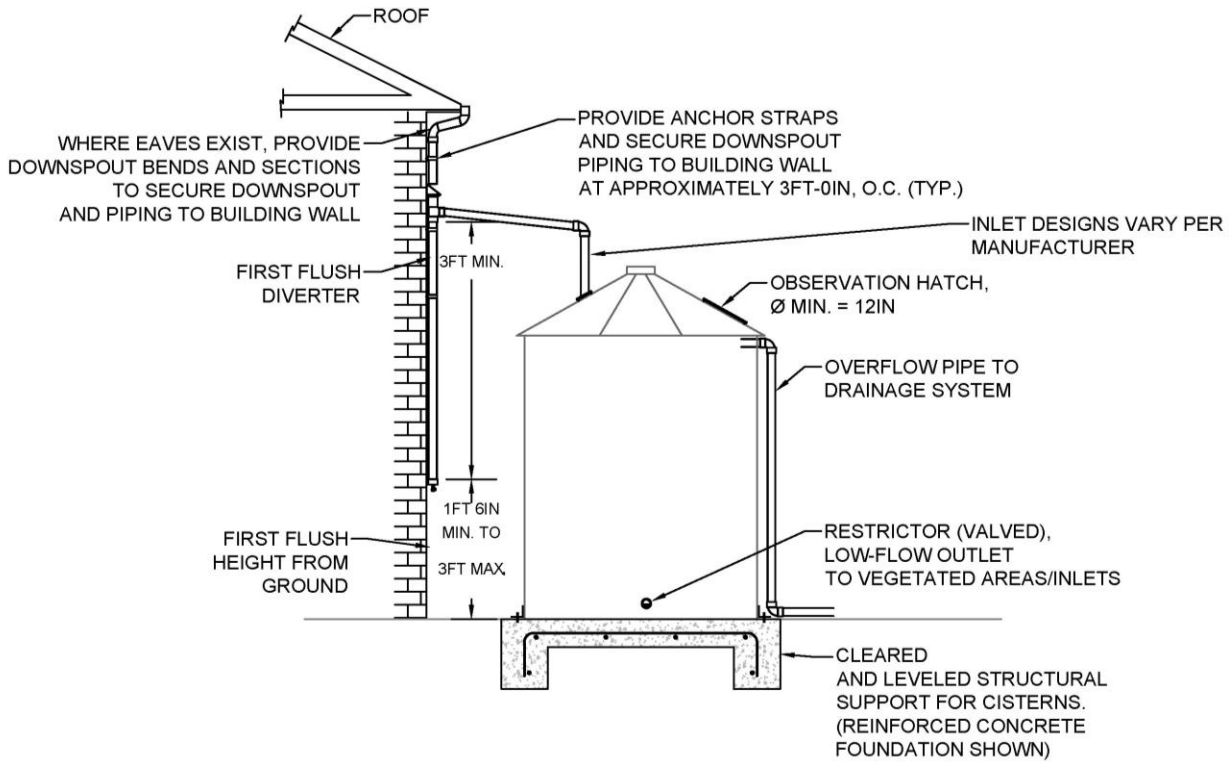


Figure 9.29 – TYPICAL CISTERN

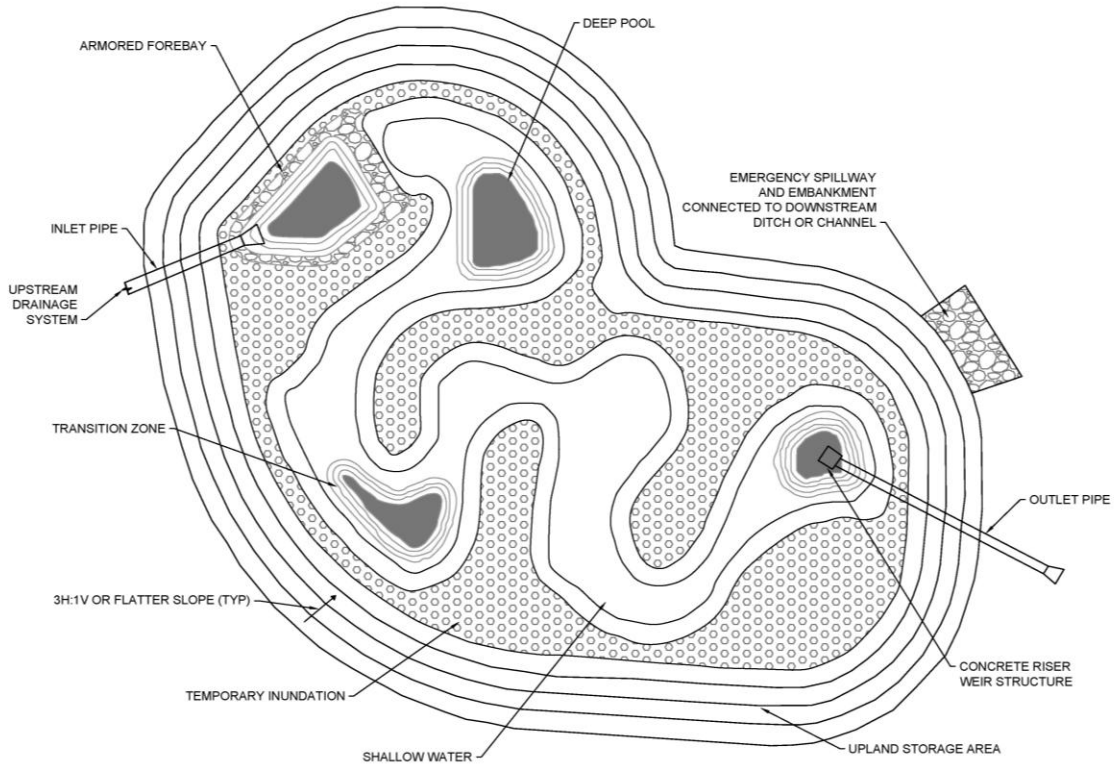


Figure 9.30 – CONSTRUCTED WETLAND BASIN

HOUSTON PUBLIC WORKS

OFFICE OF THE CITY ENGINEER
STORMWATER SECTION
STORMWATER INFORMATION FORMS

The Office of the City Engineer reviews and approves development plans to ensure the proper design and construction of storm sewer utilities in addition to enforcing private storm design criteria and parameters as stated in the City of Houston Code of Ordinances and the current City of Houston Infrastructure Design Manual.

- When a property owner proposes new development or redevelopment of property, the applicant must submit this form with their plans.
- Completion of this form does not represent an approval or commitment by the City of Houston.
- This form is informational only to assist in the review and approval of your plans.

Fee Simple Title Owner Information:	**Authorized Representative Information:**
Name:	Name:
Company:	Company:
Address:	Address:
City, State ZIP:	City, State ZIP:
Phone:	Phone:
Email:	Email:
*Signature:	Signature:

* As the fee simple owner of the property referenced in this form, I hereby authorize the referenced representative on this form (if applicable) to submit this form on my behalf. My authorized representative is also approved to make changes or corrections.

Property Information					
Service Address					
City, State ZIP Code:					
Property Tax Account Number(s):					
Lot(s):		Block:		Reserve:	
Subdivision:			Section:		

Flood Plain Information:

FIRM Panel Number: _____

Property Is Located Within the Following FEMA Flood Zone:

☐ X (shaded) ☐ X (unshaded) ☐ AE ☐ A ☐ AO ☐ Other:

FOR OFFICE USE ONLY

Log Number: _____ Private Building ILMS Project # _____

Public Plan ILMS Project #: _____ PW Record Drawing #: _____

HOUSTON PUBLIC WORKS

OFFICE OF THE CITY ENGINEER
STORMWATER SECTION
STORMWATER INFORMATION FORMS

Development Information

Provide description of development with associated footprint (in square feet):

☐ Single Family Residential Development ☐ Multiple Family Residential Development ☐ Commercial Development
☐ Other:

Existing Development:	
Proposed Development:	

Impervious Cover Information:

Improvements	Area of Existing Impervious Cover (Sq Ft.)	Area of Final Impervious Cover (Sq Ft.)
Building		
Parking Lot/Driveway		
Sidewalk/Patio		
Detention Pond		
Pool		
Other(s)		
Total Area		

Tract Size (Square Feet)		**Total Impervious Cover (Square Feet)**		**Percentage of Impervious Cover (%)**	

Storm Sewer Information:

Storm Infrastructure Is Maintained By:
NOTE: Any infrastructure maintained by outside agencies will require their respective approval prior to final City plan approval.

☐ City of Houston ☐ HCFCD ☐ TXDOT
☐ Clear Lake City Water Authority ☐ Fort Bend County ☐ Montgomery County
☐ Other:

Detention Criteria:

Stormwater detention volume was determined utilizing City of Houston Infrastructure Design Manual:

☐ 9.2.01.H.3 (b) Criteria 1 ☐ 9.2.01.H.3 (c) Criteria 2 ☐ 9.2.01.H.3 (d) Criteria 3

HOUSTON PUBLIC WORKS

OFFICE OF THE CITY ENGINEER
STORMWATER SECTION
STORMWATER INFORMATION FORMS

Proposed Storm Connection Development Will Be Connected To:

☐ Existing on-site storm sewer system that outfalls to: _____
(Street Name / Pipe Size)

☐ Public storm sewer located in: _____
(Street Name and Pipe Size)

☐ Public roadside ditch located in: _____
(Street Name)

☐ Off-road ditch/watershed: _____

Documentation

This form Must be accompanied with:

☐ A recorded deed / title report in the owner's name ☐ HCAD printout ☐ Recorded Plat/Replat ☐ Survey

The Applicant Can Also Provide the Following Documentation If Applicable to Their Project:

☐ Previous Stormwater Letter of Availability ☐ Copy of outside agency approval

☐ Storm Water Quality Permit:
Per Section 47-631 of the City of Houston Ordinance, SWQ permit is required when the development is meeting the definition of "new development" or "significant redevelopment".

☐ Drainage study/hydraulic analysis is required for developments larger than 20 acres

Developer Drainage Impact Fee Rate Information:

Service Area Rate is per service unit (1 service unit = 1,000 sf of impervious area) of increased impervious area.

Please Select One:

☐ Brays Bayou $25.00/SU ☐ Clear Creek $25.00/SU ☐ Hunting Bayou $25.00/SU ☐ Sims Bayou $25.00/SU
☐ Buffalo/White Oak ☐ Greens Bayou $25.00/SU ☐ San Jacinto $25.00/SU ☐ Vince Bayou $25.00/SU
☐ Bayou(1) $25.00/SU

(1) Now incorporates Addicks Reservoir, Barker Reservoir, and Ship Channel Service Areas

FOR OFFICE USE ONLY			
Employee:		Comments:	

StormPlanReview@houstontx.gov Coming Soon https://bit.ly/OCESWPRO

Page 3 of 3 revised: April 2024 OCE - 1001

Detention Volume Breakdown Table

Project Name
Project Address
Project Number
Number of Lots

Date

	Lot #	Total Area (SF)	Total Impervious Area* (SF)	Percentage of Lot Improvement Area	Detention Rate (acre-ft/acre)	Detention Volume Required (cu-ft)	Detention Volume Provided (cu-ft)	Detention Volume Excess (cu-ft)	Detention Credit Volume Credit (cu-ft)**
Total (SF)									

Note	* Total impervious area should include any shared driveway impervious area present as part of the lot as well as house, driveway, sidewalk, patio, pool, etc.
	** If applicable, otherwise leave empty

Figure 9.32 – DETENTION VOLUME BREAKDOWN TABLE

City of Houston

Design Manual

Chapter 10

STREET PAVING DESIGN REQUIREMENTS

Chapter 10
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Chapter 10

STREET PAVING DESIGN REQUIREMENTS

SECTION 1 – STREET PAVING DESIGN OVERVIEW

10.1.01 CHAPTER INCLUDES

10.1.01.A Geometric design guidelines for streets, criteria for street paving, and standard paving notes for drawings.

10.1.02 POLICY

10.1.02.A The design of streets within the City of Houston shall consider all users.

10.1.02.B Roadway designs shall require the use of context sensitive design principles such as those included in the ITE Recommended Practice: Designing Walkable Urban Thoroughfares: A context Sensitive Approach.

10.1.02.C The design requirements set in this chapter are not intended to be the only values used for design. Where applicable, design requirements should be exceeded to enhance safety and comfort for all road users.

10.1.02.D Project designs shall consider roadway context, including adjacent land uses, nearby destinations and infrastructure and existing or potential bicycle, pedestrian or transit use.

10.1.02.E Designers are encouraged to consider the cross sections provided in Appendix 2 of this chapter to support the roadway context of the project. Additionally, information regarding potential enhanced pedestrian environments and bicycle or transit facilities can be found in Chapter 17.

10.1.02.F Designers are encouraged to consider alternate cross sections and design standards to meet the context sensitive needs of their projects. If they find that their proposed design conflicts with portions of this manual, they should meet with the Office of the City Engineer to discuss applicability and what, if any, variances might be needed.

10.1.03 REFERENCES

10.1.03.A Access Management Manual, TRB, current edition

10.1.03.B City of Houston, Code of Ordinances, Chapter 40 – Streets and Sidewalks

10.1.03.C City of Houston, Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting

10.1.03.D Houston Complete Streets and Transportation Plan (HCSTP)

10.1.03.E Designing Walkable Urban Thoroughfares: A Context Sensitive Approach, ITE, current edition

10.1.03.F A Policy on Geometric Design of Highways and Streets ("The Green Book"), AASHTO, current edition

10.1.03.G Guide for the Development of Bicycle Facilities, AASHTO, current edition

10.1.03.H Guide for the Design of Pavement Structures, AASHTO, current edition

10.1.03.I Highway Capacity Manual (HCM), TRB, current edition

10.1.03.J Highway Safety Manual, AASHTO, current edition

10.1.03.K International Building Code (IBC), current edition

10.1.03.L City of Houston, Houston Public Works Infrastructure Design Manual Chapter 1, General Requirements.

10.1.03.M Roadside Design Guide, AASHTO, current edition

10.1.03.N Scenic Houston Streetscape Resource Guide

10.1.03.O Texas Manual on Uniform Traffic Control Devices (TMUTCD), TXDOT, current edition

10.1.03.P Traffic Engineering Handbook, ITE, current edition

10.1.03.Q Trip Generation, ITE, current edition

10.1.03.R Urban Bikeway Design Guide, NACTO, current edition

10.1.03.S Urban Street Design Guide, NACTO, current edition

10.1.03.T Signalized Intersection Information Guide. Report No. FHWA-HRT-04-091, FHWA

10.1.03.U Roadway Design Manual, TxDOT, current edition

10.1.03.V Roundabouts: An Informational Guide, National Cooperative Highway Research Program (NCHRP) Report 672, current addition

10.1.04 DEFINITIONS

10.1.04.A AASHTO - American Association of State Highway and Transportation Officials

10.1.04.B AC - asphaltic concrete.

10.1.04.C Applicant - A person who owns real property abutting an alley and seeks to improve such alley for motorized vehicular traffic use either by the public or pursuant to private rights of access.

10.1.04.D ASTM - American Society for Testing and Materials

10.1.04.E City Maintained Alley - A right-of-way dedicated to the public for an alley prior to January 1, 2023, that is open and available for vehicular use and travel by the general public and has been formally accepted for maintenance by the City of Houston (City).

10.1.04.F CMP - The City Mobility Plan is joint initiative between Planning & Development Department and HPW to examine a range of land development and growth issues by evaluating multi-modal transportation network needs and adjacent land development in the city.

10.1.04.G Complete Streets - Complete streets are streets that are designed using context sensitive design principles.

10.1.04.H Context Sensitive Design - Context sensitive design takes into account all roadway users, their interactions with one another, and overall effect on the land uses and neighborhoods for which a corridor serves to move people in a safe, effective and predicable manner. Roadway users include people who are driving or riding in cars, using mass transit, riding bicycles, walking, using wheelchairs, driving or riding in trucks, driving or being transported by emergency vehicles, and being served at their residence or property by other users. Context sensitive design principles are flexible and sensitive to community values. Context sensitive design principles take the following variables in account:

1. People being served at their residence or property by other Right-of-Way users.

2. People of all ages and abilities, including children, older adults, and persons with disabilities.

10.1.04.H continued

3. The functional classification of the road (e.g. local, collector, and thoroughfare), the level of comfort for pedestrian and bicycle traffic, as well as vehicle volumes and speeds of the roadway.

4. Multi-Modal Classification Street Type - A public street type classification that takes into account the functional classification (MTFP designation) and land use context, inclusive of right-of-way width, number of lanes and traffic volume. The context of the land use adjacent to the road comprises population and job densities (present and future), projected land use types (residential, commercial community facility or industrial), and modes of operation (pedestrian, bicycle, transit, rail, freight and vehicle lanes) can be used as a determinant in identifying Multi-Modal Classifications.

    a. Complete Streets and Transportation Plan - A plan that, at a minimum, includes the Major Thoroughfare and Freeway Plan, Bikeway/Pedestrian Plan, Rail Plan, Multi-Modal Classification Street Type, Master Parking Plan, Bayou Greenway Initiative, Context Report and METRO's Transit Plan.

    b. Major Thoroughfare - Divided into two classifications; Principal Thoroughfare and Thoroughfare. Major Thoroughfares are those streets designed for fast, heavy truck traffic, high traffic volumes and are intended to serve as traffic arteries of considerable length and continuity throughout the community. For definitions of principal thoroughfare and thoroughfare, see the latest version of the City of Houston Major Thoroughfare and Freeway Plan (MTFP) Policy Statement.

    c. Collector Streets - Public streets that accumulate traffic from local streets for distribution to the Major Thoroughfare streets. A Collector Street may be a Minor Collector or a Major Collector. For definitions of Minor collector and Major collector, see the latest version of the City of Houston Major Thoroughfare and Freeway Plan (MTFP) Policy Statement.

    d. Transit Corridor Streets - Rights-of-way or easements that METRO has proposed as a route for a guided rapid transit or fixed guide way transit system and that is included on the City's MTFP.

10.1.04.I Curb-and-gutter Sections - Full width concrete pavement with doweled on six inch curbs or monolithic curb-and-gutter sections for asphaltic concrete pavement. Curb-and-gutter sections require inlets and underground storm sewers.

10.1.04.J Geotechnical Engineer - A licensed Professional Engineer in the State of Texas who is practicing in the field of geotechnical engineering.

10.1.04.K Houston Complete Street and Transportation Plan- A plan that, at a minimum, includes the Major Thoroughfare and Freeway Plan, Bikeway/Pedestrian Plan, Rail Plan, Multi-Modal Classification Street Type and Master Parking Plan, Bayou Greenway Initiative, Context Report and METRO's Transit Plan.

10.1.04.L Intersection Sight Distance - Provides an unobstructed line of sight in each direction at intersections. The unobstructed line of sight allows for vehicles on side streets to observe approaching traffic on the main roadway and to safely enter an intersection from a side street. The unobstructed line of sight allows for vehicles on the main roadway sufficient distance to observe vehicles entering from side streets.

10.1.04.M ITE - Institute of Transportation Engineers

10.1.04.N Local Streets - Provide access to individual single-family residential lots, multifamily or commercial developments, provide entry and exit to the neighborhood, and provide connectivity to collectors and thoroughfares.

10.1.04.O MTFP - Major Thoroughfare and Freeway Plan

10.1.04.P NACTO - National Association of City Transportation Officials.

10.1.04.Q New Alley - A right-of-way dedicated to the public for an alley on January 1, 2023, or after.

10.1.04.R Privately Maintained Alley - A right-of-way dedicated to the public for an alley prior to January 1, 2023, and utilized for right of ingress and egress for property adjacent to and authorized for private access by reference to map or plat showing alleys abutting such real property, and that have not been accepted for maintenance by the City.

10.1.04.S Roadside Ditch Sections - Ditch sections adjacent to either full width reinforced concrete pavement or asphaltic concrete pavement. Roadside ditch sections do not require underground storm sewers; however, the ditch sections must be designed to accommodate storm runoff.

10.1.04.T Roadway Context - The roadway context includes adjacent land uses, traffic volumes, and multimodal components taken into consideration when determining roadway design features. Although each roadway will have a unique set of characteristics that define its specific context, five major categories of roadway context are defined: commercial, residential, mixed use, industrial and transit. Each category of roadway context has specific design features, standards, and cross sections that must be considered.

1. Commercial Street - The primary land uses adjacent to the street is commercial (with limited amounts of light industrial), and the Planning and Development Department has classified the roadway context as commercial.

2. Mixed-Use Street - The land use is a mix between commercial and residential (either single or multi-family), and the Planning and Development Department has classified the roadway context as mixed-use.

10.1.04.T continued

3. Residential Street - The primary land use is residential (typically single-family, potentially with some multi-family), and the Planning and Development Department has classified the roadway context as residential.

4. Industrial Street - The adjacent land uses are predominantly industrial with some commercial land uses, and the Planning and Development Department has classified the roadway context as industrial.

5. Transit Street - The typical adjacent land uses are those of a Mixed-Use Street with the addition of a fixed guideway or other high-capacity rapid transit system, and the Planning and Development Department has classified the roadway context as transit- related.

10.1.04.U Soils

1. Cohesive Soils are those that have 50% or more (by weight) passing the No. 200 Sieve and Plasticity Index greater than seven.

2. Granular Soils are those that have 50% or more (by weight) retain on the No. 200 Sieve.

10.1.04.V TRB - Transportation Research Board

10.1.04.W Type 1 Permanent Access Easement - A permanent access easement at least 50 feet in width that is designed and constructed like a public street in accordance with the design manual and contains one or more public utilities in an unpaved portion of the easement. Refer to Chapter 42 of the Code of Ordinances.

10.1.04.X Type 2 Permanent Access Easement - A permanent access easement at least 28 feet in width that is designed and constructed like a private street serving a development that has no public utilities other than a public water line, connected to one or more fire hydrants, that provides no domestic water services. All private utilities within a Type 2 permanent access easement must be designed to public utility standards outlined in the Infrastructure Design Manual. Refer to Chapter 42 of the Code of Ordinances.

10.1.04.Y Type A Street – A public street that intersects a transit corridor street and that abuts a blockface that is located within 1,320 feet walking distance of the end of an existing or proposed transit station platform.

SECTION 2 – PAVEMENT DESIGN REQUIREMENTS

10.2.01 ASPHALTIC CONCRETE PAVEMENT DESIGN REQUIREMENTS

10.2.01.A AC Surface Minimum Thickness - Pavement design shall be prepared by a Professional Engineer based on current AASHTO design methodology (Guide for the Design of Pavement Structure). Minimum thickness shall be as shown on City of Houston Standard Detail 02741-01.

10.2.01.B Base Course Minimum Thickness - Pavement design shall be prepared by a Professional Engineer based on current AASHTO design methodology (Guide for the Design of Pavement Structure). Minimum thickness shall be as shown on City of Houston Standard Detail 02741-01.

10.2.01.C Subgrade Treatment

1. Type, depth, and percentage of subgrade stabilization, stabilization design, and type of stabilization shall be determined by a geotechnical engineer.

2. For subgrade conditions of cohesive soils, subgrade treatment or stabilization shall be no less than eight inches.

10.2.02 CONCRETE PAVEMENT DESIGN REQUIREMENTS

The following requirements are applicable to pavement within City street rights-of-way.

10.2.02.A Minimum Pavement Thickness, Reinforcing, and Subgrade Stabilization Requirements:

1. Pavement thickness and reinforcement shall be designed by a Professional Engineer based on a current soil analysis, roadway use, traffic loadings, and minimum 50-year life span of proposed pavement. Pavement design shall be prepared by a Professional Engineer based on current AASHTO design methodology (Guide for the Design of Pavement Structure). However, in no event shall the pavement thickness be less than the minimums stated below.

2. For Residential Roadway Concrete Pavement:

   a. Minimum concrete slab thickness shall be six inches.

   b. Minimum concrete strength shall be f'c = 4,000 psi.

   c. Minimum reinforcing steel strength shall be fy = 60,000 psi.

   d. Refer to City of Houston Standard Detail 02751-01 for concrete reinforcement details.

10.2.02.A.2
continued

e. Minimum stabilized subgrade thickness shall be six inches for granular soils and eight inches for cohesive soils.

f. The type and depth of subgrade shall be as determined by a geotechnical engineer.

3. Collector Roadway with Concrete Pavement

a. Minimum concrete slab thickness shall be nine inches.

b. Minimum concrete strength shall be f'c = 4,000 psi.

c. Minimum reinforcing steel strength shall be fy = 60,000 psi.

d. Refer to City of Houston Standard Detail 02751-01 for concrete reinforcement details.

e. Minimum stabilized subgrade thickness shall be six inches for granular soils and eight inches for cohesive soils.

f. The type and depth of subgrade shall be as determined by a geotechnical engineer.

4. For Major Thoroughfares Constructed with Concrete Pavement

a. Minimum concrete slab thickness shall be 11-inches.

b. Minimum concrete strength shall be f'c = 4,000 psi.

c. Minimum reinforcing steel strength shall be fy = 60,000 psi.

d. Refer to City of Houston Standard Detail 02751-01 for concrete reinforcement details.

e. Minimum stabilized subgrade thickness shall be eight inches.

f. The type and depth of subgrade shall be as determined by a geotechnical engineer.

5. Paving headers shall be placed at the end of all concrete pavements.

10.2.02.B Curb Requirements

1. Six inch Vertical Curb:

a. Six inch vertical curb is the standard curb design and shall be in accordance with City Standard Details.

10.2.02.B.1
continued

b. Collector streets and higher volume residential streets where traffic calming measures are in place require construction of six inch vertical curb.

2. Laydown Curb

a. Is only allowed as an option for street projects on single family residential streets within the City.

b. Laydown curb shall be in accordance with City Standard Details.

c. Shall be four inches in height.

d. Laydown curb shall not be permitted if sidewalk is to be constructed immediately adjacent to the curb.

e. Laydown curb construction shall provide for necessary transition lengths at curb inlets to go from laydown curb to standard vertical curb section.

f. Transition from standard six inch to four inch vertical curb shall be extended a minimum of 10feet beyond curb inlets before beginning transitions.

SECTION 3 - GEOMETRIC DESIGN REQUIREMENTS

10.3.01 OVERARCHING CONSIDERATIONS

10.3.01.A Roadway Classifications

1. Major Thoroughfare
2. Collector
3. Transit Corridor
4. Local Street Classifications (not applicable in the ETJ)
    a. Residential Standard Density - Provides access to individual lots equal to or greater than 40-feet in width.
    b. Residential High Density - Provides access to individual lots less than 40-feet in width.
    c. Residential Main - Serves multiple streets and can be described as the "neighborhood feeder / collector."
    d. A summary of the design characteristics for the three local street classifications above is included in Table 10.1. Traffic volumes shown in column "Traffic ADT" are provided as general guidelines. These guidelines are provided to assist in the selection of context-sensitive street cross sections.

Table 10.1 - LOCAL STREET CLASSIFICATION FOR CURB AND GUTTERED STREETS

STREET CLASSIFICATION	GROSS DENSITY DU/AC (4)	TRAFFIC ADT (1)	MIN. PAVEMENT WIDTH (FEET)
Residential Standard Density (2)	0-6	250 - 350	26
Residential High Density (3)	6-27	350 - 1,500	32
Residential Main	0-27	≥ 1,500	36

Notes:
1. ADT - average dailytraffic.
2. Lot widths equal to or greater than 40-feet.
3. Lot widths less than 40-feet.
4. DU/AC - dwelling units (DU) per acre.

10.3.01.B Design Considerations

Critical design criteria shall be determined from performing a Traffic and Design Study (See 15.2.02).

1. Context factors that may influence roadway design include, but are not limited to:

   a. Number of dwelling units per acre (density).

   b. Location of services within or near the neighborhood.

   c. Pedestrian and bicycle facilities within the neighborhood.

   d. Connectivity to the collector and thoroughfare network.

   e. Connectivity to pedestrian, bicycle, and transit networks.

   f. Traffic volume guidelines (ADT) are based on full development density.

   g. Level of Comfort for bicyclists and pedestrians, as defined in Chapter 17.

   h. Transit stations and bus stops, destinations, ridership and appropriate facility design for high comfort boarding and alighting, transitions and access to platforms.

2. Design Speed

   a. For purposes of design, design and target speed shall be synonymous.

   b. The design speed shall be set by City Ordinances regulating speed limits.

   c. The minimum design speed for a roadway shall be 30-mph.

3. Vehicles

   The geometric design of a roadway is dependent on the physical characteristics of the various anticipated vehicles using that roadway. To ensure economy and safety, two sub-classifications of vehicles are established.

   a. Design Vehicle

      (1) A vehicle that must be regularly accommodated and is expected to traverse an intersection under normal conditions without encroachment into opposing traffic lanes.

10.3.01.B.3 continued

b. Control Vehicle

(1) A vehicle that infrequently must be accommodated, and is expected to traverse an intersection, but encroachment into opposing traffic lanes, multiple-point turns, or minor encroachment into the street side is acceptable.

c. The vehicles selected for the design of roadway intersections are provided in Table 10.2.

Table 10.2 - VEHICLE REQUIREMENTS

STREET TYPE	DESIGN VEHICLE	CONTROL VEHICLE
Local	P	DL23[1]
Collector	DL23	BUS40
Major Thoroughfare	BUS40	WB40
Major Thoroughfare (Truck) [2]	WB40	WB62

Notes:
1. Local streets along designated transit routes shall use a minimum control vehicle of BUS40 in street design elements that impact the transit route.
2. Major Thoroughfares that have daily truck volumes exceeding 5% of ADT. Truck design/control vehicles shall only apply at intersections where both street truck volumes exceed 5% of ADT.

4. Objects in Right-of-Way

a. Utilities (especially those above ground), trees, and other fixed objects shall not be placed within the sidewalk or otherwise interfere with pedestrian movements or access to transit stops. Sidewalks may be gently shifted to avoid existing fixed objects that cannot be moved or to enable the installation of new fixed objects when the shifting of said object is restricted; however, the designs of the sidewalk and the overall pedestrian realm must still satisfy all design requirements.

b. Utility pole locations within right-of-way: See Chapter 6.

10.3.02 INTERSECTION DESIGN

10.3.02.A Curb Radii

1. Cul-de-Sac Curb Radii

a. For approved cul-de-sac curb radii, refer to Figure 10.10.

b. Curb radii around cul-de-sacs shall be 48-feet for single family areas.

c. Curb radii around cul-de-sacs shall be 50-feet for cul-de-sacs in areas other than single family areas.

2. Street Intersection Curb Radii

10.3.02.A.2
continued

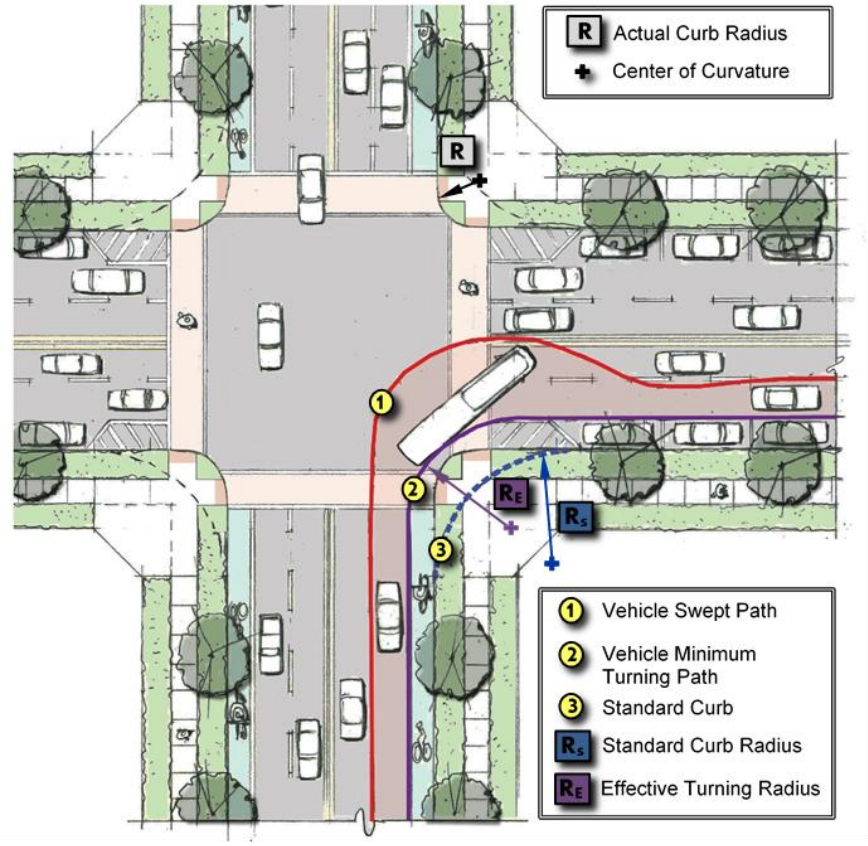


Figure 10.1 - CURB RADII

Smaller curb radii shorten the distance that pedestrians must cross at intersections. The occasional turn made by large trucks can be accommodated with slower speeds and some encroachment into the opposing traffic lanes. The existence of parking and bicycle lanes creates an "effective" turning radius that is greater than the curb-return radius Source: 10.1.03.E. NOTE: BUS40 used as control vehicle for this drawing.

10.3.02.A.2 continued

a. The curb radius is the radius of curvature, measured from the center of curvature, of a physical curb-return at the corner of a street intersection. The selection of appropriate curb radii shall consider the needs of all roadway and pedestrian traffic.

b. For standard curb radii, refer to Table 10.3.

Table 10.3 - INTERSECTION STANDARD CURB RADII

INTERSECTION TYPE	STANDARD CURB RADIUS (R_S) BY INTERSECTION ANGLE	
	90˚	80˚ - 90 ˚
Local / Local	15 ft	15 ft
Local / Collector	20 ft	20 ft
Local / Major Thoroughfare	20 ft	20 ft
Collector / Collector	25 ft	25 ft
Collector / Major Thoroughfare	25 ft	25 ft
Major Thoroughfare / Major Thoroughfare	30 ft	35 ft
Truck / Truck	45 ft	50 ft

Notes:

1. Curb radii have been selected based on the swept paths of design and control vehicles.
2. Truck/Truck radii should only be considered at intersections of streets that each have daily truck volumes exceeding 5% of ADT.
3. Other intersections experiencing heavy truck volumes shall utilize appropriate design vehicles and turning templates for curb radius design.
4. Intersections along designated transit routes shall use a minimum control vehicle of BUS40 for corners along the path of the transit route.
5. Intersecting angles smaller than 80-degrees shall require detailed engineering analysis and approval by HPW.

c. The design of curb radii is a critical component of intersection design. A curb radius that is too small for the design vehicle can be damaged and become a long-term maintenance liability. A curb radius that is too large encourages dangerous speeds, reduces pedestrian refuge areas, and increases pedestrian crossing distances as shown in Figure 10.1. In general, the smallest feasible curb radius should be chosen.

d. Curb radii may vary from Table 10.3 with adequate engineering justification, to be approved by Transportation & Drainage Operations (TDO). Justification shall include consideration of traffic counts or projection, pedestrian activity, vehicle classifications, turning template analysis, and any other documentation requested. Refer to “ITE. Designing Walkable Urban Thoroughfares: A Context Sensitive Approach” (10.1.03.E) for additional guidance on the use of smaller curb radii to encourage safe roadway operations and a pedestrian-friendly environment.

10.3.02.A.2 continued

e. Street intersection curb radii shall be designed to facilitate turning and tracking requirements of the selected design vehicle anticipated to use the facility (i.e. P, DL-23, WB-40, etc.) (10.1.03.T) The curb radii design should allow for frequently turning vehicles to remain in their lane. Larger control vehicles that make the turn less frequently may have the option of encroaching into the adjacent lane to complete their turn (10.1.03.P). A one-foot buffer distance between the face of curb and the swept path of the vehicle should be retained for all turning vehicles. The selected radius of curvature for curb radii is to be rounded up to the nearest five feet.

f. The effective turning radius (R_E), as shown in Figure 10.1 is the radius of curvature of the minimum turning path of a turning vehicle when additional curb offset is provided by a parking lane, bicycle lane, or shoulder. The use of an effective radius is encouraged whenever appropriate. Use of an effective radius will not require a variance, but it will require an engineering analysis to justify adequacy.

10.3.02.B Right-of-Way Corner Cut-Backs

1. For approved right-of-way (ROW) corner cut-back dimensions, refer to Figure 10.2 and Table 10.4.

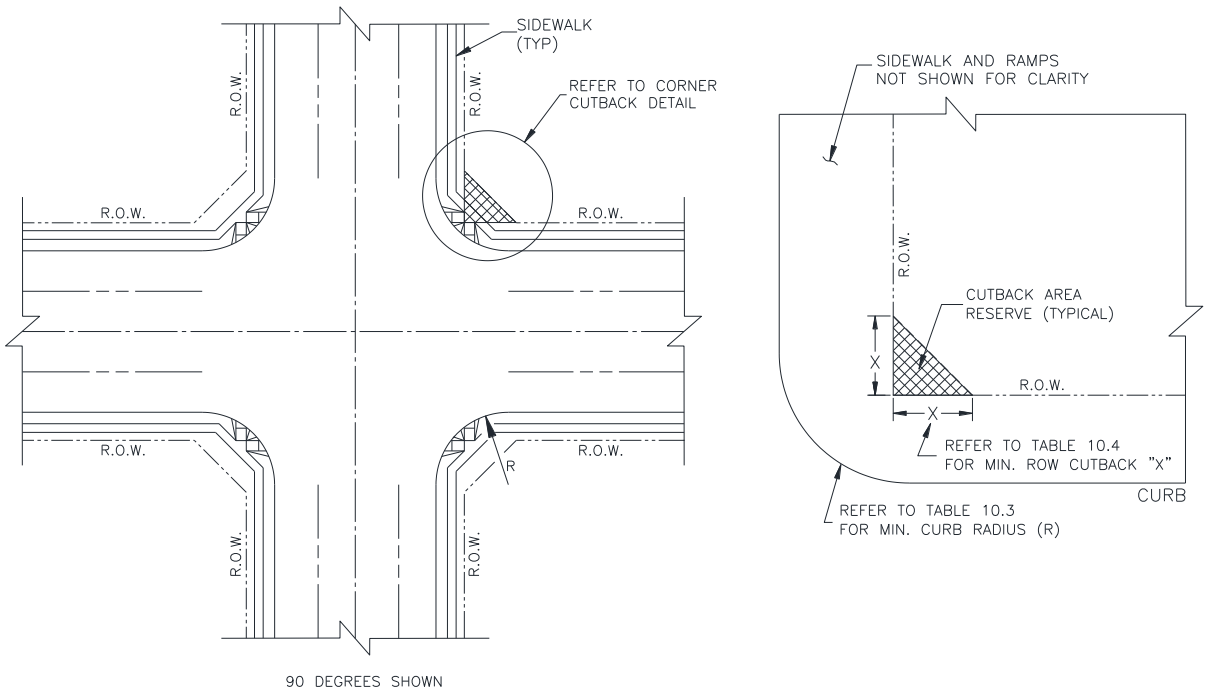


Figure 10.2 - ROW CORNER CUTBACK

10.3.02.B continued

Table 10.4 - ROW CUTBACK REQUIREMENTS

CURB RADIUS (R) (feet)	MINIMUM R.O.W. CUTBACK "X" (feet)
25 or Less	15 x 15
30	20 x 20
35	25 x 25
40	30 x 30
45 or More	35 x 35

2. Right-of-way shall be dedicated for corner cut-backs on major thoroughfares, transit corridor streets, collectors and local streets as a requirement for subdivision platting of adjacent properties under Chapter 42 of the City of Houston Code of Ordinances.
3. Corner cut-backs of right-of-way at street intersections are necessary to provide sufficient public space for intersection visibility, pedestrian sidewalk facilities and ramps, traffic control devices, street signs, street lighting, traffic signal equipment, and all encroachments which could prevent the future installation of such equipment within the cut-back area.
4. When right-of-way corner cut-backs are not feasible, visibility easements will be required. Visibility easements shall conform with Section 10.3.02.C Intersection Sight Distance.
5. In cases where the public ROW behind the curb is sufficient, corner cut-backs may not be needed to provide the required levels of visibility. The Engineer of Record (EOR) shall provide a sight triangle analysis to justify the lack of any corner cut-backs.
6. For intersections with Type 1 Permanent Access Easements, visibility easements shall be provided.

10.3.02.C Intersection Sight Distance

1. Dedicated right-of-way or easements are required to meet the intersection sight distance triangle requirements.
2. Design Basis
   a. Design Vehicle - Passenger Car
   b. Design Standard – AASHTO “A Policy on Geometric Design of Highway and Streets”.
   c. Lane Widths - See 10.3.03.C for requirements.

10.3.02.C.2 continued

d. Vertical obstructions and elevations must be considered for all users of the corridor including pedestrians and bicyclists.

e. Sight Distance - Is measured to the center of the outside lane on main roadway approaching from the left and to the center of the inside lane of traffic on the main roadway approaching from the right.

f. The intersection of local streets serving residential properties only, meeting at an angle of 85 degrees or more. Within 250-feet of the intersection, each of the uncontrolled approaches to the intersection of two local residential streets will have:

(1) land uses adjacent to the street that are exclusively single-family residential lots (or unoccupied reserves of limited size, such as landscape reserves, drainage reserves or utility reserves).

(2) Residential lots with driveway access to the uncontrolled approach street.

(3) A posted (or prima facie) speed limit of 30 mph or less.

3. Design Procedures

a. Determine design speed of main roadway based on Section 10.3.01.B.2 of this chapter.

b. Develop a scaled drawing depicting the sight triangle based on the design criteria. For the appropriate design speed, determine the minimum sight distance from Table 1 on Figure 10.6.

4. Exceptions

a. Replats and partial replats at the intersections of a local/local street, local/major collector street, and major collector/major collector street are exempt from providing intersection sight distance rights-of-way or easements where existing site conditions for abutting properties preclude compliance.

b. Variances or deviations to these guidelines will be considered on a site-by-site basis. An engineering analysis should be prepared to support the proposed sight triangle dimensions, based on criteria in the AASHTO "Green Book", latest edition (10.1.03.F). Where the uncontrolled street is existing, design speeds should be based on an analysis of the 85th percentile operating speed.

10.3.02.D Left Turn Lanes

1. Left Turn Lanes are Required:

10.3.02.D.1 continued

a. At all signalized intersection approaches.

b. At all median openings.

c. Overlaps between opposing and adjacent left turn tracking paths should be checked and shown in the intersection review design submittal.

2. Left Turn Lane Design Standards:

a. Refer to Figure 10.8 for left turn bay geometrics.

b. The volume of left turn movements shall be based on traffic studies approved by the City Engineer.

c. At median openings; openings may be directional but whenever possible, left turn lanes should be provided for both directions.

3. Dual Left Turn Lanes

a. Dual left turn lanes present challenges to people walking across the intersection. Other options for traffic mitigation should be assessed first.

b. Where other options are not feasible, dual left turn bays may be considered when left turn movement exceeds 300 vehicles for the peak hour, or when traffic analysis of the intersection indicates existing or projected left turn storage space requires dual left turn lanes before the volume threshold is reached.

c. Where dual left turn lanes are required, right of way for the intersection shall be based on the width required for dual left turns, through lanes, a right turn lane, and minimum landscape/pedestrian zone (dimension S) as shown in Figure 10.4.

4. Special conditions or other constraints may require design criteria other than shown herein.

a. Exceptions to the requirements must be demonstrated by submittal of a traffic study encompassing AASHTO criteria.

b. Approval by City Engineer is required for all variances to standard.

10.3.02.E Roadway Offset Through Intersection

1. An intersection shall not be designed such that any through lane is offset more than three feet from the corresponding receiving lane.

2. The addition of auxiliary left- and right- turn lanes shall conform with this requirement.

10.3.02.F Roundabout Intersections

1. Roundabout Planning

   a. Roundabouts shall be considered for all new or reconstructed intersections, especially signalized intersections and all-way stop intersections.

   b. Lane configuration for all approaches shall be based on an approved capacity analysis. The number of lanes may vary by approach.

   c. The analysis shall include considerations for existing traffic and for a 20-year horizon. Lane configurations should result in an overall LOS D or better for existing conditions.

   d. If the 20-year horizon requires a different lane configuration to maintain LOS D or better, the design should include phasing considerations for future modifications to implement those changes when warranted. Constructing a roundabout with more capacity than is currently needed can decrease the safety of the intersection and is discouraged.

   e. The design vehicles shall be consistent with the design vehicle on the approach roadways.

   f. For additional design guidance, refer to reference 10.1.03.V.

2. Roundabout Design

Table 10.5 - ROUNDABOUT DESIGN PARAMETERS

PARAMETERS	SINGLE LANE	MULTI LANE
Typical Capacity (all approaches)	< 20,000	< 40,000
Maximum Number of Entering Lanes	1	2
Maximum Entry Speed	20 mph	25 mph
Typical Inscribed Circle Diameter (feet)	90 to 150	150 to 180
Typical Entry Width (feet)	16 to 20	28 to 32
Typical Entry Radius (feet)	50 to 90	60 to 120
Typical Exit Radius (feet)	50 to 800	200 to 1000
Typical Circulatory Roadway Width (feet)	16 to 20	28 to 32
Minimum Splitter Island Length (feet)	50	50

   a. Design drawings for roundabouts shall include roundabout-specific signage and pavement marking sheets that include the roundabout central island centered on one sheet.

10.3.02.F.2
continued

b. Roundabout geometry shall be based on an analysis of fastest path for all through movements, left-turn movements, and right-turn movements. Fastest path speeds shall be analyzed and approved during preliminary design.

c. No roundabout will be approved for more than two entry lanes (not including right-turn lanes).

d. Physical splitter islands shall be utilized for all approaches.

e. Multilane roundabout shall be designed to minimize path overlap of adjacent entering vehicles.

f. No direct driveway access should be allowed to the roundabout.

g. Appropriate street lighting shall be provided to illuminate all conflict areas, especially entry conflicts and pedestrian conflicts.

h. The central island shall include a concrete curb and, where necessary, a truck apron. The central island shall include a minimum three feet sod mow strip.

i. Conduit for electrical wiring shall be installed to the central island even if no illumination or electrical features are currently planned.

j. All landscaping shall be designed to minimize roadside hazards and maintain required stopping and intersection sight distance throughout the roundabout.

k. The conflicting leg sight triangle decision point is located 50-feet from the yield line. Safe stopping sight distances for the approach shall be evaluated from both the yield line and marked crosswalk.

3. Pedestrian/Bicycle Considerations

a. The crossing of pedestrians/bicycles and location of bus stops at roundabouts shall be carefully considered.

b. Splitter islands shall include a pedestrian cut through with a minimum width of 10-feet and minimum length (between roadways) of six feet. The cut through shall be fully ADA compliant.

c. Raised crosswalks may be used to further improve pedestrian safety and ensure roundabout-compatible vehicular speeds.

d. Roundabout design shall not permit pedestrians to access the central island.

10.3.02.F.3 continued

e. Existing and proposed bicycle facilities shall be fully incorporated into the roundabout design. Bicycles should be brought up to the pedestrian grade, preferably in a dedicated space that is not shared with pedestrians.

f. Sidewalks shall be installed around the roundabout to maximize the buffer between the sidewalk and the edge of pavement, especially at the corners, where run-off-the-road crashes are most likely.

g. Design standards for Roundabouts are shown in Table 10.5.

10.3.03 CORRIDOR DESIGN

Table 10.6 - ROADWAY GEOMETRIC DESIGN CRITERIA

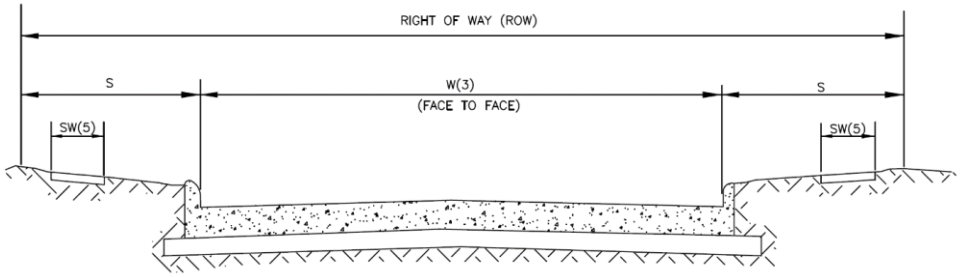
ITEM	DESIRABLE	MINIMUM
Width of Travel Lanes (feet)	10-11[4]	10[4]
Width of Turn Lanes (feet)	10-11[4]	10[4]
Horizontal Curve Radii (feet)	Varies	500
Median Width at turn lanes (feet)	17[1]	15
Median Width face of the curb to the face of curb outside the turn lanes (feet)	6-10[5]	4
Center Turn Lane Width (feet)	10	10
Non-Dedicated Bike Lane (feet)	See Chapter 17 for information	
Standard Bike Lane Width (feet)		
Pedestrian Realm Width (feet)		
Total Buffer to Sidewalk with Tree Well (feet)		
Total Buffer to Sidewalk w/o Tree Well (feet)		
Sidewalk Width (feet)		
Transit Sidewalk Width By Transit Corridor Ordinance (feet)		
Sidewalk adjacent to curb (feet)		
Shared use path/trail (feet)		
Shared use path/trail easement (feet)		

Notes:

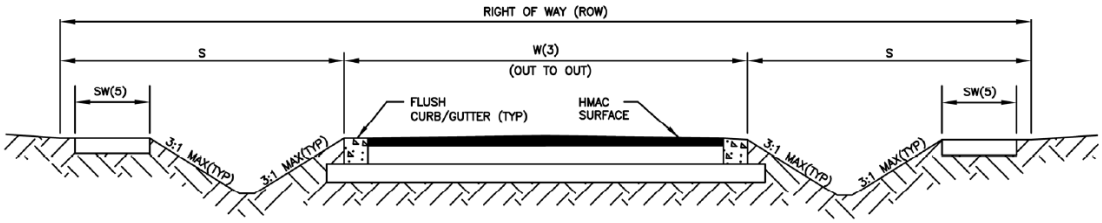
1. Median widths that exceed 17-feet require approval of Transportation and Drainage Operations (TDO). Engineer of Record shall notify TDO of any median widths that exceed 17-feet prior to preliminary design.
2. Curve design radii shall be based on the design speed of the roadway and any super- elevation that may be considered for the design. Where bicycle facility is present, curve radii should provide for highest visibility of a person on a bike by motor vehicle users.
3. For sidewalk design guidance, refer to Chapter 17, Section 3: Pedestrian Elements Requirements.
4. See paragraph 10.3.03.C for lane width requirements.
5. See Chapter 17 for more information.

10.3.03.A Roadway Cross Sections

1. The City of Houston utilizes the basic roadway cross sections shown in Figure 10.3, Figure 10.4, and Standard detail 02751-01. With the growing emphasis on Context Sensitive Design, roadway cross section variations are encouraged and will be considered by the Office of the City Engineer.



(a) - Raised Curb and Gutter



(b) - Flush Curb/Gutter with Ditch

Figure 10.3 - UNDIVIDED STREET TYPICAL CROSS SECTION

Table 10.7 - UNDIVIDED STREET DIMENSIONS

	LOCAL STREET SINGLE FAMILY RESIDENTIAL (SFR)					THOROUGHFARE/ COLLECTOR STREET		
	STANDARD DENSITY LOT		HIGH DENSITY LOT		RESIDENTIAL MAIN			
ADT	250 - 350		350 - 1,500		≥1,500	≥5,000		
ROW	50	60	55	60	60	60	70	80
W[3]	26	26	32	36	36	-[1]		
S	12	17	11.5	12	12	≥10	≥13	≥18
# OF LANES	-	-	-	-	-	2-4[2]		

Notes:
1. Roadway width for thoroughfare and collector streets is based on the overall lane configuration and approved lane widths.
2. Number of lanes to be determined through Traffic and Design Studies (See 15.2.02). Any design or redesign of a major thoroughfare, collector, or any other classified street shall require a Traffic and Design Study (see 15.2.02) or other approved traffic study to be reviewed and approved by TDO prior to design begins.
3. Width (W) does not include width for bicycle lanes. Refer to Appendix 2 for minimum requirements. Requires approval of the City Engineer. Width includes on street parallel parking where approved by City Engineer.
4. Requests for alternative street cross section shall be submitted to City Engineer for review.
5. For sidewalk design guidance, refer to Chapter 17, Section 3: Pedestrian Elements Requirements.

10.3.03.A.1
continued

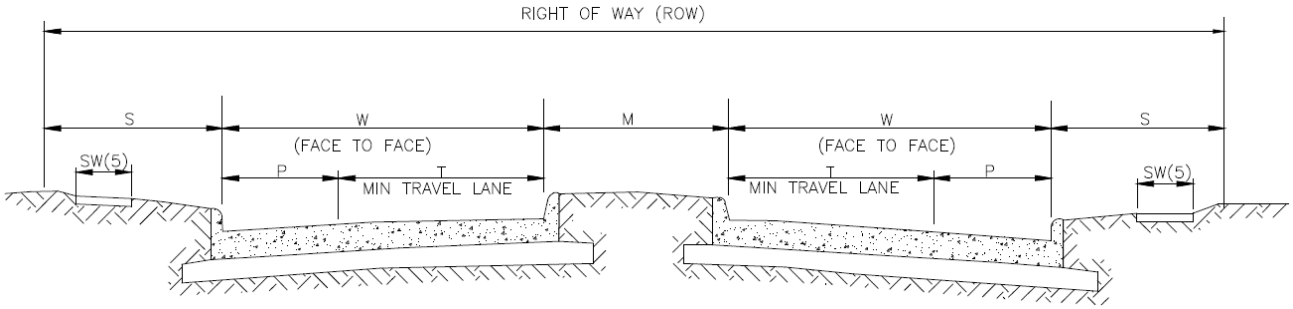


Figure 10.4 - DIVIDED STREET TYPICAL CROSS SECTION

Table 10.8 - DIVIDED STREET DIMENSIONS (FEET)

LOCAL STREET SINGLE FAMILY RESIDENTIAL (SFR)			THOROUGHFARE/COLLECTOR STREET		
	RESIDENTIAL MAIN				
	STD SW	CENTER SW			
ADT	≥1,500	≥1,500	5,000+		
ROW	70	80	80	90	100
W	20	20	-[1]		
M	8	16	17	17	17
S	11	12	≥10	≥12	≥15
T	11	11	-[1]		
P	9	9	-[2]		
# OF LANES	-	-	4	4	4

Notes:

1. Any design or redesign of a major thoroughfare, collector, or any other classified street shall require a Traffic and Design Study (see 15.2.02) or other approved traffic study to be reviewed and approved by TDO prior to design begins. This study shall determine the roadway width and travel way for the road.
2. Parking is generally not permitted along thoroughfares.
3. Any right-of-way dimensions different from those shown shall require special geometric design as determined by City Engineer.
4. Refer to Appendix 2 for optional designs to serve special mobility needs, pedestrian needs, bicycle lanes, or other requirements. Approval by City Engineer required.
5. For sidewalk design guidance, refer to Chapter 17, Section 3: Pedestrian Elements Requirements.

10.3.03.B Walking, Bicycling, and Transit Considerations

1. Transit Shelters

   a. Engineers shall coordinate with METRO or other Transit groups in regard to placement and design of Bus or other Transit Shelters when designing or rebuilding roadways for the placement of pads and other appurtenances. No bus stops, pads or shelters shall be removed from the ROW without METRO's approval. See this chapter for more information regarding transit and see Chapter 17 for more information regarding pedestrian and bicycle facilities.

2. Pedestrian Realm (Sidewalks, Accessibility Ramps, and Bus Pads)

   a. See Chapter 17 for pedestrian realm design requirements.

   b. Approved sidewalk/ramp details are shown in the City's Standard Details. Use of these details are specific to certain field conditions such as ramp direction, driveway crossings, crosswalk locations and the location of the sidewalk with respect to the curb.

   c. When right-of-way contains a Bus Stop, the engineer will contact METRO at busstops@ridemetro.org to determine the appropriate bus stop type.

      (1) Each bus stop area will be composed of three elements per Figure 10.14:

         i. Bus Pad (one): 17-feet (typical) by eight feet (minimum) (all slopes maximum 2%)
         ii. Bus Landing Area (two): Five feet by eight feet (minimum) (front door landing), and seven feet (recommended) by eight feet (minimum) (back door landing) (all slopes maximum 2%)
         iii. Transitions (two): Five feet (minimum) by eight feet aligning with the landing and tapering to the sidewalk width (maximum longitudinal slope of 5%)

      (2) As additional right-of-way is available beyond the minimum nine feet S-dimension:

         i. Pad will shift back, maintaining a one-foot distance to the edge of right-of-way.
         ii. Landings may extend in width from the curb to one foot from the right-of- way. The width will be extended in order to always maintain an ADA and TAS accessible route between the pad and landing.
         iii. Engineer will use their judgement to specify the proposed surface of the remaining portion between the pad and curb (ex. paving, grass, etc.).

10.3.03.B.2.c continued

(3) Context factors that may influence the design of Standard Bus Pad and Landings.

i. Distance from the curb to the right-of-way (or bus pad easement) is less than nine feet.

ii. Location of bus pad longitudinally along the roadway will need to account for the Critical Shelter Obstruction (as identified in City of Houston Figure 10.14) when verifying safe Intersection Sight Distances (as prescribed by per City of Houston Figure 10.6). If the stop location needs to change due to sight distance requirements, the engineer will contact METRO at busstops@ridemetro.org for coordination and approval.

(4) Where use of standard bus pad and landings details is not possible due to field conditions (ex. driveways, trees, etc.), engineer shall contact METRO at busstops@ridemetro.org for proposed variations and approval.

10.3.03.C Lane Widths

Local street travel way width is dictated by the required cross section width provided in tables 10.7 & 10.8. Lane width standards apply to lanes on major thoroughfares and collectors that are designated by pavement markings, are intended primarily for through movements, and can only accommodate one use at a time (e.g. movement or parking). For more information, refer to paragraph 10.3.03.A Roadway Cross Sections.

1. Inside Interstate 610

a. The standard lane width on a City street is 10-feet.

b. On thoroughfares with heavy truck traffic documented (daily truck volumes exceeding 5% of ADT), the use of an 11-foot outside lane may be used based on engineering judgement.

c. On thoroughfares with transit agency designated bus routes, the outside lane may be 11-feet.

2. Outside Interstate 610

a. The minimum lane width on a City street is 10-feet. The maximum lane width is 11-feet.

b. The lane width shall be determined based on engineering judgment. The engineer of record shall make a recommendation for the lane width by considering the following:

(1) Truck traffic

10.3.03.C.2.b continued

(2) Transit agency designated bus routes

(3) Pedestrian/bicycle activity

(4) Design Speed

(5) Roadway capacity

c. On thoroughfares with heavy truck traffic documented (daily truck volumes exceeding 5% of ADT), the use of an 11-foot outside lane may be used based on engineering judgement.

d. On thoroughfares with transit agency designated bus routes, the outside lane width may be 11-feet.

3. Lane widths other than what is specified above, shall require a variance signed by both the City Engineer and the City Traffic Engineer, unless otherwise specified within this chapter.

10.3.03.D Curve Radii

1. (1) Curve radii design shall be based on the design speed of the roadway and any super-elevation that may be considered for the design.

(2) Minimum curve radii for collectors/major thoroughfares is 500-feet.

(3) Minimum curve radii for local streets and minor collectors is 300-feet.

2. Reverse curves for roadways should have a minimum 100-feet tangent between curves excluding turn lane transitions.

3. Maximum super elevation rate will be 4%.

4. Reverse super elevations shall not be allowed on any city roadways.

10.3.03.E Median Design

Median design should accommodate bicycle and pedestrian movements across a street where the need has been established. Midblock crossing standards for bicycle and pedestrian access are defined in Chapter 17.

1. Minimum Median Width

a. For local streets, refer to Figure 10.4.

b. Paved medians shall be at least four feet (face to face) in width.

c. The desired width of reverse median is six feet (face to face).

10.3.03.E
continued

2. Minimum Median Length

   a. Median lengths are based on functional street classification of the main roadway and intersecting street. Median Openings should only be installed where the need for an opening exists. Before a median opening is closed, the need to continue pedestrian and bicycle movements across the corridor shall be evaluated per Chapter 17 guidance.

   b. Refer to Figure 10.7 for minimum median length requirements.

3. Median Geometry - Refer to Figure 10.8.

4. Street Taper Geometry - Refer to Figure 10.9 for subdivision street taper geometrics.

10.3.03.F Vertical Geometric Requirements

1. For Pavement Sections:

   a. Minimum grade line shall be 0.30 percent.

   b. Minimum grade line shall be 1.00 percent for radii of 35-feet or less around intersection turnouts. Grades for larger radii shall be determined on an individual basis.

   c. Superelevation - Major thoroughfares shall be super elevated in accordance with AASHTO requirements.

   d. Vertical Curves

      (1) Shall be installed when the algebraic difference in grades exceeds 1.00 percent.

      (2) Elevations shall be shown at 10-foot intervals through vertical curves.

      (3) Maintain a minimum of 0.03 foot elevation change at 10-foot intervals by altering calculated elevations.

      (4) Determine minimum vertical curve lengths based on AASHTO design criteria (minimum shall not be less than 3 times design speed).

   e. Minimum grade line around a cul-de-sac shall be 0.70 percent.

   f. Pavement Cross Slopes:

      (1) Cross slopes for pavement shall be a minimum of 1/4-inch per foot.

10.3.03.F.1.f continued

(2) Cross slopes for left-turn lanes and esplanade openings shall be 1/8-inch per foot minimum.

2. Railroad Crossings

a. Maximum Tangent Grade to Vertical Curves at Railroad Crossings:

(1) 8.0 percent for local streets

(2) 3.5 percent for major thoroughfares

b. Roadway grades at railroad crossings shall be zero percent from centerline of the track to 10-feet either side of the track's centerline, and should not cause a drop of more than six inches from the top-of-rail elevation at a distance of 30-feet either side of the track's centerline.

c. For concrete roadways, the roadway shall terminate at a railroad header, six feet from the centerline of the track and the roadway cross slope shall be zero from the railroad header to four feet before the railroad header.

d. Railroad crossings are shown in Figure 10.13.

e. All roadway crossings of a railroad shall include a minimum six feet pedestrian walkway. See Figure 10.13.

f. At railroad track approaches, decrease curbs from 6-inches to zero inches in two feet, at a distance of ten feet from the nearest track centerline.

g. All roadway crossings of a railroad that involve bicycle facilities shall include appropriate crossing angles and signage for bicyclists as defined in Chapter 17.

10.3.03.G Alleys

1. General

a. Existing Alleys:

(1) City Maintained Alley means a right-of-way dedicated to the public for an alley prior to January 1, 2023, that is open and available for vehicular use and travel by the general public and has been formally accepted for maintenance by the City of Houston (City). An inventory of these alleys is maintained by the Office of the City Engineer (OCE) of Houston Public Works and can be found on the City’s website.

10.3.03.G.1.a continued

(2) Privately Maintained Alley shall mean a right-of-way dedicated to the public for an alley prior to January 1, 2023 and utilized for right of ingress and egress for property adjacent to and authorized for private access by reference to map or plat showing alleys abutting such real property, and that have not been accepted for maintenance by the City.

b. New Alley means a right-of-way dedicated to the public for an alley on January 1, 2023, or after.

c. Applicant shall mean a person who owns real property abutting an alley and seeks to improve such alley for motorized vehicular traffic use either by the public or pursuant to private rights of access.

d. Application shall be the drawings for the proposed improvements from the Applicant's property to the public street submitted with the Applicants construction drawings for the improvement to personal property. No separate application is required.

e. Alleys platted, dedicated and/or constructed prior to September 20, 1982, are governed by the City of Houston's Code of Ordinances Chapter 40 Article XV "Alleys".

2. Access

a. Existing City Maintained Alley

(1) Alley is on the most current list of approved alleys found at https://www.houstonpermittingcenter.org/office-city-engineer/engineering-services-right-way.

(2) Applicant is responsible for providing evidence to prove that the existing alley meets the criteria stated in the Private Rights of Access section of this chapter.

(3) Alley access can be approved for residential properties.

(4) Alley access can be approved for commercial properties subject to City Engineer review and approval, and compliance with IDM Chapter 15 requirements.

b. Existing Privately Maintained Alley

(1) Privately Maintained Alleys are not for commercial use.

(2) Applicant has the right to access Privately Maintained Alley. The City is not responsible for maintaining these alleys.

10.3.03.G.2 continued

c. New Alley

(1) Alley access can be approved for residential and commercial properties.

3. Design Criteria

a. Existing City Maintained Alley

(1) Improvements to alley shall meet City of Houston roadway standards.

(2) Alley drainage must comply with Chapter 9 of the Infrastructure Design Manual.

(3) Proposed alley pavement design must be signed and sealed by a licensed professional engineer in the State of Texas.

(4) A plan and profile signed and sealed by a professional engineer licensed in the State of Texas is required to demonstrate that there are no negative impacts to drainage and traffic flow.

b. Existing Privately Maintained Alley

(1) The City's residential driveway requirements shall apply to the portion of the alley along the Privately Maintained Alley from the right-of-way (ROW) line to the public street.

(2) The portion of the alley from the City's ROW line (of public street) to the Applicant's property being developed shall be designed and constructed in accordance with the City of Houston, Houston Public Works detail as shown on Figure 10.12.

(3) Sidewalks along alley access point must follow current sidewalk policy for single family homes.

(4) Applicant must prepare and construct the surface of the alley so as to prevent the drainage of storm, surface water, or runoff onto the adjacent property.

(5) Applicant must ensure drainage of stormwater and other runoff along the alley into the intersecting street or drainage facilities.

(6) Maintenance of the alley is the responsibility of the abutting property owner(s).

(7) The City does not patrol the alley or enforce parking regulations.

10.3.03.G.3.b continued

(8) Alley drainage shall comply with Chapter 9 of the Infrastructure Design Manual.

(9) Alley shall not connect to principal thoroughfare or thoroughfare.

(10) For alley improvements, provide Office of the City Engineer a submittal signed and sealed by a professional engineer licensed in the State of Texas showing plan view, surface elevations and proposed cross sections to ensure adequate drainage. Cross sections shall be provided at 20 feet intervals from the property to the nearest City storm facility and any other locations requested by the City Engineer. A profile is required if there are proposed utilities. A profile may be required for drainage design per Chapter 9 of the Infrastructure Design Manual.

c. New Alley

(1) New Alley shall meet City of Houston roadway standards.

(2) Alley drainage must comply with Chapter 9 of the Infrastructure Design Manual.

(3) Proposed alley pavement design must be signed and sealed by a licensed professional engineer in the State of Texas.

(4) A plan and profile signed and sealed by a professional engineer licensed in the State of Texas is required to demonstrate that there are no negative impacts to drainage and traffic flow.

10.3.03.H Street Terminations

1. Where cul-de-sac streets are approved, design geometrics shall comply with Figure 10.10. Bicycle and pedestrian access to nearby existing or proposed bicycle facility or trail shall be provided where feasible.

2. Where termination of a private street or Type 2 Permanent Access Easement is approved, design geometrics shall comply with Figure 10.10. Bicycle and pedestrian access to nearby existing or proposed bicycle facility or trail shall be provided where feasible.

3. Dead-End Streets - Standard City of Houston barricades shall be placed at the end of dead-end streets not terminating in cul-de-sacs. Refer to City of Houston Standard Detail No. 01555-14. Bicycle and pedestrian access to nearby existing or proposed bicycle facility or trail shall be provided where feasible.

10.3.03.H continued

4. Street terminations shall consider impacts to bicycle and pedestrian access. Where feasible, bicycle and pedestrian access across street terminations points should be considered, especially when connecting between neighborhoods; to destinations such as commercial districts, parks, and schools; or to existing or proposed bicycle facilities and trails.

5. Temporary Street Termination - Temporary termination of streets (for future extension into adjacent development) shall include construction of street barricades as shown in City of Houston Standard Detail No. 01555-14.

10.3.03.I On-Street Parking and Cutback Parking

1. General Requirements

   a. At the discretion of the City Traffic Engineer, parking may be allowed in a traffic lane if current traffic volume do not warrant the need for the additional lane. The City Traffic Engineer may allow this parking to occur all day or may restrict it to certain times of the day as needed for mobility purposes. All parking allowed to occur within a traffic lane shall be considered to be temporary and can be removed at any time.

   b. Designated on-street parking can be approved provided that sufficient right-of-way exists. When a designated parking lane is provided, it shall be at least nine feet in width. Where on-street ADA accessible parking is provided, the minimum required width is 13-feet.

   c. As required by the City of Houston Code of Ordinances, all on-street parking shall be parallel to the curb or edge of pavement unless approved by the City Traffic engineer. Lateral parking shall be treated on a case by case basis.

   d. As required by the City of Houston Code of Ordinances, all parking within the public right-of way behind the curb (curb cutback parking) requires the approval of the Director of Houston Public Works. Parking behind the curb shall be considered on a case by case basis.

   e. Figure 10.5 applies to all on-street parking and curb cutback parking.

10.3.03.I
continued

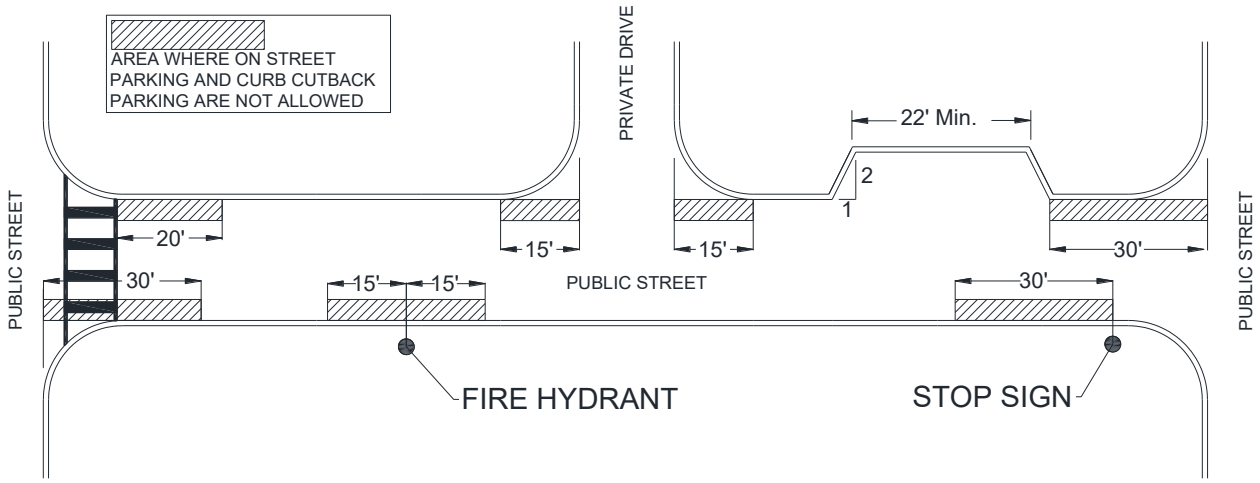


Figure 10.5 - ON-STREET PARKING

2. On-Street Parking for Existing Roadways

   a. Roadway width less than 20-feet

      (1) No parking allowed on the street.

   b. Roadway width equal to or greater than 20-feet but less than 26-feet

      (1) Parking will be allowed on one side, if parking restrictions do not exist.

      (2) If on street parking already exists on one side of the street, parking on the opposite side of the street will not be allowed.

   c. Roadways width equal to or greater than 26-feet

      (1) On-Street Parking will be allowed on both sides of the street, if parking restrictions do not exist.

3. On-Street Parking for Roadways that Require Widening

   a. Widening performed for parking must be per the requirements outlined in this manual.

   b. To allow for parking, the roadway must be widened along the entire property frontage.

   c. The roadway widening must also include transitions outside of the property frontage.

10.3.03.I.3 continued

d. The required transition must follow the requirements outlined in the Manual.

e. Transition requirements apply to both concrete and asphalt roadways.

f. For cases where the required transition starts less than 100-feet from the nearest intersection, the street must be widened along the entire property frontage and extend all the way through the nearest intersection.

4. Curb cutback parking

a. Curb cutback parking is defined as all parking within the public right-of-way:

(1) Behind the curb (Refer to 10.3.03.I.1.d) or

(2) Adjacent to the edge of the pavement for non-curbed streets.

b. Curb cutback parking will not be considered for roadway widths less than 20-feet.

c. Curb cutback parking must be nine feet wide by 22-feet long per parking space.

d. All curb cutback parking must have a curb with appropriate drainage.

(1) Curbed roadways – proposed curb must tie into the existing curb.

(2) Non-curbed roadways – proposed curb is only required along the edge parallel to the roadway.

e. All curb cutback parking shall be confined within the property frontage.

f. Cut back criteria

(1) Transitions into a cutback parking shall taper 2:1.

(2) Cut back area shall conform to all sight distance, distance to intersection and all other existing design criteria.

g. These criteria shall also apply for parking within the public right of way on streets without curb.

10.3.03.J Roadway Widening

10.3.03.J continued

1. For commercial developments, single family residential subdivision developments and multi-unit residential (MUR) subdivision developments, if the existing roadway is less than eighteen (18) feet in width, widen the roadway to at least twenty (20) feet in width to the nearest intersection along the fire access road. Roadway widening must also include transitions outside of the property frontage to comply with 10.3.03.I.3.

2. The requirements to widen a street paving does not apply to a residential development filed in a subdivision plat and recorded after January 1, 2023, if the residential development meets one or more of the following conditions:

   a. The residential development is part of a subdivision plat that is less than or equal to 15,000sf and not out of a tract larger than 15,000 square feet; or

   b. The residential development is less than 25% of the linear feet of the block face as defined in Chapter 42 of the Code of Ordinances (on any street side development is taking access from).

3. For roadways widened to less than twenty-six (26) feet in width, post "No Parking" signs as applicable in 10.3.03.I.2. Signs shall not be installed until after an evaluation by the City is conducted. Applicant must receive permission from the City prior to installation of any "No Parking" signs.

SECTION 4 – STREET CONNECTIONS AND TRANSITIONS

10.4.01 STREET CONNECTIONS

10.4.01.A Where a new street or driveway is proposed to connect to an existing signalized intersection, refer to Chapter 15 Traffic and Signal Design Requirements.

10.4.02 STREET TRANSITION REQUIREMENTS

10.4.02.A Concrete Streets

1. When transitioning from a proposed concrete street to an existing concrete street, the transition shall consist of concrete, and shall equal the existing concrete pavement thickness with a minimum thickness of eight inches.

2. Refer to City of Houston Standard Detail 02751-01.

10.4.02.B Streets Other Than Concrete Pavement

1. When transitioning from a proposed street to an existing street constructed of material other than concrete, the transition shall consist of asphaltic concrete paving.

2. Refer to City of Houston Standard Detail 02741-01.

10.4.02.C Pavement Transition Length

1. The standard transition length for all street types shall be calculated as follows:

$$L = \frac{WS^2}{60}$$

Where:

L = Transition length (feet)
S = Posted speed (mph)
W = width of offset (feet)
(Source: See 10.1.03.O)

2. Minimum transition length shall be:

   a. 50-feet for street widths less than or equal to 26-feet F-F (face to face of curb).

   b. 75-feet for street widths greater than 26-feet and less than 36-feet F-F (face to face of curb).

10.4.02.C.2 continued

c. 100-feet for street widths greater than 36-feet and less than or equal to 40-feet F-F (face to face of curb).

10.4.03 PROPOSED CURB AND GUTTER STREET CONNECTING TO AN EXISTING CURB AND GUTTER STREET

10.4.03.A When meeting an existing curb-and-gutter street, top-of-curb elevations shall be designed to meet an elevation six inches above the existing gutter.

10.4.03.B At existing inlets, top-of-curb elevations shall be designed to match existing top-of- curb elevations.

10.4.04 CONSTRUCTION REQUIREMENTS FOR CONNECTING A PROPOSED CONCRETE STREET WITH AN EXISTING CONCRETE STREET

10.4.04.A When meeting existing concrete streets at right angles, the existing street should be saw cut in a V-shape extending from the curb returns to a point where the centerline of the proposed pavement intersects the quarter point of the existing concrete street to create a crowned intersection. In the event this construction creates a situation in which traffic on the existing street, at design speed, will bottom out when crossing the proposed street intersection, a special design will be allowed to eliminate this potentially dangerous condition.

10.4.04.B Remove concrete either to an existing joint or a sawed joint. The groove of the sawed joint shall be cut to a minimum depth of two inches along the line designated by the Professional Engineer.

10.4.04.C When meeting existing concrete pavement, horizontal dowels shall be used if no exposed reinforcing steel exists. Horizontal dowels shall be Grade 60 bars, 24 inches long, drilled and embedded 12-inches into the center of the existing slab with PO ROC, or approved equal. Dowels shall be 12-inches center-to-center, unless otherwise specified.

10.4.04.D When concrete is removed for connection with proposed concrete pavement, the pavement shall be saw cut and existing concrete removed to expose a minimum of 15-inches of reinforcing steel. If no reinforcing steel exists, use horizontal dowels per Paragraph 10.4.04.C.

10.4.05 PAVEMENT CONNECTION SPECIAL REQUIREMENTS

10.4.05.A At a T-intersection with a street that has not been improved to its ultimate width, concrete shall be stopped either at the right-of-way line or the end of the curb return. The option that will require the least concrete removal at a future date should be chosen.

10.4.05.B For roadway turnouts placed at an existing cross street intersection, the turnout should be designed to fit the ultimate pavement width of the intersecting cross street and then transitioned to the existing roadway.

10.4.06 L - TYPE STREET

The minimum grade line around the longest radius on an L-type street shall be 0.40 percent.

SECTION 5 – BICYCLE FACILITIES

See Chapter 17 – Pedestrian, Bicycle, and Transit Design Requirements.

SECTION 6 – SPECIAL REQUIREMENTS

10.6.01.A Pavement Crossing Pipelines - A Letter of agreement between the City and pipeline company is required when paving is placed over a transmission pipeline.

10.6.01.B Bridge design should include a high comfort bicycle facility where a bicycle facility exists or is proposed. See Chapter 17 for details on high comfort bicycle facilities.

10.6.01.C Thoroughfare Construction Considerations

1. When the full section of a thoroughfare is located within the city limits and is dedicated on a final plat, the esplanade and all lanes of the thoroughfare shall be constructed at the time of initial construction of the roadway.

2. If approved by the City Engineer, lanes contained within a plat, left-turn lanes, bicycle facilities, and the esplanade to the centerline of the right-of-way shall be constructed at the time of initial construction of the roadway when only one side of a thoroughfare is located on a final plat. The remaining lanes, left-turn lanes, bicycle facilities and esplanade shall be constructed at the time the final plat containing the opposite side of the thoroughfare is approved.

10.6.01.D Inlets and Manholes

1. The inlet spacing and the maximum allowable curb run to an inlet shall be provided in accordance with Chapter 9.

2. City approved inlets shall be used on all curbs and gutter sections within the city limits and in the ETJ.

3. Keep proposed inlets away from esplanade opening and out of major thoroughfare intersections. For intersections between a major thoroughfare and minor street, locate inlets at the end of return (E/R) of the side street.

4. Inlets shall be placed at the end of pavement in order to eliminate drainage from the pavement gutter into a road ditch.

5. When curb and gutter streets connects to roadside ditches street, place inlets at end of curb and gutter street with reinforced concrete pipe stubs with rings to collect ditch storm water. See standard detail 02632-11- Side Street Ditch Reception.

6. Use only City standard grates for curb inlets.

7. Adjust existing manhole frames and covers within the limits of the proposed pavement to meet the proposed top-of-slab elevation.

10.6.01.D continued

8. Adjust existing manhole frames and covers outside the limits of pavement to conform to the final grading plan.

10.6.01.E When a curb and gutter street intersects a drainage ditch, the gutter elevation shall be above the designed water surface elevation of the ditch.

10.6.01.F Fill/Cut for Proposed Pavement

1. Fill Placement for Curb and Gutter Pavement Sections:

   a. Fill shall be placed to ensure a minimum of 3/8-inches per foot transverse slope toward the curb from the property line. Fill shall be placed between the curb and a point two feet outside of the right-of-way.

   b. Where fill as described above is required, and the pavement is adjacent to a nonparticipating property owner, fill easements shall be obtained, filed, and a copy of the easement shall accompany the final drawings.

   c. Construction of this nature will require back-slope drainage design to prevent trapping storm runoff.

   d. When pavement or curb grades are established below natural ground, slopelines shall be shown on the drawings.

10.6.01.G Drawings

1. Construction drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.

2. Top-of-curb grade for the outside lanes shall be labeled except at railroad crossings where gutter grades shall be labeled. Centerline grades are acceptable for sheets with roadside ditch sections.

3. For proposed driveways, call out centerline stations, widths, and radii.

END OF CHAPTER

APPENDIX 1: DESIGN FIGURES

GEOMETRIC DESIGN GUIDELINES FOR SUBDIVISION STREETS

CITY OF HOUSTON

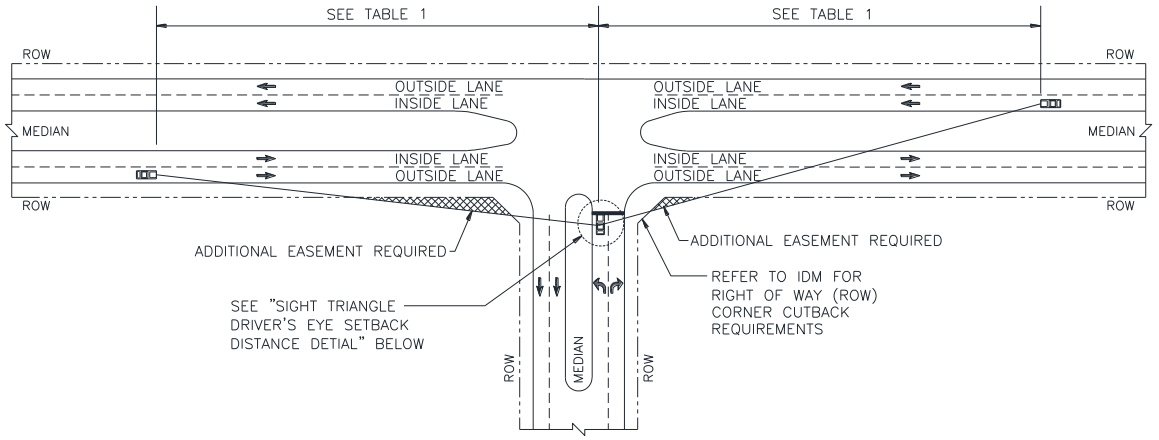
The Guidelines presented in Appendix 1 include the most often requested information regarding geometric design of subdivision streets. All streets within the City of Houston shall be considered for special design features such as presented in Appendix 2 of this Chapter. Design features not shown in Appendix 1 should be considered special design features. Agency Engineer as used throughout this section shall mean City Engineer for the City of Houston. The average daily traffic volumes presented in Table 10.7, Table 10.8, and Appendix 2 Figure 1 are provided as general guidelines to define each street classification. Professional engineering experience and judgment should be used in application of the guidelines to a specific project.

It is advisable to consult with the City and review the most recent edition of the following publications to determine adequate thoroughfare requirements and special design features.

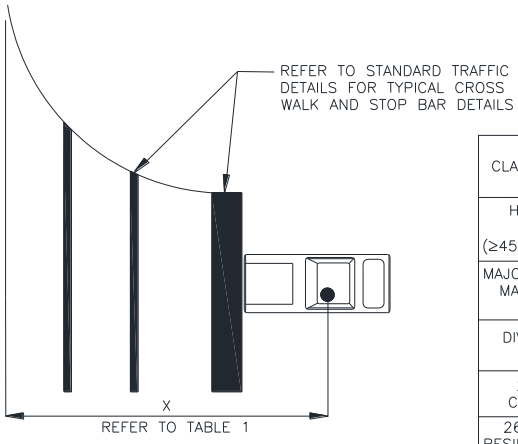
- Recommended Guidelines for Subdivision Streets, Institute of Transportation Engineers
- Guidelines for Urban Major Streets Design, Institute of Transportation Engineers
- A Policy on Geometric Design of Highways and Streets, American Associations of State Highway and Transportation Officials (AASHTO)
- Texas Manual on Uniform Traffic Control Devices (TMUTCD), Texas Department of Transportation
- Urban Street Design Guide, National Association of City Transportation Officials (NACTO)
- Urban Bikeway Design Guide, National Association of City Transportation Officials

THE GUIDELINES IN THIS APPENDIX ARE HEREBY APPROVED AS BASIC REQUIREMENTS FOR FUTURE STREET PLANNING AND DEVELOPMENT

JULY 2020



INTERSECTION GEOMETRY SIGHT DISTANCE TRIANGLE PLAN



SIGHT TRIANGLE DRIVER'S EYE SETBACK DISTANCE DETAIL

TABLE 1: TRIANGLE APPLICABILITY

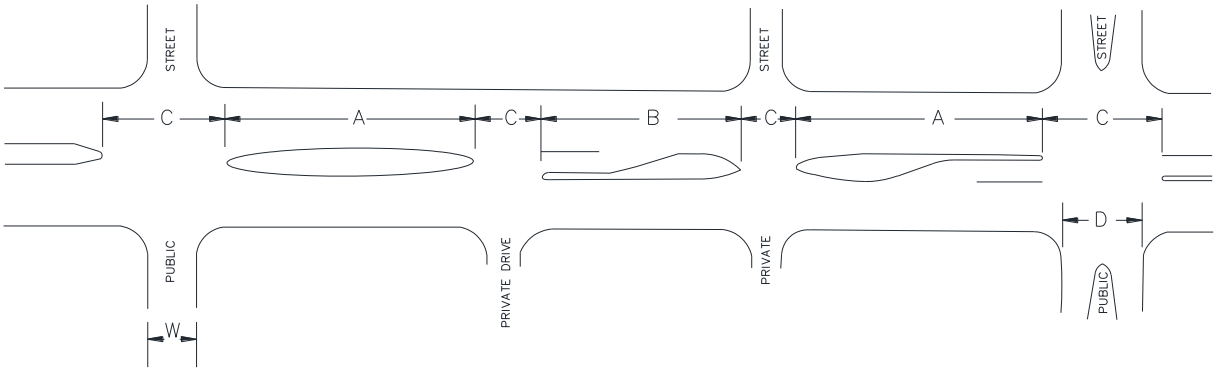
HIGHEST CLASSIFICATION/GREATER WIDTH STREET	SIGHT TRIANGLE DRIVER'S EYE SETBACK DISTANCE "X"	SIGHT TRIANGLE DIMENSION ON UNCONTROLLED STREET (DESIGN SPEED)
HIGH SPEED MAJOR THOROUGHFARE (≥45 MPH POSTED SPEED)	25 FT	SIGHT–SPECIFIC ANALYSIS
MAJOR THOROUGHFARE OR MAJOR COLLECTOR ON MTFP MAP	25 FT	500 FT (45 MPH)*
DIVIDED STREETS AND 41 FT STREETS	15 FT	500 FT (45 MPH)*
26 FT LOCAL AND COLLECTOR STREETS	15 FT	390 FT (35 MPH)*
26 FT SINGLE FAMILY RESIDENTIAL FRONTAGE ON BOTH STREETS (1)	N/A	N/A

*BASED ON A PASSENGER CAR TIME GAP

NOTES:

1. INTERSECTION SIGHT DISTANCES ARE BASED ON AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO) CRITERIA FOR INTERSECTION SIGHT DISTANCE.
2. IF ROADWAY BEING CROSSED OR TURNED INTO HAS A MEDIAN THAT IS 25 FEET OR GREATER, SIGHT DISTANCE TO THE RIGHT MAY BE MEASURED FROM THE POINT AT WHICH A VEHICLE CAN SAFELY STOP WITHIN THE MEDIAN OPENING.

Figure 10.6 - INTERSECTION GEOMETRY SIGHT DISTANCE TRIANGLE



TYPICAL MEDIAN OPENING C

MEDIAN INTERRUPTION FOR	(1) 1 LTB	(1) 2 LTB
PRIVATE DRIVE OR PRIVATE STREET	52.5'	60'
UNDIVIDED STREET W ≤ 40' W = 44'	52.5' (2) 55' (2)	60' 80'
DIVIDED STREET ALL	D+22' (3)	D+22' (3)

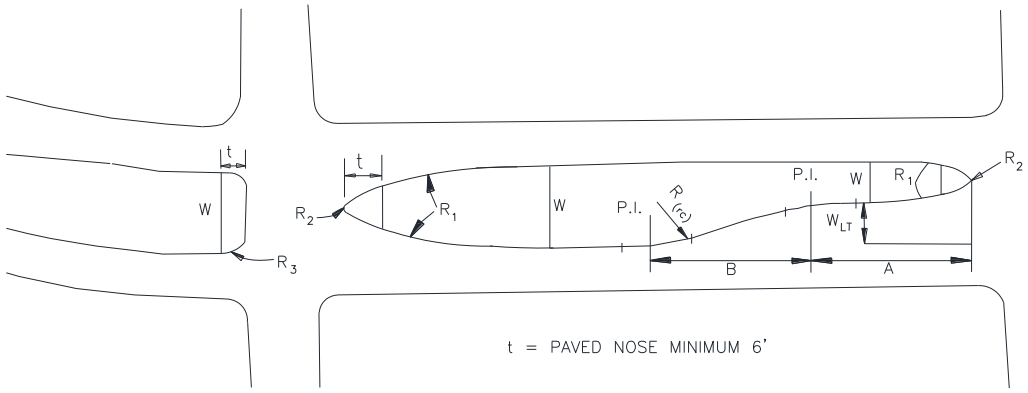
MINIMUM MEDIAN LENGTH A, B

IF DIVIDED STREET IS:	INTERSECTING STREET CLASSIFICATION			
	MAJOR THOROUGHFARE/ MAJOR THOROUGHFARE (A)	COLLECTOR STREET (A)	LOCAL STREET (A)	PRIVATE STREET OR DRIVEWAY (B)
MAJOR THOROUGHFARE/ MAJOR THOROUGHFARE	660'	660'	660'	660'
COLLECTOR STREET	660'	500'	350'	350'
LOCAL STREET	300'	300'	300'	300'

NOTE:

(1) LTB–LEFT TURN BAY.
(2) DISTANCE FROM CENTERLINE OF OPENING TO MEDIAN NOSE WITH LEFT TURN LANE IS 30' FOR RIGHT ANGLE INTERSECTIONS. FOR INTERSECTIONS OTHER THAN 90°, APPLY DESIGN VEHICLE TURNING TEMPLATE TO DETERMINE DIMENSION TO MEDIAN NOSE CUT OFF.
(3) "W" AND "D" DENOTE THE PAVEMENT WIDTH MEASURED FROM FACE OF CURB TO FACE OF CURB

Figure 10.7 - MEDIAN LENGTH AND OPENING



LEFT TURN BAY PLAN

MEDIAN DIMENSIONS

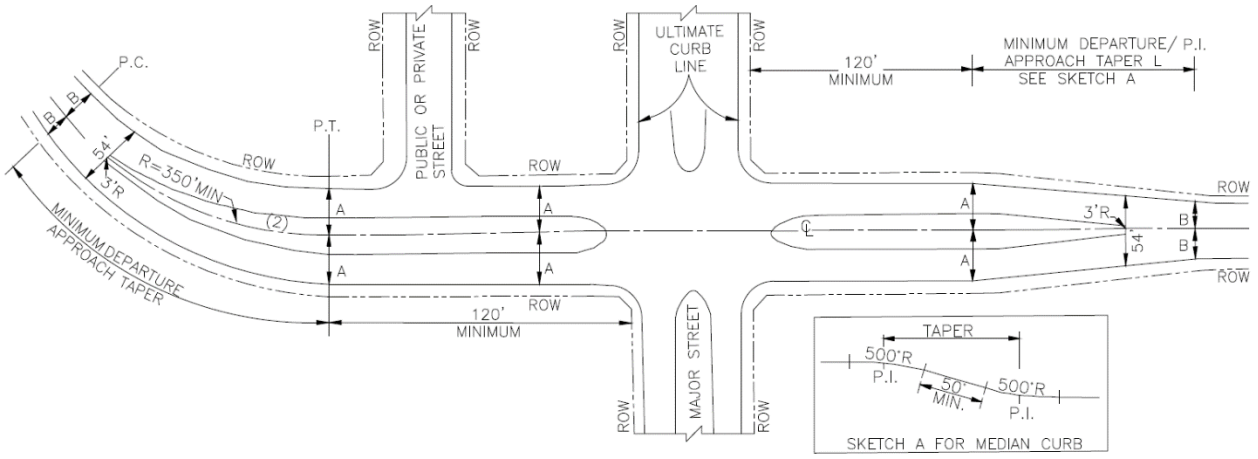
W	R_1	R_2	R_3
≤10'	NONE	$\frac{W}{2}$	NONE
>10'≤40'	90	2'	NONE
>40'	NONE	NONE	15

LEFT TURN BAY DIMENSIONS

INTERSECTION TYPE	DESIGN SPEED	A	B	$R_{(rc)}$	$W_{(LT)}$
MAJOR THOROUGHFARE – MAJOR THOROUGHFARE	≤35 MPH ≥35 MPH	150' 150'	86' 118'	150' 300'	10'/11' 10'/11'
MAJOR THOROUGHFARE – MAJOR COLLECTOR	≤35 MPH ≥35 MPH	150' 150'	86' 118'	150' 300'	10'/11' 10'/11'
ALL OTHER	≤35 MPH ≥35 MPH	100' 100'	86' 118'	150' 300'	10'/11' 10'/11'

TABLE NOTES:
1) $R_{(rc)}$ – REVERSE CURVE RADIUS
2) LEFT TURN BAY LANE WIDTH (W_{LT}) TO CONFORM TO LANE WIDTH REQUIREMENTS SPECIFIED IN SECTION 10.3.03: CORRIDOR DESIGN

Figure 10.8 - MEDIAN NOSE AND LEFT TURN BAY



NOTES:

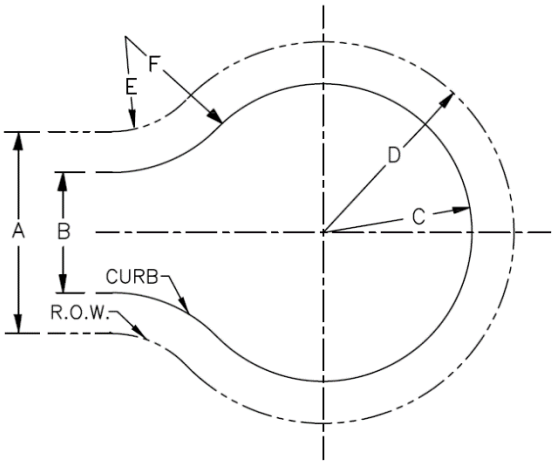
1) APPROACH AND DEPARTURE TAPER REQUIREMENT:
$L = \frac{WS^2}{60}$ WHERE L = LENGTH IN FEET
S = SPEED IN M.P.H.
W = LATERAL OFFSET IN FEET
S = 30 M.P.H. MINIMUM DESIGN SPEED FOR SUBDIVISION STREETS

W = A–B

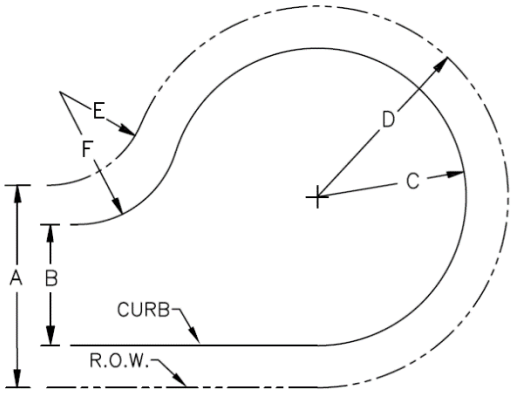
2) 300' MINIMUM CENTERLINE RADIUS FOR HORIZONTAL CURVE WITH APPROACH OR DEPARTURE TAPERS.

3) REFER TO STANDARD DRAWING NO. 10.8 FOR MEDIAN LENGTHS AND MEDIAN OPENING.

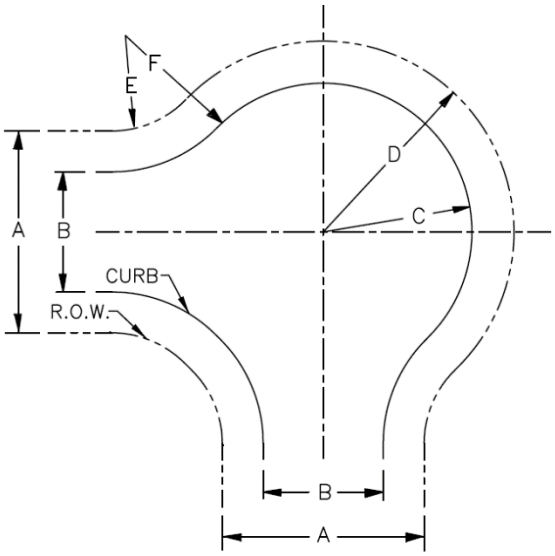
Figure 10.9 - ROADWAY TAPERS FOR MEDIAN DESIGN (LOCAL STREETS)



SYMMETRICAL CUL–DE–SAC



OFFSET CUL–DE–SAC



KNUCKLE CUL–DE–SAC

TABLE 1: CUL–DE–SAC DIMENSIONS

DIMENSION	SINGLE FAMILY	ALL OTHER
A	VARIES (1)	VARIES (1)
B	VARIES (1)	VARIES (1)
C	48 FT	50 FT
D	58 FT	60 FT
E	25 FT	25 FT
F	35 FT	35 FT

NOTES:

1. FOR STREET AND ROW WIDTHS, REFER TO PARAGRAPH 10.3.03.A OF THE IDM.
2. CURB DENOTES THE FACE OF CURB

Figure 10.10 - STREET TERMINATION CUL-DE-SAC

PUBLIC USE ALLEY REMOVED

ANY PUBLIC USE ALLEY ROW SHOULD MEET CITY ROADWAY STANDARDS

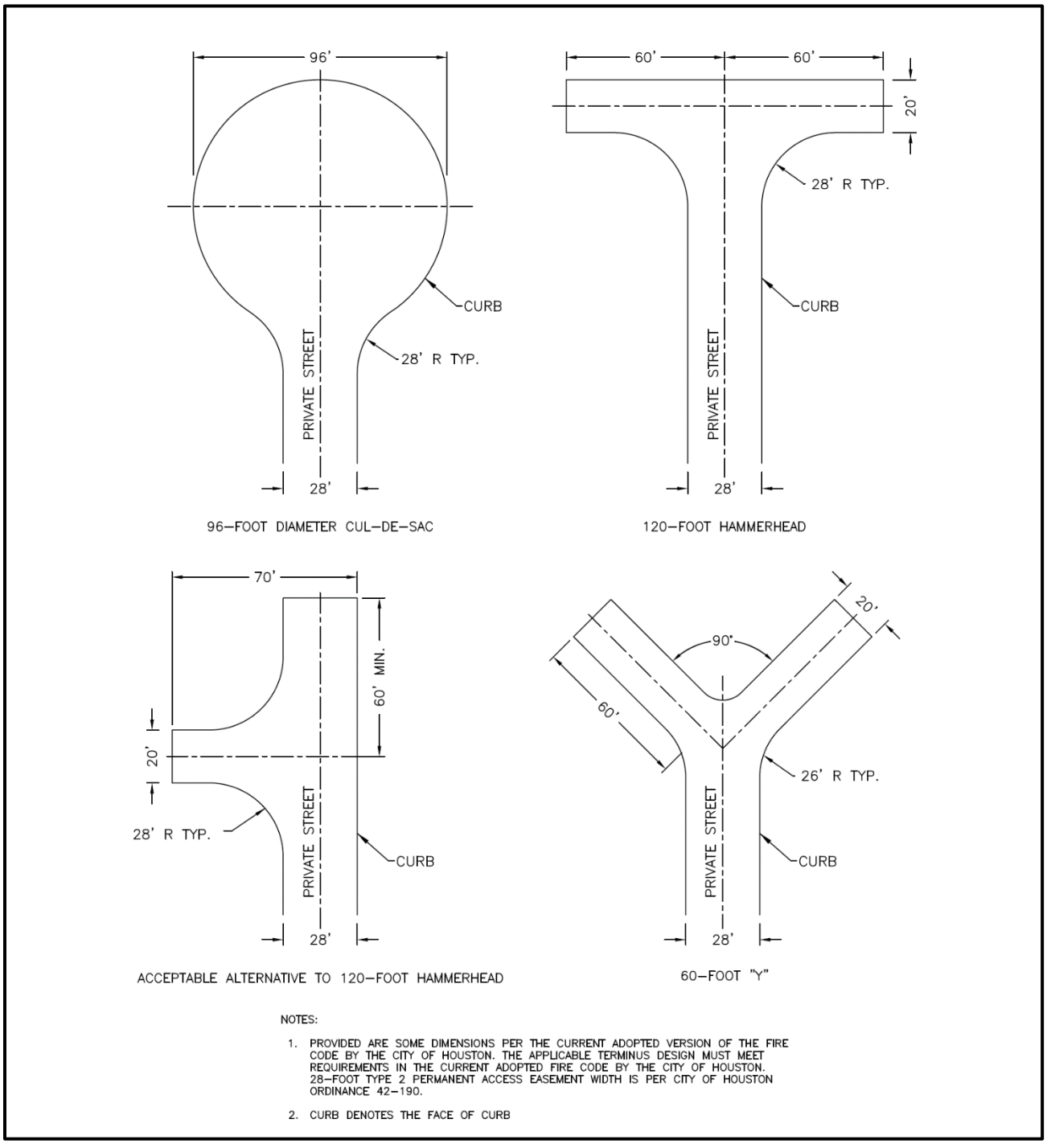


Figure 10.11 - TYPE 2 PERMANENT ACCESS EASEMENT

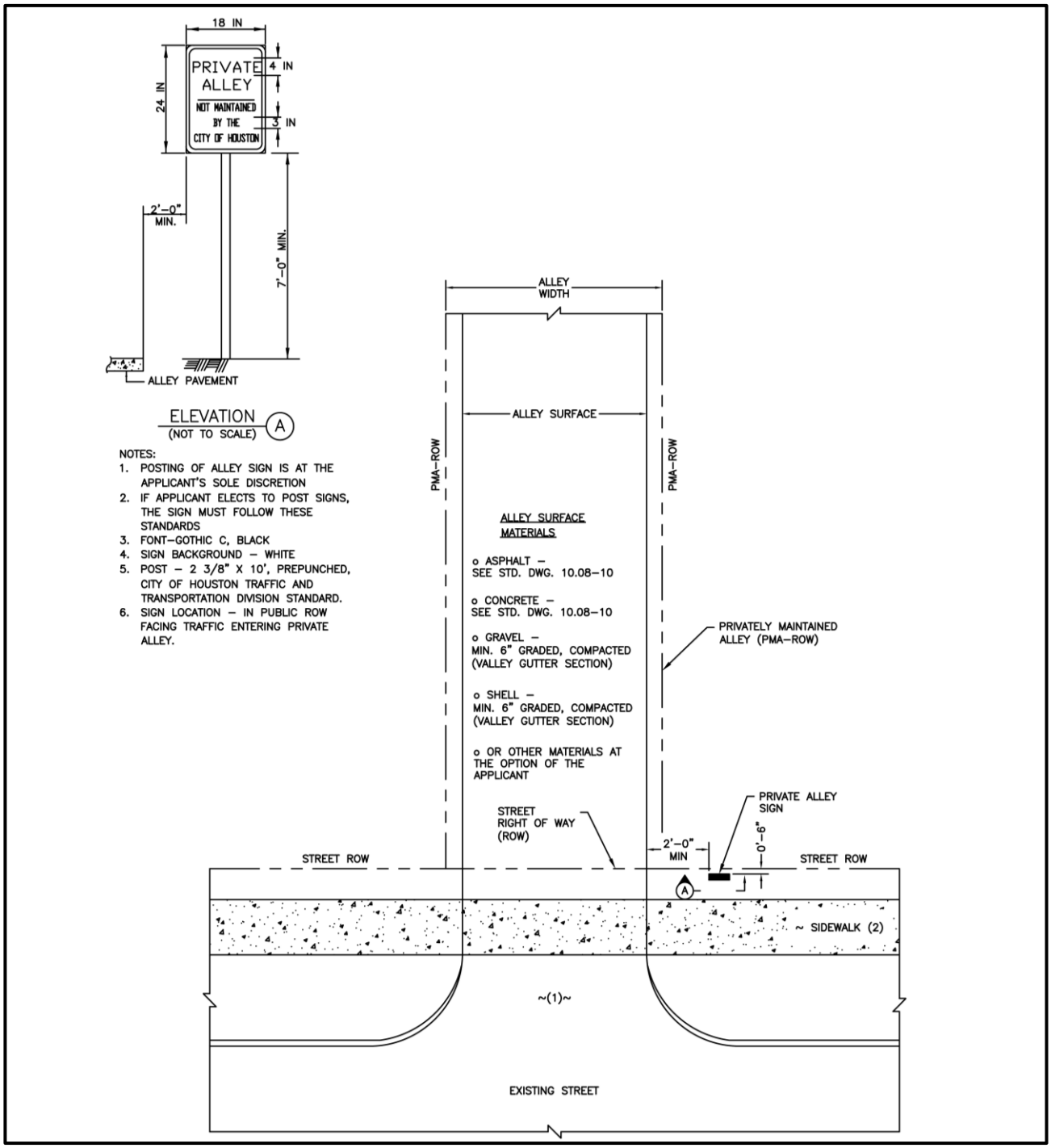


Figure 10.12 - PRIVATELY MAINTAINED ALLEY

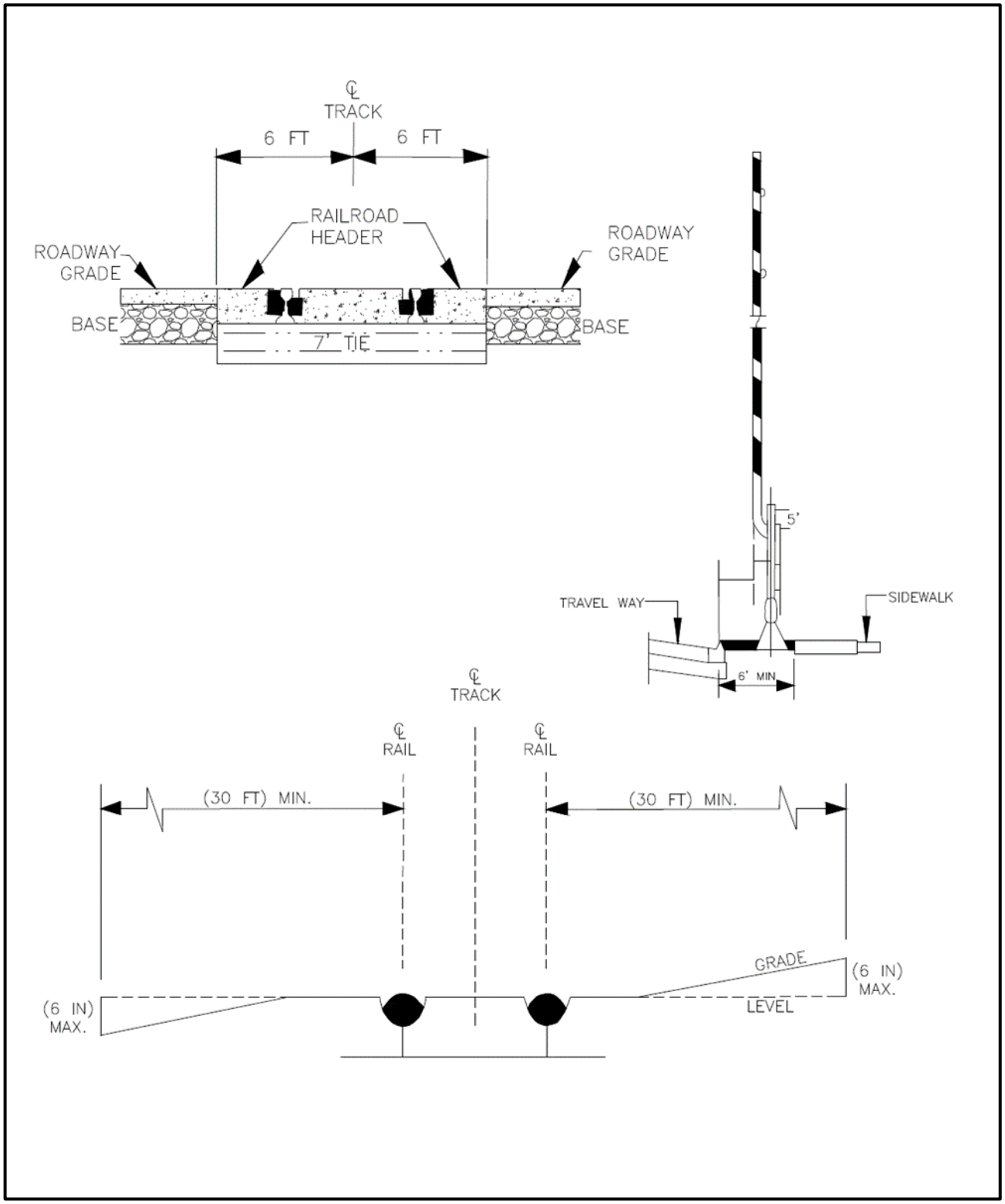


Figure 10.13 - RAILROAD CROSSING

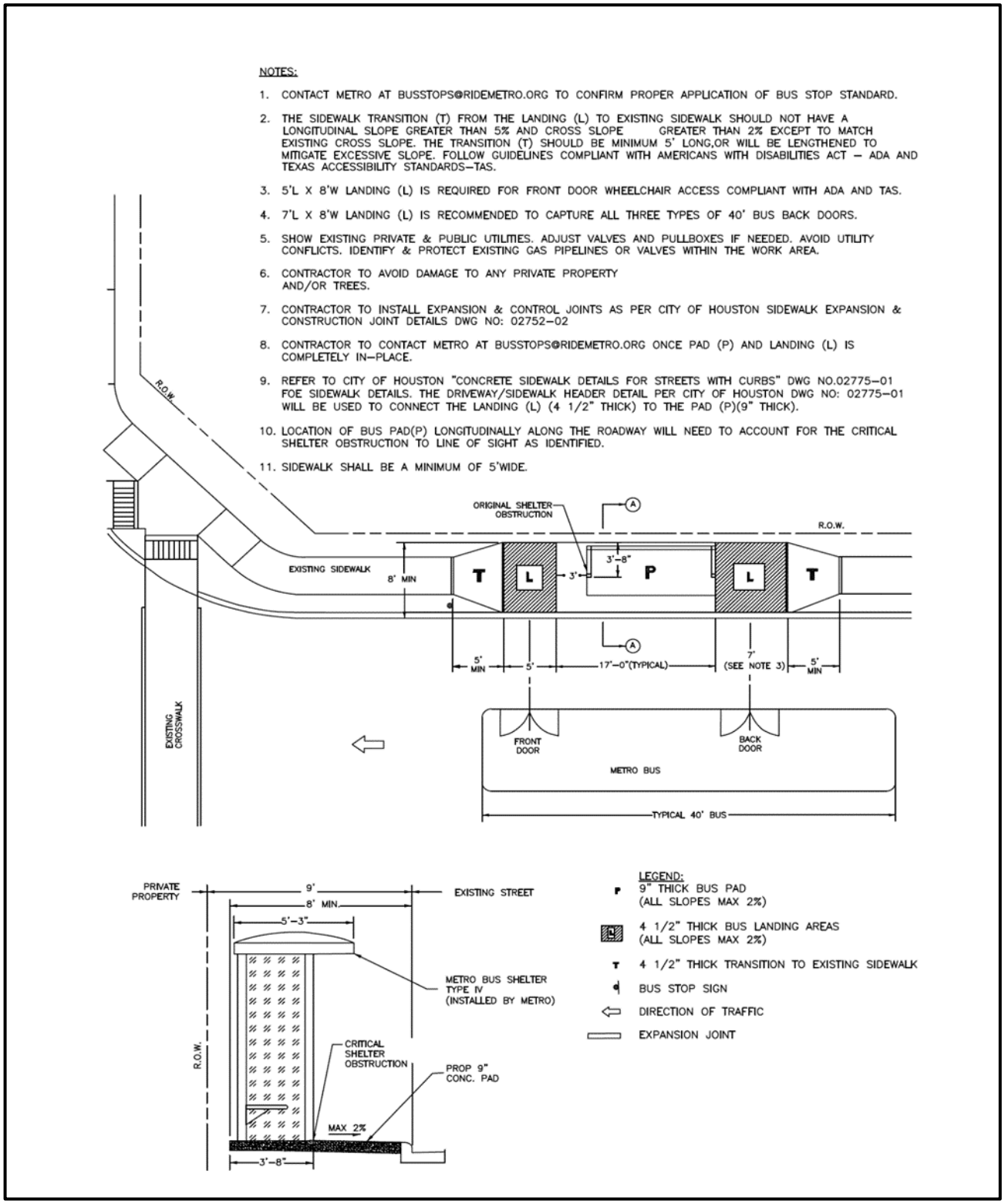


Figure 10.14 - STANDARD BUS PAD AND LANDINGS

APPENDIX 2: STREET DESIGN MENU

Appendix 2 presents a "Street Design Menu" with examples of optional roadway corridor sections that are a result of the 2009 City of Houston Mobility Planning Study. Figure 1 is provided to cross reference the street classifications in the Major Thoroughfare and Freeway Plan to the corridor sections within the City Mobility Plan. These corridor sections can be utilized for development of roadway systems within the City limit of Houston. These roadway sections are not applicable in the ETJ of the City. The tables identify the right-of-way requirements and element dimensions associated with each corridor section.

The design engineer, in consultation with the City, shall determine the appropriate Multimodal Street Classification is applicable for each street using context sensitive design principles. While full right-of-way dedication may not be required under Chapter 42 of the City of Houston Code of Ordinances, it is expected that developer's utilizing these alternative sections will make available the necessary public right-of-way dimensions at no cost to the City of Houston.

NOTES

1. Sidewalk dimensions shown are options. Minimum sidewalk dimension for Transit Street designations and Major Thoroughfare is six feet and five feet for all others.

2. TW - Tree Wells will be considered for use in lieu of a green space dimension where shown in Tables.

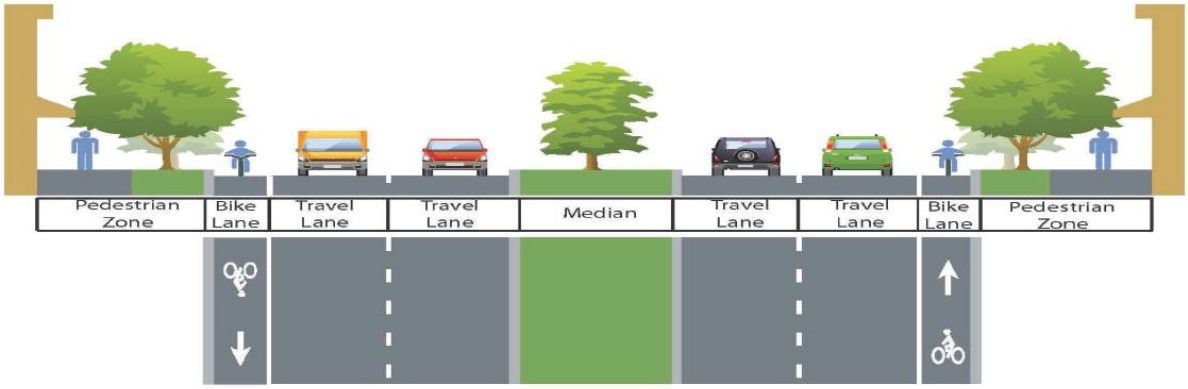
CITY MOBILITY PLAN (CMP)				MAJOR THOROUGHFARE AND FREEWAY PLAN (MTFP)				
MULTIMODAL STREET CLASSIFICATION				EXISTING CLASSIFICATION				
	Proposed Right-of-Way	Number of Lanes	Typical Design Avg Daily Traffic Vol (vpd)	Principal Thoroughfare	Thoroughfare	Major Collector	Minor Collector	Local Street
BOULEVARD								
Commercial	80' - 140'	4 - 8	15,000 - 80,000					
Mixed Use	80' - 140'	4 - 6	15,000 - 50,000					
Residential	80' - 120'	2 - 6	15,000 - 30,000					
Transit	120'	4 - 6	15,000 - 30,000					
Industrial	80' - 140'	4 - 6	15,000 - 50,000					
AVENUE								
Commercial	80' - 100'	2 - 4	1,500 - 30,000					
Mixed Use	80' - 100'	2 - 4	1,500 - 30,000					
Residential	80' - 100'	2 - 4	1,000 - 20,000					
Transit	100'	2	1,500 - 15,000					
Industrial	80' - 100'	3 - 5	5,000 - 35,000					
COUPLET								
Commercial	60' - 100'	2 - 5	1,000 - 45,000					
Mixed Use	60' - 100'	2 -5	1,000 - 45,000					
Residential	60' - 100'	2 -3	1,000 - 25,000					
Transit	60' - 100'	2 - 4	1,000 - 35,000					
Industrial	60' - 100'	2 - 5	1,000 - 45,000					
STREET								
Commercial	60'	2	1,000 -15,000					
Mixed Use	60'	2	1,000 - 15,000					
Residential	60'	2	500 - 5,000					
LOCAL STREET								
Residential Main	60' - 70'	2	≥ 1,500					
Residential High Density	55' - 65'	2	350 - 5,000					
Residential Std. Density	50' - 65'	2	250 - 5,000					

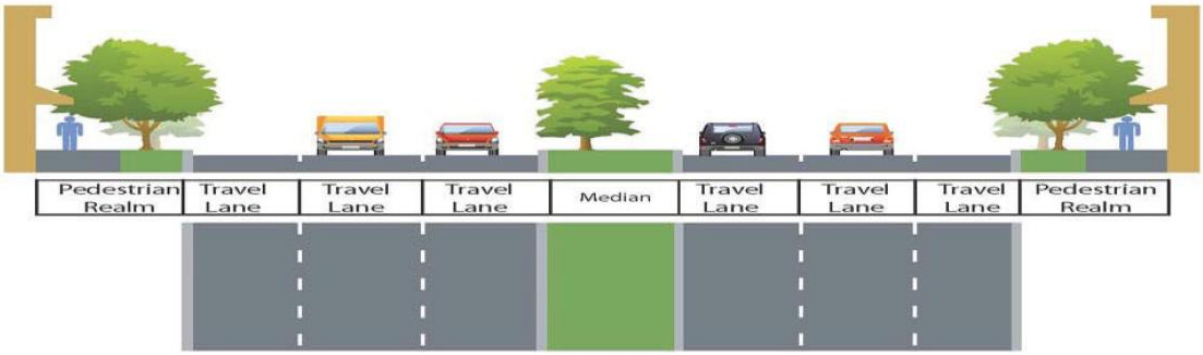
Indicates Shared Classification

Figure 1

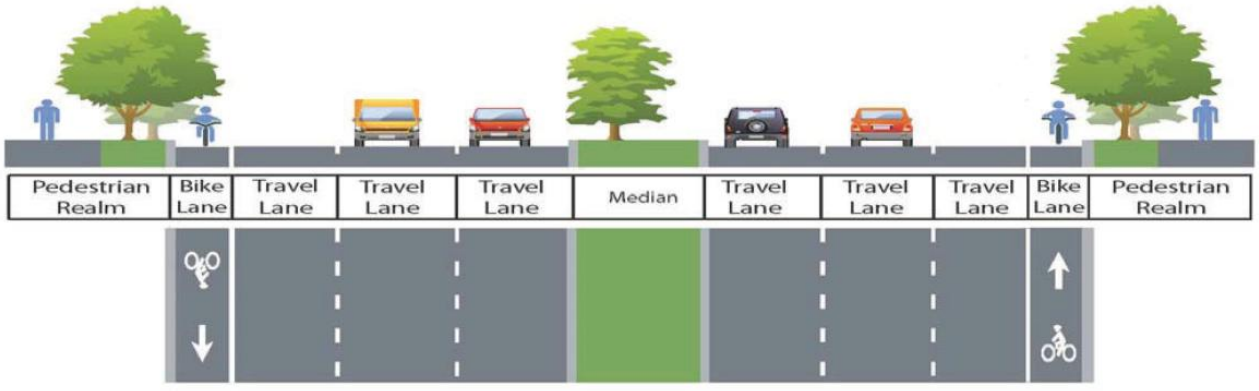
Commercial/Mixed Use Boulevard Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 10 = 20	TW	N/A	N/A	16	4 x 11 = 44	15,000 - 30,000
100	2 x 18 = 36	TW	N/A	N/A	20	4 x 11 = 44	15,000 - 30,000
	2 x 12 = 24	TW	N/A	2 x 6 = 12	20	4 x 11 = 44	15,000 - 30,000
	2 x 10 = 20	TW	2 x 8 = 16	N/A	20	4 x 11 = 44	15,000 - 30,000
	2 x 13.5 = 27	TW	N/A	2 x 6 = 12	17	4 x 11 = 44	15,000 - 30,000
	2 x 10 = 20	TW	N/A	N/A	14**	6 x 11 = 66	15,000 - 40,000
120	2 x 17 = 34	TW	N/A	N/A	20	6 x 11 = 66	15,000 - 30,000
	2 x 11 = 22	TW	N/A	2 x 6 = 12	20	6 x 11 = 66	15,000 - 30,000
	2 x 12.5 = 25	TW	N/A	2 x 6 = 12	17	6 x 11 = 66	15,000 - 30,000
	2 x 10.5 = 21	TW	2 x 8 = 16	N/A	17	6 x 11 = 66	15,000 - 30,000
140	2 x 16 = 32	TW	N/A	N/A	20	8 x 11 = 88	20,000 - 50,000
	2 x 11.5 = 23	TW	N/A	2 x 6 = 12	17	8 x 11 = 88	20,000 - 50,000

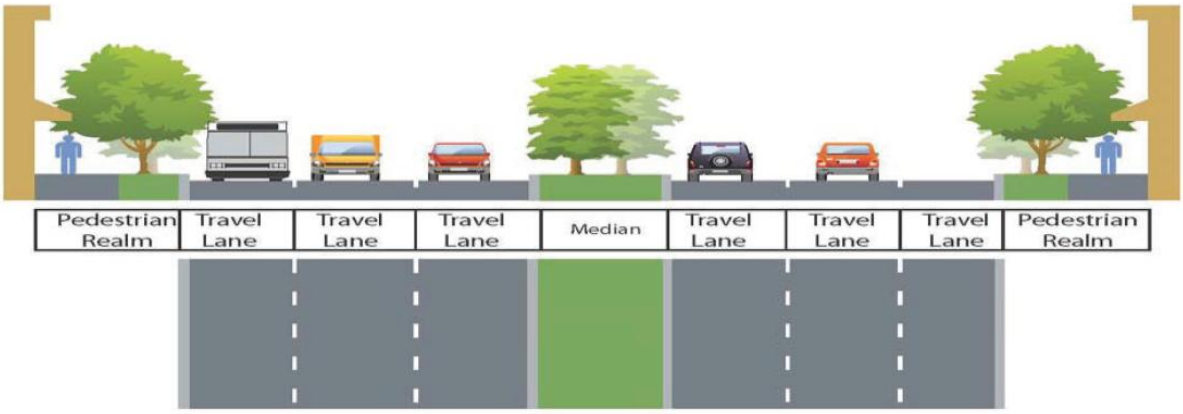
* - Minimum Sidewalk width is a minimum of 5 feet.
** - Not recommended. Requires the concurrence of the City Engineer and the City Traffic Engineer.



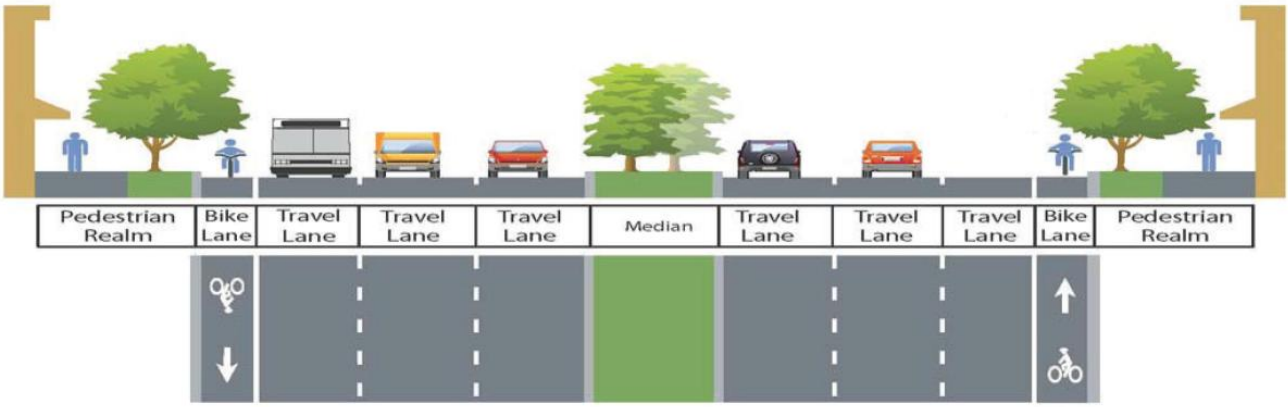


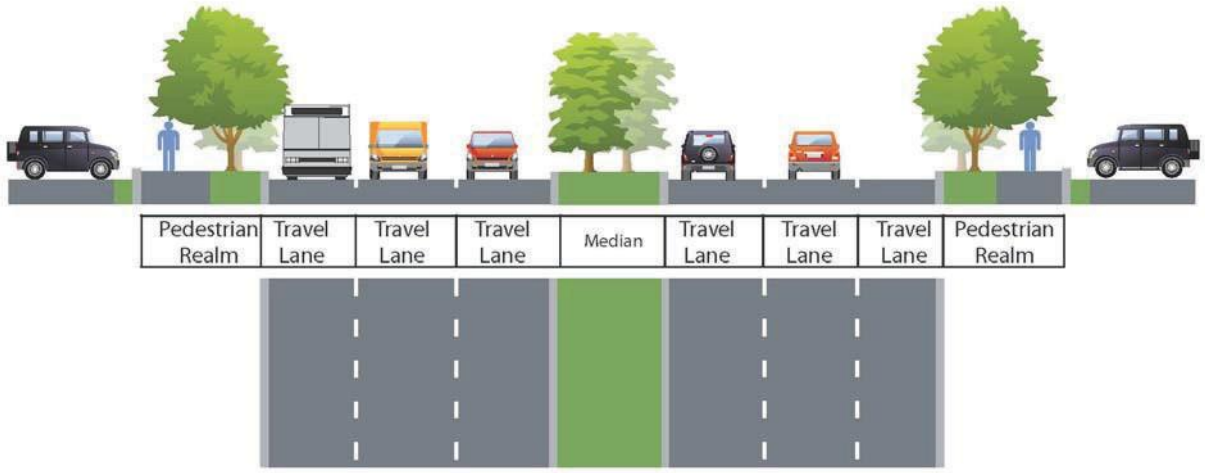
Residential Boulevard Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 11 = 22	TW	2 x 8 = 16	N/A	20	2 x 11 = 22	5,000 - 15,000
	2 x 13 = 26	TW	N/A	2 x 6 = 12	20	2 x 11 = 22	5,000 - 15,000
	2 x 10 = 20	TW	N/A	N/A	16	4 x 11 = 44	15,000 - 30,000
100	2 x 10 = 20	2 x 12.5 = 25	2 x 8 = 16	N/A	17	2 x 11 = 22	5,000 - 15,000
	2 x 10 = 20	2 x 14.5 = 29	N/A	2 x 6 = 12	17	2 x 11 = 22	5,000 - 15,000
	2 x 12 = 24	TW	N/A	2 x 6 = 12	20	4 x 11 = 44	15,000 - 30,000
	2 x 11.5 = 23	TW	2 x 8 = 16	N/A	17	4 x 11 = 44	15,000 - 30,000
120	2 x 10 = 20	2 x 12 = 24	N/A	2 x 6 = 12	20	4 x 11 = 44	15,000 - 30,000
	2 x 12.5 = 25	TW	N/A	2 x 6 = 12	17	6 x 11 = 66	15,000 - 50,000
	2 x 10 = 20	2 x 7 = 14	N/A	N/A	20	6 x 11 = 66	15,000 - 50,000
* - Minimum Sidewalk width is a minimum of 5 feet.							



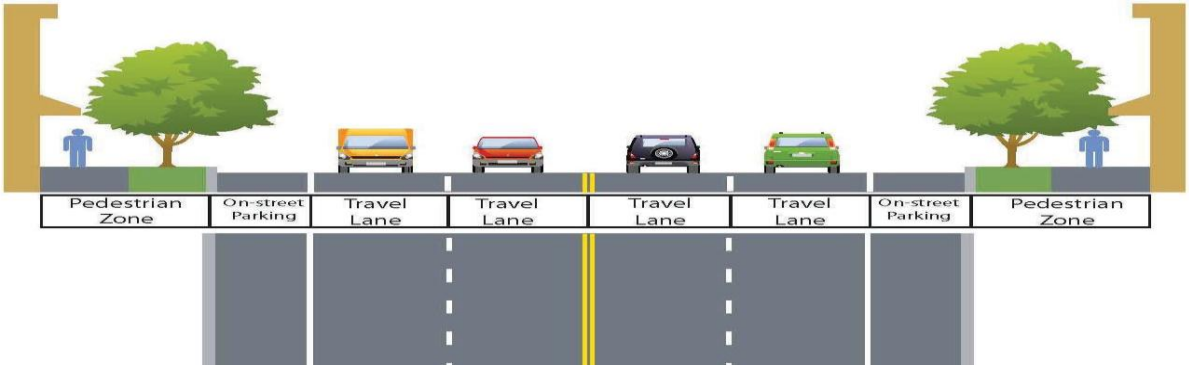


Transit Boulevard Designation							
Minimum R.O.W (feet)	**Pedestrian Realm* (feet)**	**Tree Well or Swale**	**On-Street Parking (feet)**	**Bike Lane (feet)**	**Median Width (ft)**	**Lane Widths (feet)**	**ADT (vpd)**
100	2 x 13 = 26	TW	N/A	N/A	28	2 x 12 = 24 2 x 11 = 22	15,000 - 30,000
110	2 x 18 = 36	TW	N/A	N/A	28	2 x 12 = 24 2 x 11 = 22	15,000 - 30,000
120	2 x 17 = 34	TW	N/A	2 x 6 = 12	28	2 x 12 = 24 2 x 11 = 22	15,000 - 30,000
	2 x 16 = 32	TW	N/A	N/A	20	2 x 12 = 24 4 x 11 = 44	15,000 - 40,000
* - Minimum Sidewalk width is a minimum of 6 feet.							



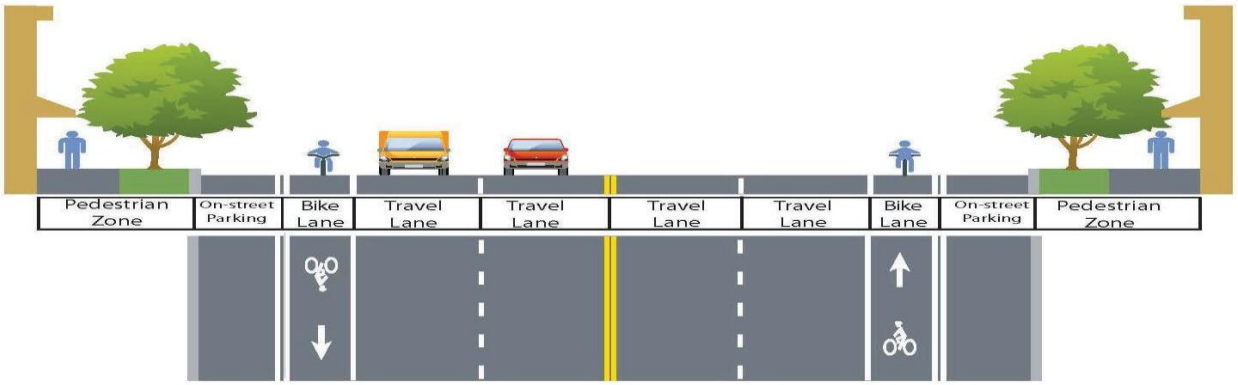


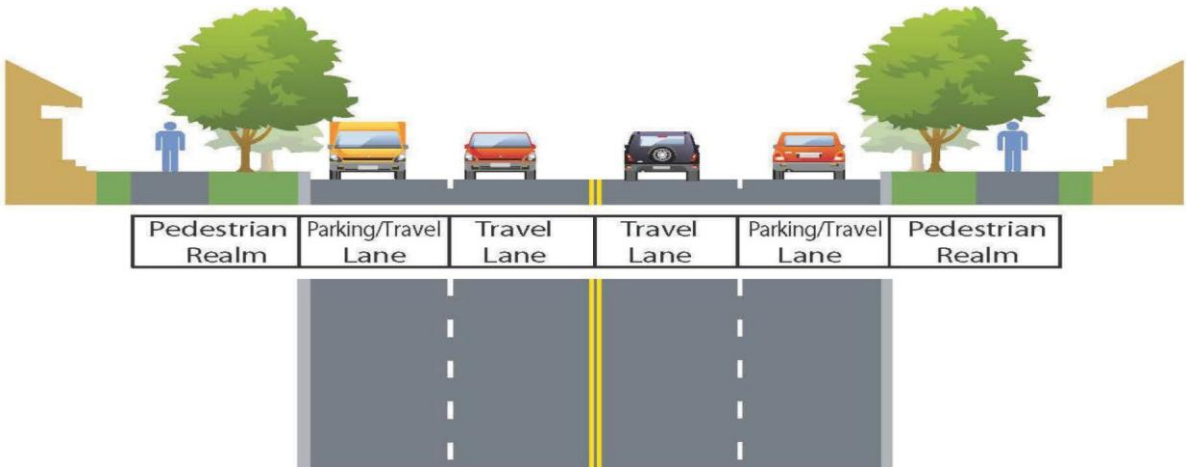
Industrial Boulevard Designation							
Minimum R.O.W (feet)	**Pedestrian Realm* (feet)**	**Tree Well or Swale**	**On-Street Parking (feet)**	**Bike Lane (feet)**	**Median Width (ft)**	**Lane Widths (feet)**	**ADT (vpd)**
100	2 X 17 = 34	TW	N/A	N/A	20	2 X 11 = 22 2 X 12 = 24	15,000 - 30,000
	2 X 11 = 22	TW	N/A	2 X 6 = 12	20	2 X 11 = 22 2 X 12 = 24	15,000 - 30,000
	2 X 10.5 = 21	TW	2 X 8 = 16	N/A	17	2 X 11 = 22 2 X 12 = 24	15,000 - 30,000
120	2 X 16 = 32	TW	N/A	N/A	20	4 X 11 = 44 2 X 12 = 24	15,000 - 50,000
	2 X 10 = 20	TW	N/A	2 X 6 = 12	20	4 X 11 = 44 2 X 12 = 24	15,000 - 50,000
* - Minimum Sidewalk width is a minimum of 5 feet.							



Commercial/Mixed Use Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 X 21 = 42	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 11 = 22	TW	2 X 18 = 36**	N/A	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 15 = 30	TW	2 X 8 = 16	2 X 6 = 12	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 15 = 30	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,500 - 15,000
	2 X 22 = 44	TW	N/A	N/A	N/A	2 X 11 = 22 + 1 X 14 (CLTL***) = 36	5,000 - 20,000
	2 X 14 = 28	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22 + 1 X 14 (CLTL***) = 36	5,000 - 20,000
	2 X 16 = 32	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22 + 1 X 14 (CLTL***) = 36	5,000 - 20,000
	2 X 18 = 36	TW	N/A	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 X 10 =20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 X 12 = 24	TW	N/A	2 X 6 = 12	N/A	4 x 11 = 44	10,000 - 30,000
100	2 x 28 = 56	TW	N/A	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 22 = 44	TW	N/A	2 x 6 = 12	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 20 = 40	TW	2 x 8 = 16	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 10 = 20	TW	2 x 18 = 36**	N/A	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 14 = 28	TW	2 x 8 = 16	2 x 6 = 12	N/A	4 x 11 = 44	10,000 - 30,000
	2 x 17 = 34	TW	N/A	N/A	N/A	6 x 11 = 66	10,000 - 30,000
	2 x 11 = 22	TW	N/A	2 x 6 = 12	N/A	6 x 11 = 66	10,000 - 30,000

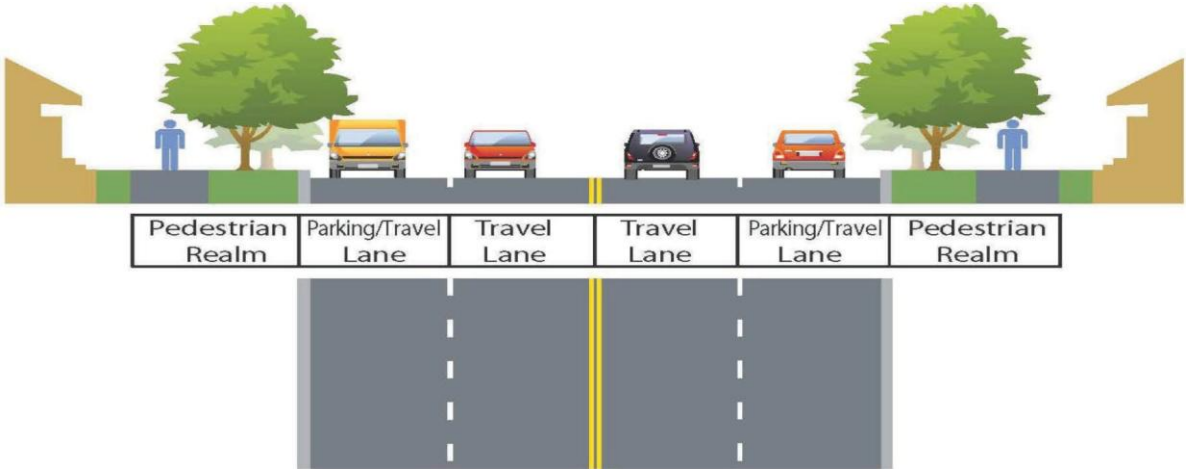
* - Minimum Sidewalk width is a minimum of 5 feet.
** - Angle Parking. Requires permission from the City Traffic Engineer.
*** - CLTL = Continuous Two-Way Left Turn Lane.





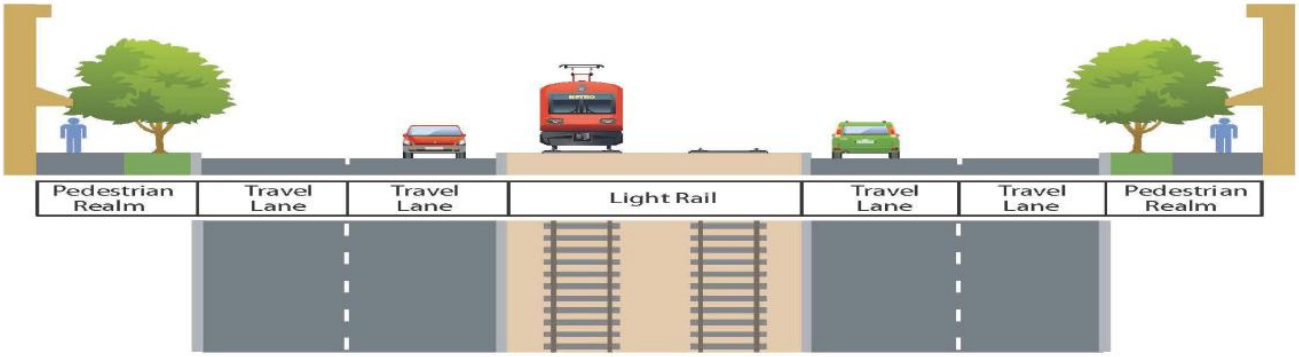
Transit Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 11 = 22	2 x 10 =20	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 8 = 16	2 x 7 = 14	2 X 8 = 16	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	2 x 10 = 20	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 X 8 = 16	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 10 =20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 12 = 24	TW	N/A	2 X 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
100	2 x 18 = 36	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 12 = 24	2 x 10 = 20	N/A	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 10 = 20	2 x 10 = 20	2 x 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 14 = 28	TW	2 x 8 = 16	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000

* - Minimum Sidewalk width is a minimum of 5 feet.



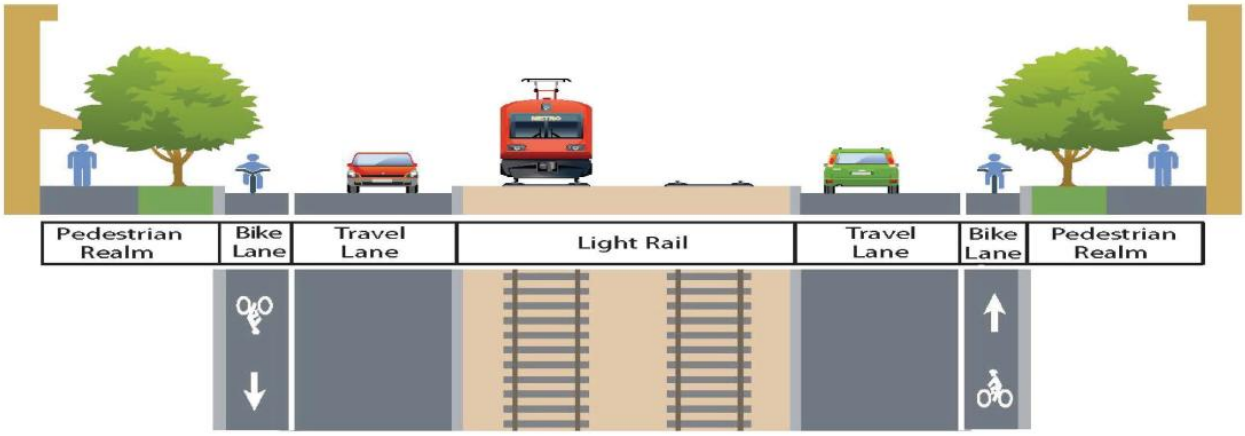
Residential Avenue Designation							
Minimum R.O.W (feet)	**Pedestrian Realm* (feet)**	**Tree Well or Swale**	**On-Street Parking (feet)**	**Bike Lane (feet)**	**Median Width (ft)**	**Lane Widths (feet)**	**ADT (vpd)**
80	2 x 11 = 22	2 x 10 =20	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 8 = 16	2 x 7 = 14	2 X 8 = 16	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	2 x 10 = 20	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 X 8 = 16	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 10 =20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 12 = 24	TW	N/A	2 X 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
100	2 x 18 = 36	2 x 10 = 20	N/A	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 12 = 24	2 x 10 = 20	N/A	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 10 = 20	2 x 10 = 20	2 x 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 14 = 28	TW	2 x 8 = 16	2 x 6 = 12	N/A	4 x 11 = 44	5,000 - 20,000

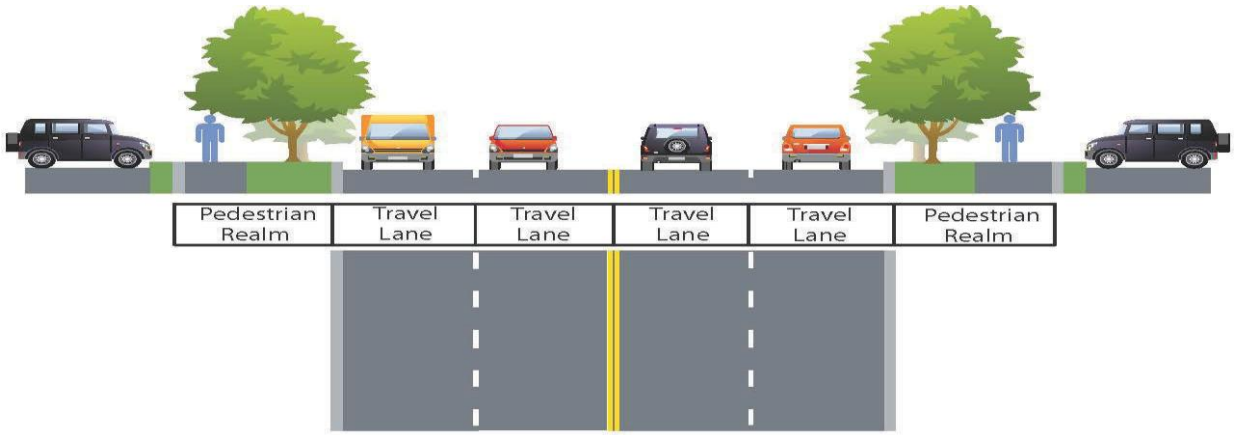
* - Minimum Sidewalk width is a minimum of 5 feet.



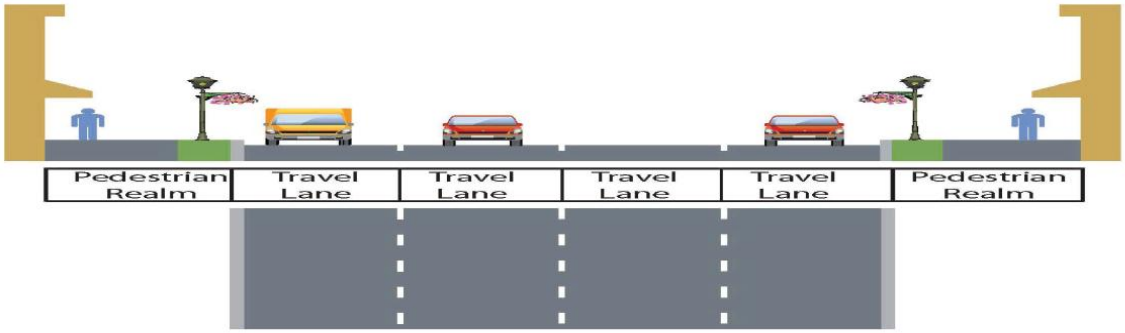
Transit Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Transit Lanes** (ft)	Lane Widths (feet)	ADT (vpd)
100	2 x 27 = 54	TW	N/A	N/A	2 x 12 = 24	2 x 11 = 22	1,000 - 15,000
	2 x 21 = 42	TW	N/A	2 x 6 = 12	2 x 12 = 24	2 x 11 = 22	1,000 - 15,000
	2 x 19 = 38	TW	2 x 8 = 16	N/A	2 x 12 = 24	2 x 11 = 22	1,000 - 15,000
	2 x 13 = 26	TW	2 x 8 = 16	2 x 6 = 12	2 x 12 =24	2 x 11 = 22	1,000 - 15,000

* - Minimum Sidewalk width is a minimum of 6 feet.
** - Transit lanes may be tranist vehicle onl or allow for mixed traffic.



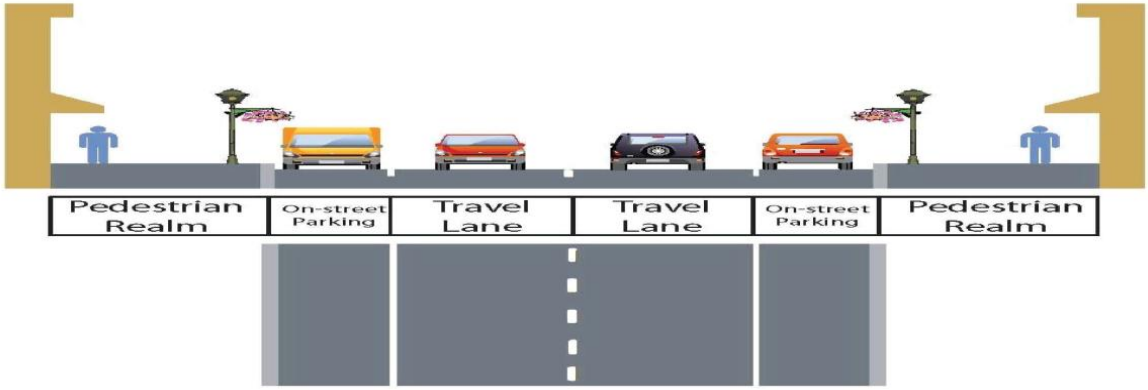


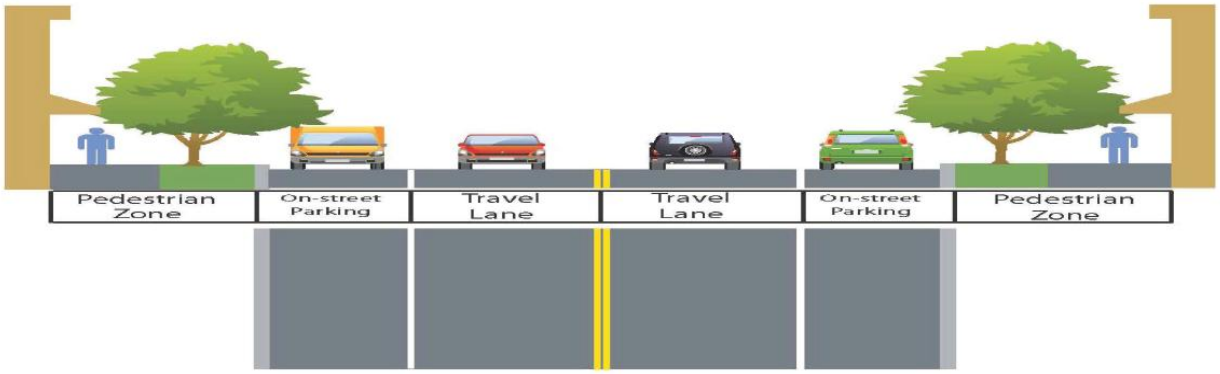
Industrial Avenue Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
80	2 x 10 = 20	2 x 7 = 14	N/A	N/A	N/A	2 x 11 + 2 x 12 = 46	10,000 - 25,000
	2 x 11 = 22	2 x 10 = 20	N/A	N/A	N/A	1 x 14(CLTL**) + 2 x 12 = 38	5,000 - 15,000
90	2 x 18 = 36	TW	2 x 8 = 16	N/A	N/A	1 x 14(CLTL**) + 2 x 12 = 38	5,000 - 15,000
100	2 x 10 = 20	2 x 10 =20	N/A	N/A	N/A	1x14(CLTL**)+ 2x12+2x11= 60	10,000 - 35,000
* - Minimum Sidewalk width is a minimum of 5 feet.							
** - CLTL = Continuous Two-Way Left Turn Lane.							



Commercial/Mixed Use Couplet Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
60	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	TW	N/A	1 x 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
80	2 x 21 = 42	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 23 = 46	TW	N/A	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15 = 30	TW	2 x 8 = 16	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15.5 = 31	TW	2 X 8 = 16	N/A	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 17.5 = 35	TW	N/A	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 9.5 = 19	TW	2 X 8 = 16	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 10 = 20	TW	2 X 8 = 16	N/A	N/A	4 x 11 = 44	5,000 - 20,000
	2 X 12 = 24	TW	N/A	1 X 6 = 6	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 12.5 = 25	TW	N/A	N/A	N/A	5 x 11 = 55	10,000 - 25,000
100	2 x 14 = 28	TW	2 x 8 = 16	1 x 6 = 6	N/A	4 x 11 = 44	5,000 - 20,000
	2 x 14.5 = 29	TW	2 x 8 = 16	N/A	N/A	5 x 11 = 55	10,000 - 25,000
	2 x 15.5 = 31	TW	N/A	1 x 6 = 6	N/A	5 x 11 = 55	10,000 - 25,000
	2 x 9.5 = 19	TW	2 x 8 = 16	1 x 5 = 5	N/A	5 x 11 = 55	10,000 - 25,000

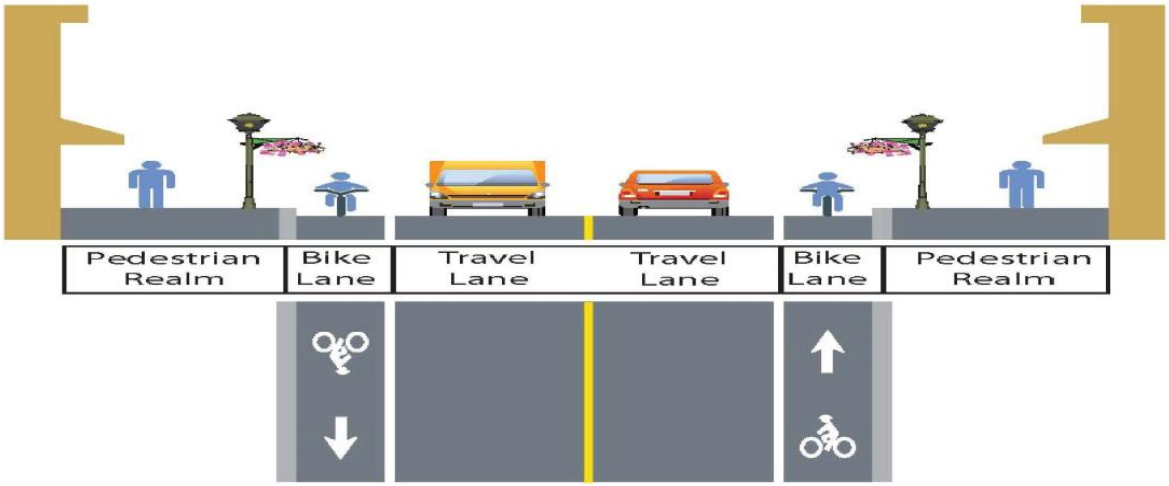
* - Minimum Sidewalk width is a minimum of 5 feet.

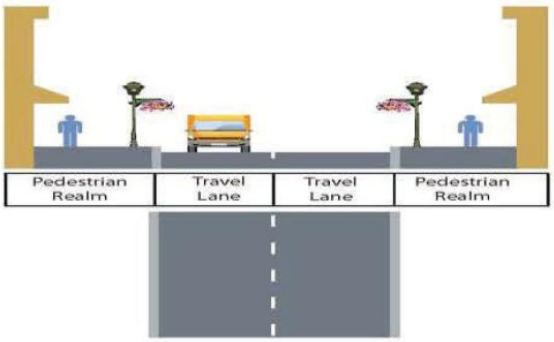


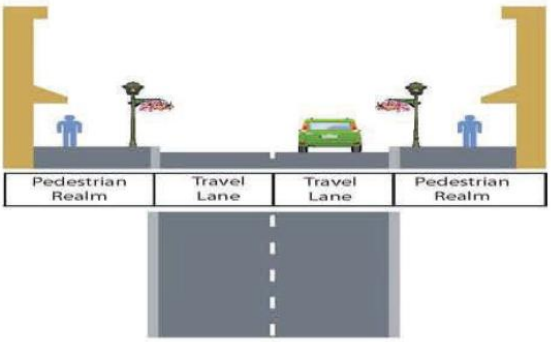


Commercial/Mixed Use Street Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
	2 x 19 = 38	TW	N/A	N/A	N/A	2 X 11 = 22	1,000 - 10,000
60	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22	1,000 - 10,000
	2 X 12 = 24	TW	N/A	N/A	N/A	2 X 11 = 22 + 1 X 14 (CLTL**) = 36	1,000 - 15,000

* - Minimum Sidewalk width is a minimum of 5 feet.
** - CLTL = Continuous Two-Way Left Turn Lane.

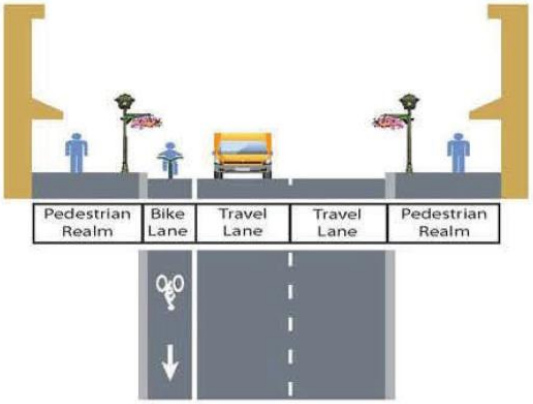


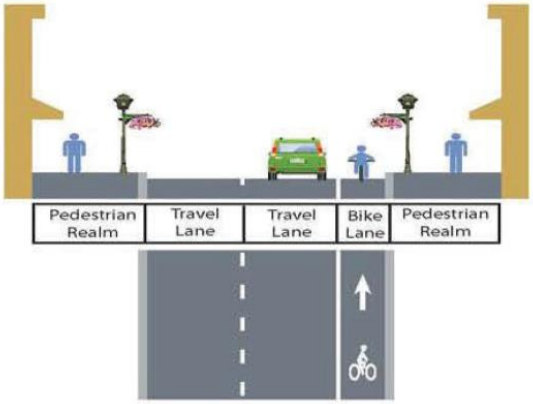


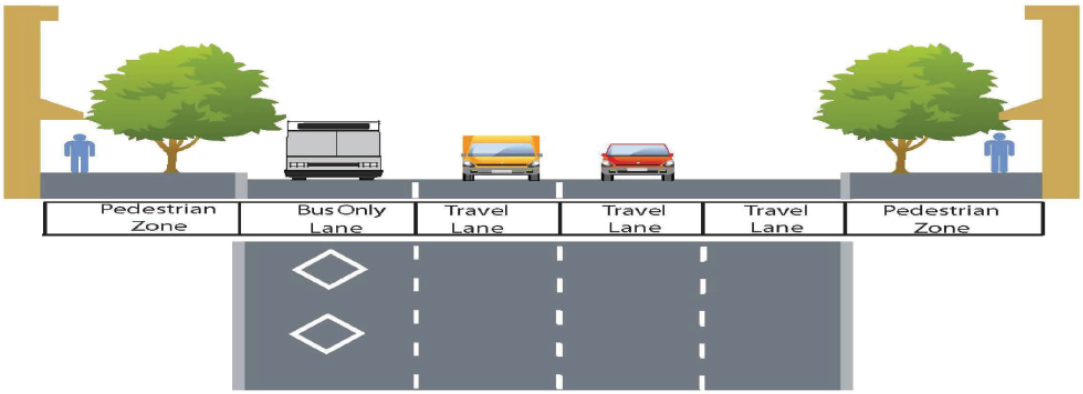


Residential Couplet Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
60	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 13 = 26	TW	N/A	1 x 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
80	2 x 10 = 20	2 x 10.5 = 21	2 X 8 = 16	N/A	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 10 = 20	2 x 13 = 26	N/A	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15 = 30	TW	2 x 8 = 16	1 X 6 = 6	N/A	2 X 11 = 22	1,000 - 10,000
	2 x 15.5 = 31	TW	2 X 8 = 16	N/A	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 17.5 = 35	TW	N/A	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 9.5 = 19	TW	2 X 8 = 16	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000
	2 x 9.5 = 19	TW	2 X 8 = 16	1 X 6 = 6	N/A	3 x 11 = 33	1,500 - 15,000

* - Minimum Sidewalk width is a minimum of 5 feet.

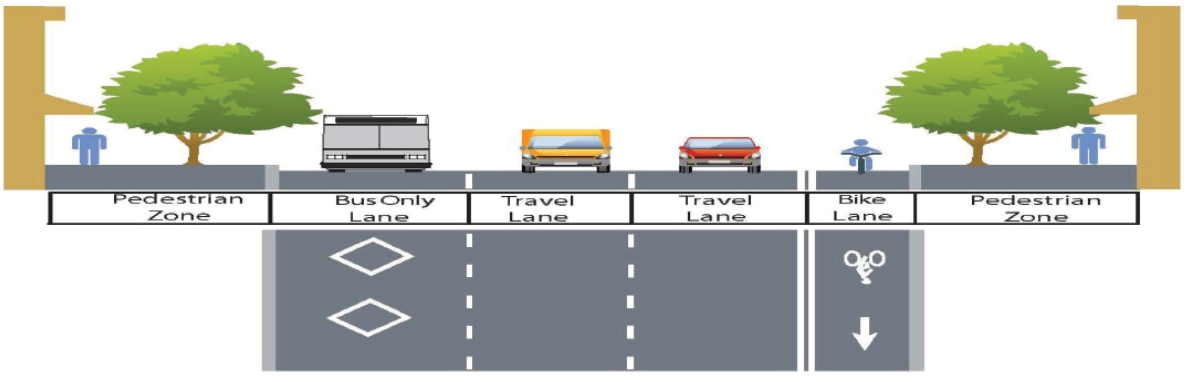


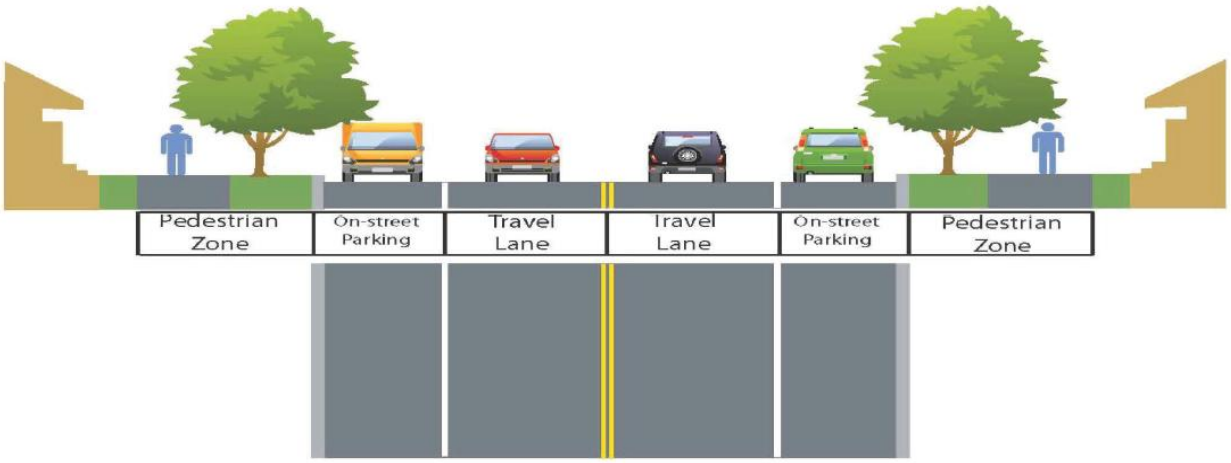




Transit Couplet Designation							
Minimum R.O.W (feet)	**Pedestrian Realm* (feet)**	**Tree Well or Swale**	**On-Street Parking (feet)**	**Bike Lane (feet)**	**Median Width (ft)**	**Lane Widths (feet)**	**ADT (vpd)**
60	2 x 10.5 = 21	TW	2 X 8 = 16	N/A	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 12.5 = 25	TW	N/A	1 x 6 = 6	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
80	2 x 20.5 = 41	TW	2 X 8 = 16	N/A	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 22.5 = 45	TW	N/A	1 X 6 = 6	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 14.5 = 29	TW	2 x 8 = 16	1 X 6 = 6	N/A	1 x 12 + 1 X 11 = 23	1,000 - 10,000
	2 x 15 = 30	TW	2 X 8 = 16	N/A	N/A	1 x 12 + 2 x 11 = 34	1,500 - 15,000
	2 x 17 = 34	TW	N/A	1 X 6 = 6	N/A	1 x 12 + 2 x 11 = 34	1,500 - 15,000
	2 X 11.5 = 23	TW	N/A	1 X 6 = 6	N/A	1 x 12 + 3 x 11 = 45	5,000 - 20,000
	2 x 12 = 24	TW	N/A	N/A	N/A	5 x 11 = 55	10,000 - 25,000
100	2 x 13.5 = 27	TW	2 x 8 = 16	1 x 6 = 6	N/A	1 x 12 + 3 x 11 = 45	5,000 - 20,000
	2 x 14 = 28	TW	2 x 8 = 16	N/A	N/A	1 x 12 + 4 x 11 = 56	10,000 - 25,000

* - Minimum Sidewalk width is a minimum of 6 feet.

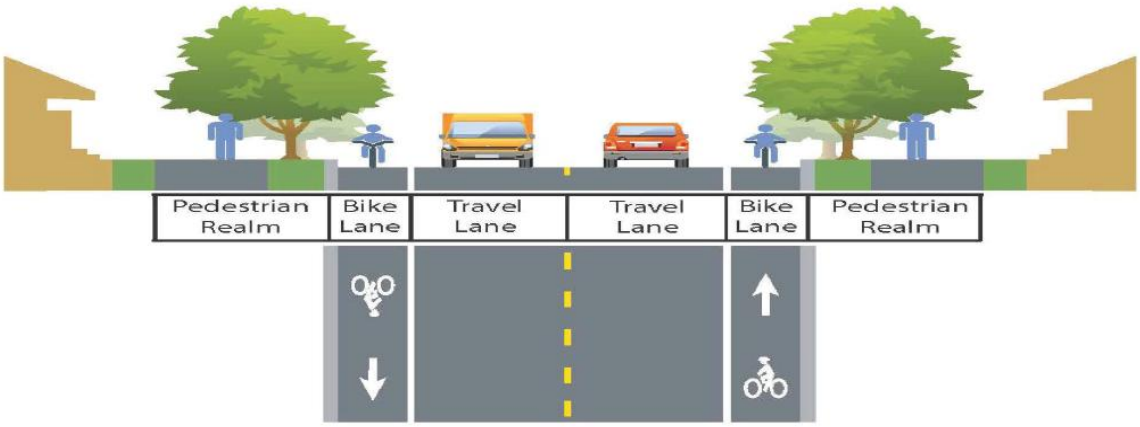




Residential Street Designation							
Minimum R.O.W (feet)	Pedestrian Realm* (feet)	Tree Well or Swale	On-Street Parking (feet)	Bike Lane (feet)	Median Width (ft)	Lane Widths (feet)	ADT (vpd)
50	2 x 12 = 24	TW	N/A **	N/A	N/A	2 x 13 = 26	500 - 5,000
60	2 x 9 = 18	2 x 8 = 16	N/A **	N/A	N/A	2 X 13 = 26	500 - 5,000
	2 x 11 = 22	TW	2 X 8 = 16	N/A	N/A	2 X 11 = 22	500 - 5,000
	2 x 13 = 26	TW	N/A	2 X 6 = 12	N/A	2 X 11 = 22	500 - 5,000

* - Minimum Sidewalk width is a minimum of 5 feet.

** - While space is not specifically set aside for parking, parking may be allowed on a 26' wide residential street.



City of Houston

Design Manual

Chapter 11

GEOTECHNICAL AND ENVIRONMENTAL REQUIREMENTS

Chapter 11
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Chapter 11

GEOTECHNICAL AND ENVIRONMENTAL REQUIREMENTS

SECTION 1 - GEOTECHNICAL AND ENVIRONMENTAL OVERVIEW

11.1.01 CHAPTER INCLUDES

11.1.01.A Section 2: Includes minimum Geotechnical Investigation Requirements for projects inside the city limits of Houston and within its extra territorial jurisdiction (ETJ).

11.1.01.B Section 3: Includes minimum Phase I Environmental Site Assessment (ESA I) and Phase II Environmental Site Assessment (ESA II) Requirements for land involved in the City of Houston real estate transactions, interdepartmental transfers, ETJ, and rights-of-way which will be involved in the construction projects.

11.1.01.C Section 4: Includes minimum Engineer of Record efforts and Drawing requirements.

11.1.02 REFERENCES

The latest versions of the following references shall be reviewed in conjunction with this chapter:

11.1.02.A The American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures.

11.1.02.B The American Society for Testing and Materials (ASTM) standard test methods and environmental site assessments processes.

11.1.02.C The City of Houston's Standard Construction Specifications.

11.1.02.D The Harris County Flood Control District's (HCFCD) Geotechnical Investigation Guidelines.

11.1.02.E The Houston Geological Society (HGS) requirements for conducting fault studies.

11.1.02.F Rules and regulations published by the Occupational Safety and Health Administration (OSHA).

11.1.02.G Rules and regulations published by the Texas Commission on Environmental Quality (TCEQ).

11.1.02.H Rules and regulations published by the Texas Department of Licensing and

11.1.02.H continued Regulation (TDLR) including Texas Administrative Code (TAC) Chapter 76 - Water Well Drillers and Water Well Pump Installers.

11.1.02.I Rules and regulations published by the Texas Board of Professional Engineers and Land Surveyors (TBPELS).

11.1.02.J Geotechnical Manual issued by the Texas Department of Transportation (TxDOT).

11.1.02.K The Texas Manual on Uniform Traffic Control Devices (TMUTCD).

11.1.03 DEFINITIONS

11.1.03.A Engineer of Record - Project Civil Design Consultant.

11.1.03.B Project Manager - An authorized representative of the City of Houston who manages the project or the Engineer of Record for private development.

11.1.03.C Geotechnical Consultant – A consultant who is practicing in the field of Geotechnical Engineering in the State of Texas and has a valid status with TBPELS.

11.1.03.D Geotechnical Baseline Report (GBR) – An interpretive report that establishes a contractual baseline of the subsurface conditions for bidding.

11.1.03.E Environmental Consultant – A consultant who is practicing in the environmental field.

11.1.03.F Environmental Professional - An individual who is meeting the education, training, and experience requirements as set forth in 40 CFR 312.10(b).

11.1.03.G Licensed Engineer - An engineer currently licensed to practice engineering in the State of Texas and is in good standing with the TBPELS.

11.1.03.H Licensed Geoscientist - A geoscientist currently licensed to practice geosciences in the State of Texas and is in good standing with the Texas Board of Professional Geoscientists.

11.1.03.I Potentially Petroleum Contaminated Area (PPCA) – An area, within station-to-station locations, identified where petroleum contamination has been detected in the soil or groundwater.

SECTION 2 - GEOTECHNICAL REQUIREMENTS

11.2.01 GEOTECHNICAL REQUIREMENTS

11.2.01.A A detailed Geotechnical Investigation (by borings) is required for the completion of the design of the proposed facilities. Subsurface information from the earlier project design activities shall be incorporated if it is sufficient and reliable for the current project as determined by the Project Manager in consultation with the Geotechnical Consultant.

11.2.01.B The purpose of the Geotechnical Requirements is to outline the minimum recommended procedures for implementing a uniform approach for the preparation of the Geotechnical Investigation Reports on the City of Houston projects including its ETJ.

11.2.01.C The scope of the Geotechnical Investigation may need to be expanded or modified on a case by case basis as determined necessary and appropriate by the Project Manager. It is not the intent of the Geotechnical Requirements to specify methods or scope of Geotechnical Investigation for individual projects, or to supplant the judgment of the Licensed Engineer. No provision in these requirements should be construed to constitute a statute, ordinance, or regulation, unless stipulated elsewhere.

11.2.01.D In the event that any part of the Geotechnical Requirements should be found to be in conflict with laws or regulations of competent jurisdiction or ruled to be invalid by a court authority of competent jurisdiction, the remainder of the Geotechnical Requirements shall remain in full force and effect, and the conflicting section or item shall be deleted or revised as required and as determined necessary by the City of Houston.

11.2.01.E These Geotechnical Requirements are not applicable when another agency (e.g. HCFCD) will maintain the facility, or the funding source (e.g. TxDOT) has specific requirements that must be met in order to receive funding for the project. In which case, another agency's requirements shall be applicable.

11.2.01.F Not all of the information in this chapter will be applicable to every project, but the investigative scope should be consistent with the sensitivity of the intended use and the physical constraints of the project.

11.2.02 GEOTECHNICAL CONSULTANT'S EFFORTS

11.2.02.A The Geotechnical Consultant shall confirm with the Engineer of Record that the proper scope of the project is proposed in the proposal.

11.2.02.B The Geotechnical Consultant shall include the project description, location, and Key Map Number(s) in the geotechnical proposal. Also, a proposed Plan of Boring(s) may be included in the geotechnical proposal, if available.

11.2.02.C The Geotechnical Consultant has a responsibility to obtain the latest information of the project from the Engineer of Record before starting the field investigation. If modifications are required in the original Geotechnical Investigation scope, then the Project Manager shall be contacted by Engineer of Record before commencement of the field investigation.

11.2.02.D The planning of field investigation, laboratory testing, engineering analyses, and close supervision of the work shall be performed by a Licensed Engineer of the Geotechnical Consultant who has experience in this type of work.

11.2.02.E All Geotechnical Laboratory tests shall be conducted by the Geotechnical Consultant with current accreditation by the American Association of Laboratory Accreditation (A2LA) or any other accreditation agency approved by the City of Houston.

11.2.02.F The Geotechnical Consultant is responsible for adhering to all pertinent federal, state, and local regulations and laws throughout the Geotechnical Investigation.

11.2.03 SITE ACCESS

11.2.03.A When the Geotechnical Investigation will be within the public right-of-way and easement, the Geotechnical Consultant shall obtain necessary permits and arrange for access to boring locations from the appropriate governmental agency.

11.2.03.B When the Geotechnical Investigation will require entry onto a private property, the Geotechnical Consultant may require assistance from the Engineer of Record in obtaining permission to enter in the private property.

11.2.03.C It shall be the ultimate responsibility of the Geotechnical Consultant to ensure necessary permits are obtained before commencement of drilling for the project.

11.2.04 TRAFFIC CONTROL

11.2.04.A The Geotechnical Consultant is responsible for the safety of drilling work area during field operations, including traffic control commensurate with the traffic while working in the street right-of-way.

11.2.04.B Traffic control shall be in accordance with the TMUTCD.

11.2.04.C Provide a Certified Flagman to control movement of vehicular and pedestrian traffic when field investigation encroaches on public traffic lanes. Provide a Uniformed Peace Officer for work along major thoroughfares and at signalized intersections.

11.2.05 FAULT INVESTIGATION

11.2.05.A As a part of the Geotechnical Investigation, geologic fault maps, aerial photographs, and literature available in Geotechnical Consultant's library shall be reviewed to evaluate the potential for known active faults that may impact the project.

11.2.05.B If a review of available existing information suggests that a known fault may impact the project, a Phase I Geological Fault Study shall be performed as defined by the current HGS guidelines.

11.2.05.C At a minimum, the Phase I Geological Fault Study shall consist of a detailed literature review, a remote sensing study with examination of historical aerial photographs (including LiDAR and false color infra-red imagery), a study of subsurface geologic structure maps, topographic maps, and a detailed field reconnaissance.

11.2.05.D If the project is part of a larger tract for which a Phase I, II, or III Geological Fault Study is available, the results of the study on the larger tract may satisfy this requirement. In this circumstance, the necessity of a Phase I Geological Fault Study shall be decided by the Project Manager.

11.2.05.E The Phase I Geologic Fault Study may also be conducted on areas where no faults appear in published literature and maps but when there is evidence that surface faults and possibly blind faults could exist in that area. In this circumstance, the necessity of a Phase I Geological Fault Study shall be decided by the Project Manager.

11.2.05.F When required, the Phase I Geological Fault Study shall be performed as a separate study to supplement the Geotechnical Investigation.

11.2.05.G The entire Phase I Geological Fault Study, when required, shall be performed by a licensed geoscientist or a Licensed Engineer in the State of Texas who has substantial experience and training in investigating surface faults in the Greater Houston area. At the least, such experience and training should include a general knowledge of the location of known surface faults in the Gulf Coast, an understanding of fault mechanics, and a familiarity with the many subtle ways that surface faults manifest themselves.

Additional criteria that shall be met by a licensed geoscientist or a licensed engineer are as follows:

1. Ability to recognize surface faults on aerial images and topographic maps.

2. Ability to distinguish surface faults from other natural and man-made features.

3. Ability to distinguish ground deformation caused by expansive clay soils from

11.2.05.G.3 continued that caused by active faults.

4. Ability to determine and map the width of the zone of disturbed ground along an active fault.

11.2.05.H At a minimum, the Phase I Geologic Fault Study shall determine the likelihood of a surface fault impacting the project along with estimated vertical and horizontal fault movements. If a fault is determined to be present at the project, it should be delineated on a map. In the event that the fault is clearly visible at the Earth's surface, the width of the fault's associated deformation zone should be determined and mapped. The mapping shall be considered as an additional study.

11.2.05.I When a fault is not clearly visible at the surface, its delineation and mapping may require an investigation employing Phase II and III subsurface methods. In this circumstance, the necessity of the Phase II or Phase III shall be decided by the Project Manager.

11.2.05.J The qualifications, including specific geologic fault project experience, of the professional performing the Phase I Geological Fault Study shall be included in the fault report.

11.2.05.K The draft report of the Phase I Geological Fault Study report shall be submitted before the final report.

11.2.05.L The final report of the Phase I Geological Fault Study shall be signed and may be stamped by the professional conducting the study.

11.2.05.M The Phase I Geological Fault Study Report, when required, shall be included in the appendix of the Geotechnical Investigation Report.

11.2.06 GENERAL INVESTIGATION

11.2.06.A Some of the facilities in which Geotechnical Investigation may be required are given below:

1. Above ground water storage tanks and associated structures.
2. Bridges (roadway, pedestrian, and pipe support).
3. Clarifiers and associated structures.
4. Detention/Retention basins.
5. Lift stations and associated structures.
6. Open channels.
7. Retaining walls.

11.2.06.A continued

8. Street pavement.

9. Traffic signal foundations.

10. Tunnels.

11. Underground utilities using open cut or trenchless methods.

11.2.06.B Geotechnical Investigation may also be required for:

1. Construction that could affect the integrity of adjacent structures (with the exception of interconnections such as service connections and meter vault installations).

2. Proposed construction work near ground slopes, such as drainage channels or natural waterway.

11.2.07 PROTECTION OF UNDERGROUND UTILITIES AND STRUCTURES

11.2.07.A On the public rights-of-way and easements, it shall be the responsibility of the Geotechnical Consultant to have existing utility lines marked and boring locations cleared prior to drilling.

11.2.07.B On private properties, it shall be necessary to employ the property owner's assistance to estimate the locations of the underground utilities and structures.

11.2.07.C Drilling shall not begin until clearance has been provided or notification that all underground utility lines are marked has been received by the Geotechnical Consultant.

11.2.07.D If there is any reason to believe that an underground facility exists in an area to be drilled, and its location cannot be determined with reasonable accuracy, then that boring shall be moved from the area of concern.

11.2.08 FIELD INVESTIGATION NOTIFICATIONS

11.2.08.A The Project Manager shall be informed (via email) about the start date of drilling approximately 48 hours prior to beginning drilling.

11.2.08.B If any unusual conditions are encountered during the field investigation (e.g., signs of contamination in the boring, cavity, underground utilities, loose or soft soils at the bottom of the planned boring depth, etc.), then the Project Manager shall immediately be informed.

11.2.09 FIELD INVESTIGATION

11.2.09.A The field logging of the soil samples shall be performed by an experienced soils technician of the Geotechnical Consultant.

11.2.09.B For the proposed open cut utility construction, the borings shall be drilled along or as close as possible to the center line of the alignment.

11.2.09.C For the proposed trenchless construction, the borings shall be drilled outside the planned utility alignment but within 20 feet of the centerline of the alignment.

11.2.09.D Soil Sample Methods and Intervals:

1. Undisturbed cohesive soils samples should be recovered by using a thin-walled tube sampler in general accordance with ASTM D1587. For granular soils, Split-Barrel samplers should be used in general accordance with ASTM D1586.

2. Continuous soil sampling shall be performed at about 2-foot depth intervals to a minimum depth of about 20 feet of the borings and at about 5-foot interval thereafter to the termination depth of borings with the exception for bridge, retaining wall, lift station, and tunnel borings. If the boring depth is less than 20 feet, then continuous sampling shall be performed to the termination depth of the boring.

3. If a soil boring for bridge or retaining wall is within the TxDOT right-of-way, then the current TxDOT guidelines shall be followed including performing Texas Cone Penetration (TCP) testing.

4. If a soil boring for bridge or retaining wall is outside the TxDOT right-of-way, then the TCP testing is not required. However, TxDOT sampling interval guidelines shall be followed.

5. For lift stations, continuous soil sampling shall be performed at 2-foot depth intervals from natural ground to 5-foot below the depth of the excavation.

6. For tunnels, continuous soil sampling shall be performed from two bore diameters (or minimum of 12 feet) above the bore crown to two bore diameters (or minimum of 12 feet) below the bore invert level and at about 5-foot intervals in the remainder of the boring.

7. If unusual soils are encountered (e.g., loose or soft soils, etc.) after the depth of 20 feet, then the intermittent soil sampling shall be changed to continuous soil sampling through the anomalous layer.

11.2.09.E Boring Spacing

1. Soil borings shall be conducted in order to obtain sufficient information about the subsurface soil stratigraphy and water level conditions.

11.2.09.E
continued

2. The recommended boring spacing is given in unless waived by the Project Manager in writing.

3. For geotechnical features that are not mentioned in Table 11.1, the Project Manager shall be contacted.

4. Based on the reliability of soil information available to the City of Houston from the previous project design activities, the recommended boring spacing may be modified by the Project Manager in consultation with the Geotechnical Consultant.

11.2.09.F Boring Depth

1. The minimum boring depths are given in Table 11.1, unless waived by the Project Manager in writing.

2. For geotechnical features that are not mentioned in Table 11.1, the Project Manager should be contacted.

3. Boring depth shall be increased by the Geotechnical Consultant if unusual soil conditions are encountered during field investigation (e.g., loose or soft soil at the bottom of the planned boring depth, etc.).

4. The depth of borings for paving in conjunction with utility work is governed by utility requirements.

Table 11.1 - BORING SPACING AND DEPTH

Project Type	Approximate Spacing	Minimum Depth
FACILITIES		
Above Ground Water Storage Tank	At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet.	At center: one tank diameter. At periphery: 0.75 tank diameter.
Electrical or Other Building	Depends on the size of the building and loading.	20 feet.

Project Type	Approximate Spacing	Minimum Depth
Clarifier	At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet.	At center: one clarifier diameter. At periphery: 0.75 clarifier diameter.
Lift Station (Less than 30-foot diameter)	At least one (1) soil boring within the footprint.	Proposed Lift Station depth plus: o At center: diameter of lift station o At periphery: 0.75 times diameter of lift station.
Lift Station (30-foot or larger diameter)	At center: One (1) boring at the center. At periphery: At a minimum spacing of 100 feet.	
DRAINAGE		
Detention / Retention Basin	The HCFCD guidelines should be followed.	
Open Channel	The HCFCD guidelines should be followed. In addition, one boring with a minimum depth of 30 feet to be drilled on each side of the channel and as close as safely possible to the channel.	
UNDERGROUND UTILITIES		
Open Cut	Minimum distance of 500 feet.	o 15 feet for trenches up to 10-foot deep. o Trench depth plus ten feet for trenches between 10-foot and 25-foot deep. o One and one half times the trench depth for trenches greater than 25- foot deep.
Augered	Minimum distance of 500 feet.	5-foot below the proposed invert level.
Tunnels and Microtunnels	Minimum distance of 250 feet.	Minimum one tunnel diameter or 15-foot below the proposed invert level (whichever is greater).

Project Type	Approximate Spacing	Minimum Depth
Shafts for Tunnels	Each Location.	One times the shaft diameter below the bottom of the shaft but not less than 30 feet.
STREET & BRIDGE		
Pavement (Street) only along each street	Maximum distance of 250 feet.	10 feet.
Pedestrian and Pipe Bridge	Each side of drainage channel.	40 feet below the bottom of drainage channel.
Retaining Walls	The TxDOT guidelines should be followed.	
Roadway Bridge	The TxDOT guidelines should be followed.	
Traffic Signal Foundation	Each location.	20 feet.
OTHER		
Discretion of Geotechnical Consultant, Engineer of Record, and the City of Houston.		

11.2.09.G Piezometers

1. Piezometers may be included in the scope of the Geotechnical Investigation if the project includes any of the following:

   a. Excavation exceeding 15 feet in depth.

   b. Crossing underneath a major drainage channel.

   c. Crossing underneath a major TxDOT or the Harris County Toll Road Authority corridor.

   d. Tunneling (hand or Tunnel Boring Machine) or Microtunneling installation for an extended length.

2. Piezometers shall be installed in accordance with the applicable rules and regulations of TDLR.

3. A minimum of two water level readings are required on each piezometer. The Geotechnical Consultant shall read water levels at 24 hours and 30 days (long term) after the installation of the piezometer, unless otherwise approved by the Project Manager.

11.2.09.G continued

4. For utility lines, spacing between piezometers shall be no greater than 2,500 feet in any direction.

5. One piezometer shall be installed within the footprint of a proposed deep structure, such as wet well or access shaft.

6. The Piezometer Installation Report (as shown on Figure 11.1) shall be included in the Geotechnical Investigation Report.

11.2.10 SITE RESTORATION

11.2.10.A The Geotechnical Consultant shall be responsible for clean up and site restoration upon completion of the field investigation.

11.2.10.B If for any reason the borehole must remain open, then appropriate measures shall be taken by the Geotechnical Consultant to protect the safety of the public.

11.2.10.C Plugging of Piezometer(s).

1. The Geotechnical Consultant shall plug piezometer(s) installed for the project in accordance with the TDLR (Chapter 76 of TAC) soon after measuring long term water level readings. A copy of Piezometer Installation and Plugging Reports (submitted to the TDLR) shall be included in the Geotechnical Investigation Report.

11.2.10.D Backfilling of Borings.

1. All borings under the existing or proposed pavement shall be backfilled with cement bentonite grout using the tremie method.

2. In unpaved areas where boring depth exceeds 10 feet (or if free water is encountered) boreholes shall be backfilled with cement bentonite grout using the tremie method. For depths of 10 feet or less, soil backfill tamped into the borehole is acceptable.

3. Boreholes in known contaminated areas, or in which contamination otherwise has been detected, shall be backfilled with cement-bentonite or non-shrink grout using tremie method.

11.2.10.E Restoration of Pavement Cores.

1. Boreholes or cored pavements shall be restored for the full depth of pavement using cold patch in asphalt paved areas and ready-mix concrete in concrete paved areas. Larger penetrations shall be repaired following the current City of Houston guidelines.

11.2.10.E continued

2. The pavement shall not be restored until the borehole grout has taken initial set to allow for any settlement or shrinkage of the grout.

11.2.11 SURVEY REQUIREMENTS

11.2.11.A The locations and elevations of boreholes and piezometers shall be surveyed by the Engineer of Record or another member of the project team.

11.2.11.B The elevation and coordinates shall be shown on boring and piezometer logs by the Geotechnical Consultant.

11.2.11.C The station and offset of boreholes and piezometers may also be shown on boring and piezometer logs (in addition to coordinates) by the Geotechnical Consultant.

11.2.11.D Boring survey information shall meet the minimum technical standards set forth in the City of Houston Infrastructure Design Manual (IDM), Chapter 13, Geospatial Data Deliverables.

11.2.12 LABORATORY TESTING

11.2.12.A The purposes of the laboratory testing are to define the soil classification, soil stratigraphy, and the relevant engineering properties of the soils.

11.2.12.B The laboratory tests shall be performed in general accordance with the latest revision of the ASTM standards.

11.2.12.C The laboratory tests may include but not limited to the following:

1. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Modified Unified Soil Classification System)
2. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
3. ASTM D1140 - Standard Test Methods for Amount of Material in Soils Finer Than the No. 200 (75-µm) Sieve
4. ASTM D2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
5. ASTM D2166 - Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
6. ASTM D2850 - Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils

11.2.12.D The selection of appropriate laboratory tests beyond the above tests is left to the discretion of the Geotechnical Consultant in consultation with the Project Manager.

11.2.12.E To assist in properly classifying the soils in general accordance with ASTM D2487, the laboratory testing program shall include a minimum of one set of Liquid and Plastic Limits (ASTM D4318) and Percent Passing Number 200 Sieve (ASTM D1140) tests on a representative cohesive soil sample in each boring.

11.2.12.F The water content test (ASTM D2216) shall be performed on all cohesive soil samples to determine the moisture profile.

11.2.12.G The Unconfined Compression Strength test (ASTM D2166) shall not be performed on a soil sample containing seams or slickensides.

11.2.12.H If the invert level of the utility is greater than 5 feet, a minimum of one Unconsolidated- Undrained Triaxial test (ASTM D2850) shall be performed on a representative cohesive soil sample in each boring.

11.2.12.I Aggressivity tests (Sulfates, Chlorides, pH, and Electric Resistivity) shall be performed on soil and water samples. Geotechnical Consultant shall not discard soil samples without ensuring from Engineer of Record that corrosion monitoring and/or corrosion control recommendations are made and soil samples are not needed.

11.2.12.J All the test results shall be summarized in the report in a table format. The Geotechnical Consultant shall include the summary of the test results on the most updated template format (or approved equal), as provided by the City of Houston (as shown on Figure 11.2).

11.2.13 BORING LOG FORMAT

11.2.13.A The Geotechnical Consultant shall submit the boring log on the most updated template format (or approved equal), as provided by the City of Houston and shown on Figure 11.3.

11.2.13.B The City of Houston project number shall be written on all boring logs.

11.2.13.C Any test data that is not included in boring log shall be reported separately in general accordance with the reporting guidelines mentioned in the ASTM standard of that test.

11.2.14 BORING LOG PROFILE

11.2.14.A When more than one borings are drilled for the project, boring log profile(s) along the project alignments(s) shall be included in the Geotechnical Investigation Report as shown on Figure 11.4.

11.2.14.B If the invert depths of utility line are known, then utility line shall be plotted on the boring log profile(s) as shown on Figure 11.4.

11.2.15 ENVIRONMENTAL CONCERNS

11.2.15.A The Geotechnical Consultant shall look for obvious signs of visual staining of the soil samples, note any odors (specifically of hydrocarbon nature) during drilling, and summarize this information in the report.

11.2.16 GEOTECHNICAL INVESTIGATION REPORT - GENERAL REQUIREMENTS

11.2.16.A The Geotechnical Investigation Report shall be an in-depth evaluation that entails a review of available pertinent literature, geologic fault information, field subsurface investigation, laboratory testing, engineering analysis of the data obtained, and recommendations concerning the proposed facilities.

11.2.16.B The content of the Geotechnical Investigation Report shall be project specific.

11.2.16.C The Geotechnical Consultant shall review any soil information (provided by the Project Manager) that may be available from the previous project design activities. The summary is to be included in the Subsurface Conditions section of the Geotechnical Investigation Report. The boring logs and the plan of borings shall be included in the appendix of the Geotechnical Investigation Report.

11.2.16.D Any illustration containing copyright information (e.g., aerial views from the Internet or Key Map for Plan of Borings, Vicinity Map, etc.) shall have proper reproduction permission and credits written on the illustration.

11.2.16.E All drawings (including drawings for the slope stability analyses) shall be at a scale available on a standard engineering scale.

11.2.16.F The pavement design shall be in accordance with the latest edition of the AASHTO Guide for Design of Pavement Structures.

11.2.16.G The Geotechnical Consultant shall perform a quality control review of the Geotechnical Investigation Report before its submittal. The Engineer of Record shall provide a separate review of the Geotechnical Investigation Report prior to its submittal.

11.2.16.H For the City of Houston projects, the Geotechnical Consultant shall submit a Draft Geotechnical Investigation Report (hard copy) to the City of Houston for review

11.2.16.H continued prior to submitting the Final Geotechnical Investigation Report. The title of the report shall identify if the report is a draft or final report.

11.2.16.I The Final Geotechnical Investigation Report shall be signed and sealed by a Licensed Engineer.

11.2.17 GEOTECHNICAL INVESTIGATION REPORT – RECOMMENDATIONS

The minimum geotechnical recommendations shall address the following:

11.2.17.A	Open-Cut Installation:	Bedding, backfill, excavation wall and bottom stability, thrust restraint, dewatering, and pipe design parameters.
11.2.17.B	Auger Installation:	Soil design parameters, ground stability, auger pit excavation stability, and dewatering.
11.2.17.C	Tunnels and Shafts:	External pressures on primary and permanent liners, wall and bottom stability, and dewatering. If the shaft is expected to be within PPCA, then recommendations other than dewatering for the shaft construction shall be included (e.g., sheet piling).
11.2.17.D	Open Channel:	Slope angle or slope ratio, setback distance for structures or appurtenances included in the project, and erosion protection.
11.2.17.E	Detention Pond:	Slope angle or slope ratio, setback distance for structures or appurtenances included in the project, and erosion protection

11.2.17.F Paving:

1. The requirements in Chapter 10 "Street Paving Design Requirements" of the City of Houston Infrastructure Design Manual shall be followed.

2. For rigid paving: At a minimum, the pavement thickness and minimum subgrade treatment shall be included. All the selected design parameters used in obtaining the pavement thickness shall be provided in the report.

3. For flexible paving: At a minimum, the design Structural Number (SN), recommended pavement section and its SN, and subgrade treatment shall be included. All the selected design parameters used in obtaining the pavement thickness shall be provided in the report.

11.2.17.F continued

4. For overlay projects, recommendations for rehabilitation shall be provided.

11.2.18 GEOTECHINCAL INVESTIGATION REPORT - TABLE OF CONTENTS

11.2.18.A The Geotechnical Investigation shall be presented in report including the text sections, tables, illustrations, and appendices as shown below:

Transmittal Letter - The transmittal letter in accordance with the TBPELS rules.

Executive Summary - Summarize the work performed for the project including findings and recommendations.

Table of Contents (with page numbers)

1. Introduction
    a. General
    b. Authorization
    c. Location and Description of the Project
    d. Purpose
    e. Scope
2. Field Investigation
    a. General
    b. Geotechnical Borings
    c. Piezometer Installation
3. Laboratory Testing
4. Subsurface Conditions
    a. Geology
    b. General Fault Information
    c. Soils Stratigraphy
    d. Soils Stratigraphy from the Previous Project Design Activities (if applicable)
    e. Water Levels

11.2.18.A
continued

5. Engineering Analyses and Recommendations

6. Construction Considerations

7. Limitations

8. Tables

    a. Summary of Boring Information (Number, depth, survey information with baseline and datum). The survey coordinates shall be as per Texas South Central Zone No. 4204 State Plane Grid (not surface) Coordinates (NAD83).

    b. Geotechnical Design Parameters

    c. Summary of Test Results

9. Illustrations (varies based on the project requirements, using 8.5 x 11 pages)

    a. Vicinity Map

    b. Fault Map

    c. Plan of Borings

    d. Boring Log Profile (showing utility lines)

    e. Earth Pressure Diagrams

    f. Thrust Force

    g. Liner Load

    h. Vertical Stress on the Pipe

    i. Stability of Bottom for Braced Cut

    j. Uplift Resistance

    k. Pile/Shaft Capacity Curves

    l. Any other relevant illustration

10. Appendices (several of the following may be combined in one appendix)

11.2.18.A.10 continued

a. Boring Logs

b. Piezometer Installation Report (Figure 11.1 and report submitted to the TDLR)

c. Piezometer Plugging Report (report submitted to the TDLR)

d. Grain Size Distribution Curves (if applicable)

e. CU, Pinhole, or any other test results (if applicable)

f. Slope Stability Analyses Information (if applicable)

g. Fault Study Report (if applicable)

h. Pavement Design Calculation

i. Information from the Previous Project Design Activities (if applicable)

j. Any other relevant information

11.2.18.B When required, a separate Trench Safety Report shall be provided for the City of Houston projects. The Trench Safety Report shall satisfy statutory requirements for contracting for trench safety construction.

11.2.18.C The Geotechnical Consultant shall provide an electronic version (in pdf format) of the entire Final Geotechnical Investigation Report (one file).

11.2.18.D The Geotechnical Consultant shall also provide electronic files of the final boring logs. The files must be compatible with input files used by "gINT" LogWriter software.

11.2.18.E The "Summary of Laboratory" tables shall also be as specified in the City of Houston IDM, Chapter 13, Section 13.4.04 - Geotechnical and Environmental Information.

11.2.19 GEOTECHNICAL BASELINE REPORT

11.2.19.A For tunneling and/or Microtunneling projects, a GBR may be required on a case by case basis (e.g., major structures, major bayous, etc.).

11.2.19.B GBR must be conducted in general accordance with the guidelines in the latest version of the ASCE publication “Geotechnical Baseline Reports for Construction.”

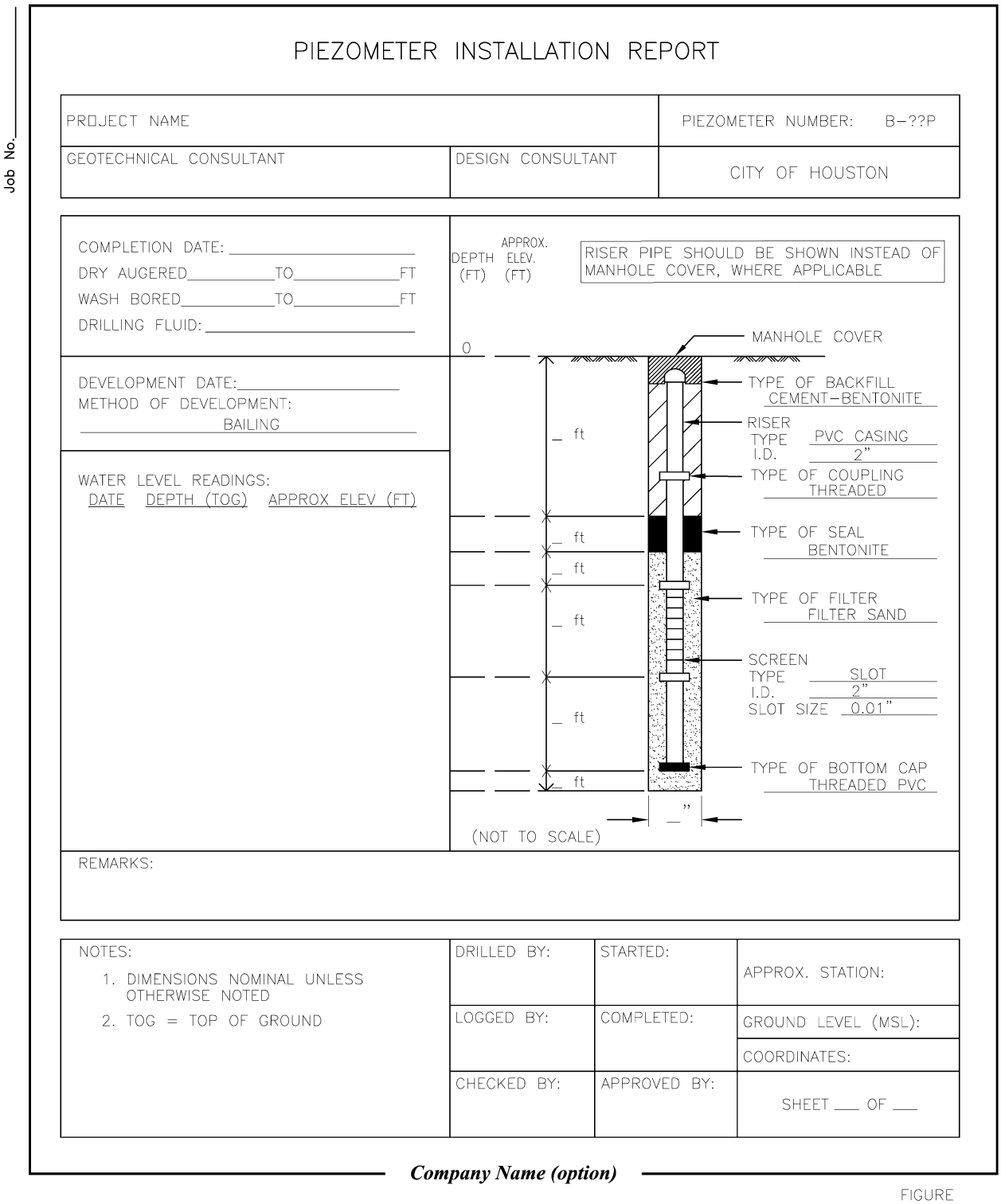


Figure 11.1 - PIEZOMETER INSTALLATION REPORT FORMAT

SUMMARY OF LABORATORY TEST RESULTS

PROJECT NAME:

COH WBS NUMBER:

Geotechnical Consultant's Name

CONSULTANT PROJECT NUMBER:

BORING NO.	SAMPLE NO.	SAMPLE DEPTH (FT) Top	SAMPLE DEPTH (FT) Bottom	SAMPLE TYPE	SPT (BLOWS/FT)	WATER CONTENT (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS LL (%)	ATTERBERG LIMITS PL (%)	ATTERBERG LIMITS PI (%)	PERCENT PASSING SIEVE 200 (%)	SHEAR STRENGTH (TSF) UNCONFINED COMPRESSION TEST	SHEAR STRENGTH (TSF) UU TEST (CONFINING PRESSURE, TSF)	SHEAR STRENGTH (TSF) TORVANE	SHEAR STRENGTH (TSF) POCKET PENETR-OMETER	TYPE OF MATERIAL
B-1	1	0.0	0.5	AG		25										Fat Clay
	2	0.5	2.0	UD		23	100	68	24	44	95	1.5		2.0	2.0	Fat Clay
	3	2.0	4.0	UD		22							1.25 (0.4)	1.5	1.5	Fat Clay
	4	4.0	5.5	SS	22	12					35					Silty Sand
B-2	1															

LEGEND

UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD
SS = SPLIT SPOON SAMPLE
AG = AUGER CUTTINGS
SPT = STANDARD PENETRATION TEST

LL = LIQUID LIMIT
PL = PLASTIC LIMIT
PI = PLASTICITY INDEX
UU = TRIAXIAL COMPRESSION

NOTES:

FIGURE

Figure 11.2 - SUMMARY OF TEST RESULTS FORMAT

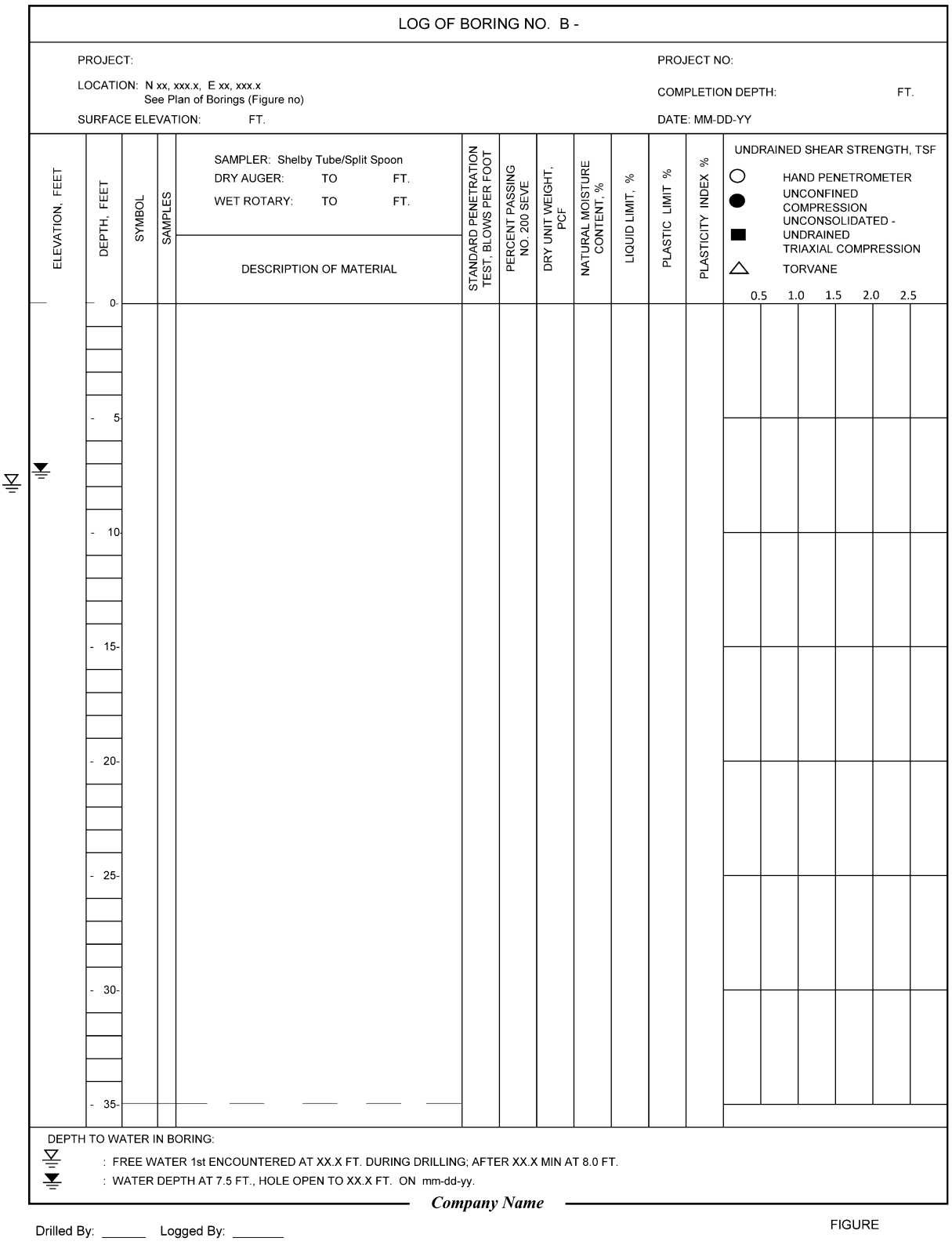


Figure 11.3 – BORING LOG FORMAT

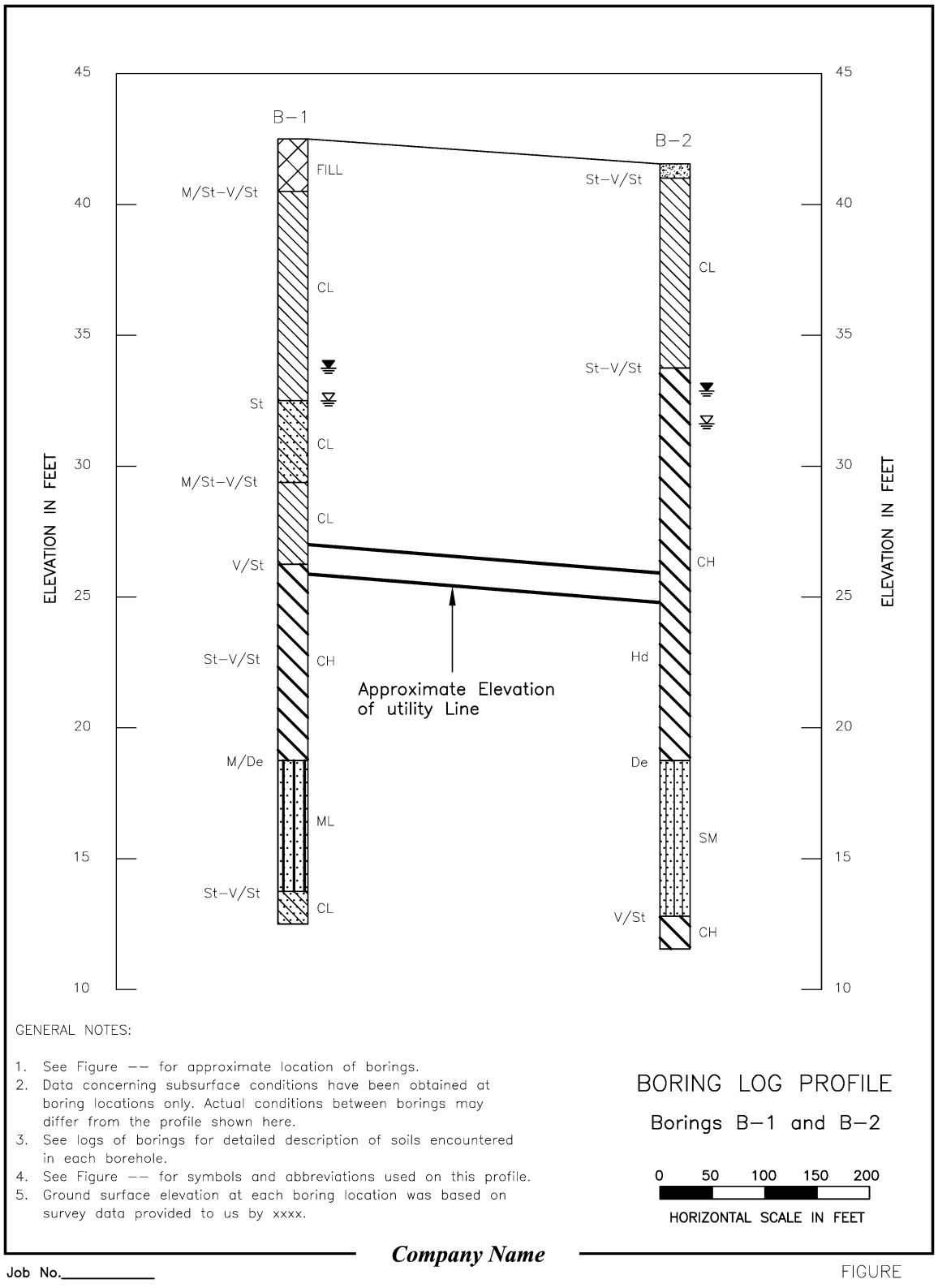


Figure 11.4 - BORING LOG PROFILE FORMAT

SECTION 3 - ENVIRONMENTAL REQUIREMENTS

11.3.01 PHASE I ENVIRONMENTAL SITE ASSESSMENT (ESA I) REQUIREMENTS

This section categorizes various types of projects that require an ESA I and sets a minimum scope of work for:

11.3.01.A Property to be acquired by the City of Houston and property involved in divestitures and inter-departmental transfers; and

11.3.01.B The City of Houston construction projects.

11.3.02 PROPERTY TO BE ACQUIRED BY THE CITY OF HOUSTON AND PROPERTY INVOLVED IN DIVESTITURES AND INTER-DEPARTMENTAL TRANSFERS

The ESA I/ESA I Update conducted on a property to be acquired by the City of Houston shall conform to the latest ASTM Standard Practice E1527 with the following stipulations:

11.3.02.A The sources of historical data reviewed for a property shall include, at a minimum, historical aerial photographs, Sanborn fire insurance maps (where available), local city street directories (where available), and United States Geological Survey (USGS) maps. The chain-of-title search is not required as an historical search. Applicable copies of these sources shall be presented in the report. Since City Directories are copyright protected, copies of these should not be presented in the report. One aerial photograph for every five to ten years interval from approximately 1950 to the present shall be obtained of an appropriate scale between 1” = 500’ and 1” = 700’, to clearly indicate property details. Properties inside the IH-610 Loop shall have property usage identified from the present, back a minimum of 100 years (where available), or to the property's obvious first development, whichever is earlier.

11.3.02.B If regulatory records indicate that Leaking Petroleum Storage Tank (LPST) facilities are located within approximately 500 feet of the property, the latest comprehensive assessment or monitoring report maintained on the facility by the TCEQ (Houston District Office) shall be reviewed and summarized in the report. All record reviews shall be conducted during the ESA I process.

11.3.02.C If regulatory records indicate that a federal superfund facility, or Texas Hazardous Waste Sites (HWS)/Texas State Superfund Sites is located within approximately ¼ mile of the site, the files maintained on that facility by the TCEQ shall be reviewed and summarized in the report.

11.3.02.D The TCEQ's Voluntary Cleanup Program (VCP) governmental regulatory database shall be searched for facilities that are located within approximately 500 feet of the property.

11.3.02.E If the project includes demolition/renovation of buildings/structures, the report

11.3.02.E continued shall include recommendation for asbestos survey.

11.3.02.F If the project includes renovation of buildings/structures constructed before 1978, the report shall include recommendation for lead based paint survey.

11.3.02.G If the property includes undeveloped land, available wetlands maps shall be obtained and reviewed, the presence of hydric soil types shall be reviewed using published information, and the presence of standing or flowing water shall be investigated during the site reconnaissance. The environmental professional shall make a statement in the report concerning the potential for the presence of wetlands on the property and whether or not full wetlands determination delineation is needed.

11.3.02.H If the property is in an area of known oil and gas production operations, a record search for oil and gas exploration and production wells on or adjacent to the property shall be included in the report.

11.3.02.I Flood Insurance Rate Maps (FIRM) available from the Federal Emergency Management Agency (FEMA) shall be reviewed to identify areas of the property located within flood plains.

11.3.02.J A minimum of five interviews (where applicable) shall be conducted in accordance with the latest ASTM E1527 Standard Practice.

11.3.02.K The environmental professional who conducted the ESA I shall make recommendations for an ESA II, as appropriate, which shall be thorough enough to support an ESA II.

11.3.02.L The environmental Consultant shall submit an Environmental Site Assessment Draft Report (hard and an electronic copies) to Houston Public Works for review prior to submitting the Environmental Site Assessment Final Report. The title of the report shall identify if the report is a draft or final report. At minimum, hard copies of the executive summary section of the governmental regulatory database including radius maps and pages pertinent to the sites of recognized environmental conditions (REC) discussed shall be included in the report. The report and the complete governmental regulatory database shall be included in the attached electronic copy. The electronic copy of the report shall be in the pdf format.

11.3.03 THE CITY OF HOUSTON CONSTRUCTION PROJECTS

The ESA I/ESA I Update conducted on rights-of-way which will be involved in City construction projects shall conform to the latest ASTM Standard Practice E1527 with the following stipulations:

11.3.03.A The approximate minimum search distance for Standard Environmental Record Sources may be reduced, pursuant to ASTM E1527, to a radius of 500 feet unless there is a justifiable reason to maintain a larger radius; except the minimum search

11.3.03.A continued

distance for Federal National Priorities List (NPL), Federal Resource Conservation and Recovery Act - Treatment, Storage, and/or Disposal (RCRA TSD) Facilities, and Texas Hazardous Waste Sites (HWS)/Texas State Superfund Sites shall be maintained at the ASTM specified distance of 1.0 mile.

11.3.03.B The sources of historical data reviewed for the alignment/parcel shall include, at a minimum, historical aerial photographs, Sanborn fire insurance maps (where available), local city street directories (where available), and United States Geological Survey (USGS) maps. The chain-of-title search is not required as an historical search. Applicable copies of these sources shall be presented in the report. Since City Directories are copyright protected, copies of these should not be presented in the report. One aerial photograph for every five to ten years interval from approximately 1950 to the present shall be obtained of an appropriate scale between 1" = 500' and 1" = 700', to clearly indicate the alignment/parcel details.

11.3.03.C If the project includes demolition/renovation of buildings/structures, the report shall include recommendation for asbestos survey.

11.3.03.D If the project includes renovation of buildings/structures constructed before 1978, the report shall include recommendation for lead based paint survey.

11.3.03.E If the project includes undeveloped land, available wetlands maps shall be obtained and reviewed. The environmental professional shall make a statement in the report concerning the potential for the presence of wetlands on/along the alignment/parcel and whether a full wetlands determination delineation is recommended.

11.3.03.F If the project includes undeveloped land, the environmental professional shall make a statement in the report that "Threatened and Endanger Species", and "Historical, Cultural, and Archeological" surveys are warranted.

11.3.03.G If the project involves construction of any infrastructure crossing or within a waterway easement, the environmental professional shall make a statement in the report that the jurisdictional authority should be consulted prior to construction.

11.3.03.H If the project is in or crossing an area of known oil and gas production operations, a record search for oil and gas exploration and production wells on or adjacent to the alignment/parcel shall be included and discussed in the report.

11.3.03.I The FIRM Map available from the FEMA shall be reviewed and discussed to identify areas of the alignment/parcel located within flood plains.

11.3.03.J A minimum of five interviews, where applicable, shall be conducted in accordance with the latest ASTM E1527 Standard Practice.

11.3.03.K The environmental professional who conducted the ESA I shall make recommendations for an ESA II, as appropriate, which shall be thorough enough to support an ESA II.

1. A regulated site listed in the governmental regulatory database with impacted soil and/or groundwater shall be considered for ESA II provided it is located adjacent to the alignment/parcel.

2. A historical site (gasoline, filling, and service stations, and dry cleaners) not currently listed in the governmental regulatory database shall be considered for ESA II provided it is located adjacent to the alignment/parcel.

3. A regulated site distant from the alignment/parcel can be considered for ESA II provided TCEQ (Houston office) has documents indicating that regulated site has impacted a large area including the alignment/parcel.

11.3.03.L The Environmental Consultant shall submit an Environmental Site Assessment Draft Report (hard and an electronic copies) to the City of Houston for review prior to submitting the Environmental Site Assessment Final Report. The title of the report shall identify if the report is a draft or final report. At minimum, hard copies of the executive summary section of the governmental regulatory database including radius maps and pages pertinent to the sites of recognized environmental conditions (REC) discussed shall be included in the report. The report and the complete governmental regulatory database should be included in the attached electronic copy. The electronic copy of the report shall be in the pdf format.

11.3.03.M The Phase I ESA report shall be formatted according to the latest ASTM E1527, Section 12.

11.3.04 PHASE II ENVIRONMENTAL SITE ASSESSMENT (ESA II) REQUIREMENTS

The primary objective for performing an ESA II is to evaluate the Recognized Environmental Conditions (REC) sites identified in the ESA I for the purpose of providing information regarding the nature and extent of contamination to assist in engineering design process. The ESA II shall conform to the latest ASTM Standard Practice E1903 with the following stipulations.

11.3.05 FIELD INVESTIGATION NOTIFICATIONS

The Environmental Consultant or Engineer of Record shall inform Houston Public Works' Technical Services (via email) 48 hours prior to drilling and sampling.

11.3.06 PROCEDURES

The following are the minimum requirements for an ESA II conducted on City of Houston construction projects, land acquisitions, and inter-departmental transfers.

11.3.06.A Field Activities

The location of the environmental borings shall be based on the judgement of the environmental professional.

1. *Frequency of samples –*

   a. For linear project, the borings shall be advanced incrementally (every one foot) to allow continuous sampling and screening. Three (3) or more borings (approximately 150 feet apart for a rough delineation) shall be drilled along the proposed excavation at each REC location.

   b. For non-linear project, the frequency and spacing of the borings should be determined by the environmental professional in consultation with Houston Public Works' Technical Services.

2. *Termination of boring* - Borings shall be advanced to a maximum depth of five (5) feet below the planned excavation. Borings may be advanced to greater depths if warranted by site-specific circumstances. If borings are terminated due to field conditions (e.g., obstructions), borings should be relocated at the discretion of the environmental professional.

3. *Cross-contamination* - To prevent cross-contamination, sampling and boring equipment shall be decontaminated prior to drilling each soil boring /collecting samples. Environmental professional shall follow applicable federal, state, and local regulations to prevent cross-contamination.

4. *Sampling procedure*:

   a. Soil

      (1) Obtain a minimum of one soil sample from each boring for laboratory analysis. Additional soil samples may be collected as deemed necessary by the environmental professional.

      (2) Perform field screening of all soil samples collected from borings.

      (3) The sample for laboratory analysis shall be collected from the zone exhibiting the highest Photoionization Detector/ (PID) reading. If the PID readings are non-detected, the sample shall be collected from the soil-groundwater interface. If no saturated zone exists, then the sample shall be collected from the bottom of the boring.

11.3.06.A.4.a continued

(4) Place all samples in clean pre-labeled containers composed of materials with the appropriate preservatives as required by the respective analytical method. To prevent volatilization, place samples on ice in an insulated cooler prior to and during transportation to the analytical laboratory.

b. Groundwater

If groundwater is encountered during drilling, one (1) groundwater sample shall be collected from each REC location. The groundwater sample shall be collected from a temporary installed sampling well.

c. Each boring log shall include the following:

(1) Soil classification according to ASTM D2488.

(2) Detection of hydrocarbon or other odors.

(3) Visible hydrocarbon or other contamination (if present, including degree, location, and extent of staining).

(4) PID readings.

(5) Other field screening as required by the type of contaminations.

(6) The depth at which groundwater was first encountered.

(7) Boring locations and log information shall be delivered in a digital format that meets the minimum technical standards set forth in the City of Houston IDM, Chapter 13, Geospatial Data Deliverables.

(8) Boring identification.

(9) City project number.

5. *Site Clean up and Restoration* - The environmental professional is responsible for the site clean up upon completion of field operations, commensurate with site conditions.

a. Generation of Waste

11.3.06.A.5.a continued

(1) Wastes may be generated during the assessment implemented as part of the ESA II (for example, drill cuttings and purged groundwater, etc.). The wastes generated during the assessment should be collected and stored in tightly fitted container(s).

(2) Wastes should be categorized according to the regulatory requirements and disposed at an approved facility within a 60-day time frame. All completed waste manifests are to be included in the ESA II final report or provided to the Project Manager.

(3) Techniques that minimize the generation of waste shall be utilized to the extent feasible, consistent with the information and data quality objectives of the planned assessment and applicable regulatory requirements.

b. Backfill of Borings

Completed borings shall be backfilled with cement-bentonite or non-shrink grout. Boreholes or other cored penetrations of pavements shall be restored with the same or equivalent materials as the existing pavement.

11.3.06.B Laboratory Analysis

1. Environmental Professional shall assign analytical testing in accordance with applicable United States Environmental Protection Agency (USEPA) and the TCEQ procedures.

2. Laboratory Documentation

a. Chain of Custody

A completed chain of custody record shall accompany each shipment of samples to the analytical laboratory and shall be included in the report.

b. Laboratory Results

Laboratory results for samples shall include the following:

(1) Date of collection.

(2) Date of extraction, analysis, and report.

(3) Extraction and analytical methods used.

(4) Method detection limits.

(5) Standard utilized in the analysis.

11.3.06.B.2.b continued

(6) Sample identification and depth.

(7) Laboratory QA/QC report.

11.3.06.C Report

1. Site Characterization

   a. The soil characteristics of significance to the design and construction work shall be described with particular emphasis on the occurrence of transmissive soils at or below the elevation in which contamination was detected, or which have potential for providing pathways for contaminant migration. Geologic characteristics, which affect the migration potential of a contaminant, shall be addressed.

   b. Potential sources of contamination shall be clearly described in the report. Areas of contamination within or adjacent to the alignment/parcel which were confirmed, and their spatial relationship to the planned construction activity, shall also be clearly identified.

2. Type of Contamination

   a. The report shall address the basis for determining which contaminants were potentially present and the methods that were used to verify their presence or absence. Where specific contaminants are present, the report is to describe the concentrations and indicate whether or not they are above relevant action levels.

3. Impact of Planned Construction

   a. The report shall describe, based on the available information, the estimated vertical extent and lineal extent (station-to-station) of the PPCA at the REC location. The determination of probable extent should be based on reasonable interpretation of both analytical and geological data. The report shall clearly address the following:

      (1) Comparison of contaminant concentration to regulatory criteria.

      (2) Potential for contaminated runoff entering the work area.

   b. The report shall address the potential impact of the contamination on the planned construction including the potential for contaminant impact on construction dewatering. Specifically, the report shall address the potential for migration of contamination from the investigated sources and plumes into the construction area, and due to groundwater withdrawal.

   c. A quality control review of the report shall be performed by the Engineer of Record, where applicable, before its submittal to Houston Public Works.

11.3.06.C continued

4. Recommendations

   The report shall provide recommendations for construction phase monitoring which should take into account:

   a. Vertical extent and Lineal extend (station-to-station) of PPCA.

   b. Worker protection and general health and safety.

   c. Potential contaminated media screening, testing, handling, and disposal consistent with Federal, State, and City Regulations and Specifications.

   d. PPCA investigation along the alignment shall begin and end at a clean boring. If the laboratory test results indicate that the PPCA cannot be determined (station-to-station) by the number of borings sampled at a REC site, the Environmental Professional shall inform the Engineer of Record and project manager for additional work.

5. Exhibits

   a. Site plan identifying the location of the REC's and boring locations.

   b. Boring locations and log information shall be delivered in a digital format that meets the minimum technical standards set forth in the City of Houston IDM, Chapter 13, Geospatial Data Deliverables.

   c. Analytical results including tables summarizing analytical results.

   d. Photographs of drilling activities.

6. The Environmental Consultant shall submit an Environmental Site Assessment Draft Report (hard and electronic copy) to Houston Public Works for review prior to submitting the Environmental Site Assessment Final Report. The title of the report shall identify if the report is a draft or final report. The electronic copy of the report shall be in .pdf format.

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11.4.01 ENGINEER OF RECORD'S EFFORTS

11.4.01.A The Engineer of Record, at the proposal stage of the project, shall work with the Geotechnical Consultant to develop the proper scope of the project.

11.4.01.B The Engineer of Record shall inform the Geotechnical Consultant of any changes in the project related to Geotechnical Investigation as soon as possible.

11.4.01.C The Engineer of Record shall assist the Geotechnical Consultant in obtaining required permits for drilling, if requested by the Geotechnical Consultant.

11.4.01.D The Engineer of Record shall provide survey information of the borings (after drilling) to the Geotechnical Consultant to be used in the Geotechnical Investigation Report. Boring survey information shall meet the minimum technical standards set forth in the City of Houston IDM, Chapter 13, Geospatial Data Deliverables.

11.4.01.E The Engineer of Record shall provide a base map using engineering scale (showing the alignments and/or structures) of the project to the Geotechnical Consultant that can be used as a Plan of Borings.

11.4.01.F The Engineer of Record shall verify the Geotechnical Investigation performed by the Geotechnical Consultant for conformance with the Geotechnical Requirements, project specific conditions, and design requirements.

11.4.01.G The Engineer of Record shall review the Geotechnical Investigation Report and attach their review comments with the Geotechnical Investigation Report prior to submittal to the City of Houston.

11.4.02 DRAWING REQUIREMENTS

11.4.02.A Bore Holes

The Engineer of Record shall include geotechnical boring information in the Drawings if both the project scope requires construction of tunnel shafts greater than 30 feet deep and the contract documents utilize City of Houston Standard Specification 02400-Tunnel Shafts. See IDM Chapter 3 for graphic requirements and example plan sheets.

11.4.02.B Precast Storm Manhole Foundations

The engineer of record shall select the foundation type and provide this information to the contractor in the contract documents.

END OF CHAPTER

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Chapter 12

STREET CUT REQUIREMENTS

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Chapter 12

STREET CUT REQUIREMENTS

SECTION 1 – STREET CUT REQUIREMENTS OVERVIEW

12.1.01 CHAPTER INCLUDES

12.1.01.A Criteria for street pavement cuts, excavation, backfill, and pavement restoration in Public Ways.

12.1.01.B This chapter applies to excavation in Public Ways which have been improved for street, sidewalk, surface drainage, or related public transportation infrastructure.

12.1.02 REFERENCES

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

12.1.02.B Rules and Regulations for Excavation in Public Way

12.1.02.C City of Houston

12.1.02.D City of Houston Street Cut Ordinance

12.1.02.E City of Houston Standard Details

12.1.03 DEFINITIONS

12.1.03.A Excavation - An activity that disturbs, alters, or penetrates any portion of the public way that has been improved for street, driveway, sidewalk, surface drainage, or related public transportation infrastructure purposes. The term includes but is not limited to cutting, tunneling, jacking and boring, backfilling, restoring, and repairing the public way. The term does not include a transportation improvement or maintenance of publicly owned utility systems, such as water and wastewater lines and facilities.

12.1.03.B Backfill - Excavation fill material that meets city specified quality requirements or the placement thereof.

12.1.03.C Facility - Any structure device improvements that may be installed or maintained in, or, within, under, over or above a public way by an excavation.

12.1.03.D Five - Year CIP - Street improvement projects included in a Capital Improvement Program by the City of Houston, Harris County, METRO, TxDOT, or other organization for construction.

12.1.03.E Hole - Excavation in the Public Way with the excavation having a length less than the width of the pavement.

12.1.03.F Patch - Method of pavement replacement that is temporary in nature. A patch consists of: (1) the compaction of the subbase and aggregate base, and (2) the replacement, in kind, of the existing pavement for a minimum of two feet beyond the edges of the excavation in all directions.

12.1.03.G Public Way - Any public street right-of-way located in the city, including the entire area between the boundary lines of every way (including but not limited to roads, streets, alleys, highways, boulevards, bridges, tunnels, or similar thoroughfares), whether acquired by purchase, grant, or dedication and acceptance by the City or by the public that has been opened to use of the public for purpose of vehicular travel.

12.1.03.H Restoration - The process by which an excavated public way and surrounding area, including pavement and foundation, is returned to the same condition or better that existed before excavation.

12.1.03.I Trench - An excavation in the pavement with the excavation having length equal to or greater than the width of the pavement.

SECTION 2 – STREET CUT DESIGN REQUIREMENTS

12.2.01 DESIGN REQUIREMENTS

12.2.01.A Design project so that restoration returns public way to the same or better condition that existed prior to excavation. Minimum limits and methods for pavement restoration shall be in accordance with City Standard Details 02951-01, 02951-02, 02951-03, 02951-04, and 02951-05.

12.2.01.B Comply with requirements for all open-cut construction including excavation for auger or directional drilling insertion pits.

1. Saw cut existing pavements along lines parallel to and perpendicular to traveled way center lines unless otherwise approved by the City Engineer.

2. For concrete pavements and for Hot Mix Asphaltic Concrete (HMAC), conform to requirements of the City of Houston Infrastructure Design Manual, Chapter 10 – Street Paving Design, paragraph 10.2.02 and Section 3 – Geometric Design Requirements.

3. Construction documents shall require that one lane of traffic be open at all times with a flagman and work zone signage at both ends of the construction unless otherwise provided on an approved traffic control plan.

4. For open-cut construction in street pavement, the drawings shall call for secured steel plate to be placed over open-cut sections whenever the contractor is not working within the open-cut area so that traffic will have full use of the roadway.

12.2.01.C Prepare plan view drawings for all excavations that identify and locate existing underground facilities. If excavation is greater than or equal to three (3) feet in depth, then drawings shall also include profile view. Driveway projects do not require a profile view. The drawings, or verification statements, shall confirm that the underground facilities have been identified, located, and marked by the following organizations:

1. Texas Underground Facility Notification Corporation

2. City of Houston Traffic Operations Division

12.2.01.D The City may require Plan and Profile drawings for complex projects or when the constructing agency has demonstrated previous non-compliance with underground facility location procedures.

12.2.01.E Plan view drawings shall be in accordance with Chapter 3 – Graphic Requirements in the City of Houston Infrastructure Design Manual.

12.2.01.F Final drawings shall include a list of City of Houston Standard Specifications and related standard details for excavation, bedding, backfilling, and pavement repair and resurfacing.

12.2.02 QUALITY ASSURANCE

12.2.02.A For projects which include conduits, duct banks or pipelines over one-inch, have final design drawings sealed, signed, and dated by the Professional Engineer responsible for development of the drawings.

END OF CHAPTER

City of Houston

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Chapter 13

GEOSPATIAL DATA DELIVERABLES

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Chapter 13

GEOSPATIAL DATA DELIVERABLES

SECTION 1 - GEOSPATIAL DATA DELIVERABLES OVERVIEW

13.1.01 CHAPTER INCLUDES

13.1.01.A Guidelines summarizing the geospatial data deliverables as referred to in the other chapters contained within the Infrastructure Design Manual (IDM) and GIS data in support of the Houston Public Works operations geospatial asset management and infrastructure.

13.1.02 BACKGROUND

13.1.02.A The City of Houston has adopted geographic information systems (GIS) technology in order to store, manage, and maintain spatially related geographic data. Houston Public Works (HPW) stores all its spatial assets within an enterprise geodatabase. It is a native data structure for ArcGIS, which is a collection of geographic datasets, including Feature Classes, Geometric Networks, raster data, attribute tables, annotation, Topology, etc. It provides the ability to leverage data relationships and enforce integrity using data-rich features. Its benefits include centralized data storage, efficient data delivery, Database Management Systems (DBMS) security and reliability, Geodatabase Replication, archiving, and multi-user editing.

13.1.02.B This chapter provides guidance for contractors and design consultants in developing and delivering digital geospatial data for public infrastructure projects, including but not limited to capital improvement projects (CIP) and developer participation contracts (DPC). Also included in this chapter is guidance for contractors in developing and delivering digital geospatial data for some privately owned and operated telecommunications projects. These datasets shall be provided in the City of Houston Enterprise GIS geodatabase model format. GIS digital deliverables for projects shall meet or exceed the requirements detailed in this chapter. It is not the intent of this chapter to be a training guide for AutoCAD, ArcGIS or other geospatial software and associated products.

13.1.03 REFERENCES

13.1.03.A City of Houston Code of Ordinances, Chapter 33 – Planning and Development, Article IV – City Surveys.

13.1.03.B City of Houston, Geospatial Data Deliverables Properties Guide, Current Edition.

13.1.04 DEFINITIONS

13.1.04.A Computer Aided Design (CAD) – Preparation of drawings, plans, prints, and other related documents through the use of computer equipment and software programs.

13.1.04.B Database Management System (DBMS) – A set of software applications used to create and maintain databases according to a Schema. They provide tools for adding storing, changing, deleting, and retrieving data.

13.1.04.C Engineer of Record – A professional engineer who seals drawings, reports or documents for a project.

13.1.04.D Feature Class – Homogeneous collections of features with a common spatial representation and set of attributes stored in a database table.

13.1.04.E Geodatabase Replication – A method of distributing data across two or more geodatabases in order to synchronize data changes. An entire geodatabase or a subset of a geodatabase can be replicated. There are three types of Geodatabase Replication: 2-way replication, 1-way replication, and check-out replication.

13.1.04.F Geometric Network – A set of connected edges and junctions, along with connectivity rules, that are used to represent and model the behavior of a common network infrastructure in the real world. Geodatabase Feature Classes are used as the data sources to define the Geometric Network.

13.1.04.G GNSS - Global Navigation Satellite System which includes USA Global Positioning System (GPS), Russian Global Navigation Satellite System (GLONASS), and other regional systems.

13.1.04.H Metadata – A unit of information used to describe a particular characteristic of the data.

13.1.04.I Project Manager – An authorized representative of the City of Houston who manages the project or the Engineer of Record for private development.

13.1.04.J Registered Professional Land Surveyor (RPLS) - A surveyor currently registered and in good standing with State of Texas Board of Professional Engineers and Land Surveyors (TBPELS).

13.1.04.K Schema – The structure or design of a database or database object, such as a table, view, index, stored procedure, or trigger. In a relational database, the Schema defines the tables, the fields in each table, the relationship between fields and tables, and the grouping of objects within the database.

13.1.04.L Topology – The spatial relationships between adjacent or neighboring features.

SECTION 2 - DATA ACCURACY

13.2.01 SPATIAL REFERENCES

13.2.01.A For information regarding the official coordinate system utilized by the City of Houston, refer to the City of Houston Code of Ordinances, Article IV, Chapter 33, Section 33-81, unless project requirements differ.

13.2.02 HORIZONTAL ACCURACY

13.2.02.A The horizontal accuracy of any feature shall meet or exceed submeter accuracies of two (2) feet horizonal root mean square (RMS).

SECTION 3 - GIS DATA COLLECTION METHODS

13.3.01 COLLECTION METHOD REQUIREMENTS

13.3.01.A GIS digital data collection shall be captured using one of two approaches: field data collection with office processes or only office processes. The appropriate method shall be determined by the Engineer of Record and Project Manager. If the accuracy required in this chapter is not possible through office processes alone, field data collection is required.

13.3.01.B Field Data Collection with Office Processes.

1. Field data collection, if required, shall be performed by a Registered Professional Land Surveyor (RPLS).
2. Utilize conventional methods or Global Navigation Satellite System (GNSS) devices/receivers to achieve the accuracy required by this chapter.
3. Use the appropriate software to collect data in the field.
4. Collect the spatial location of assets specified in this chapter for which the accuracy required in this chapter is not possible through office processes alone. The flow lines and elevations can be determined from the post construction as-built or CAD drawings.
5. The line and polygon features can be created in the office provided they connect field verified points.
6. Provide a GIS deliverable signed and sealed by a RPLS that includes the process by which the field data is gathered, GNSS information (e.g. number of satellites), and any associated field notes and sketches.

13.3.01.C Office Processes Only.

1. Data from the post construction as-built and CAD drawings can be converted through various methods to digital features.
2. When digitizing features from maps/ drawings, the source, scale, date, and methods (i.e., process steps) shall be provided to the City and be signed and sealed by the Engineer of Record.

SECTION 4 - ASSET SPECIFICS

13.4.01 STORM WATER ASSET INFORMATION

13.4.01.A Storm Water Asset Descriptions.

1. Abandoned Gravity Main – Any storm water sewer that was installed, used, maintained, and is no longer in use (includes removed infrastructure).

2. Abandoned Open Drain – Any storm water open system (e.g., channel, ditch) that was filled in or replaced with storm water sewer.

3. Abandoned Point – Any storm water node (e.g., manhole, inlet, fitting) that was installed, used, maintained, and is no longer in use (includes removed infrastructure).

4. Detention – Storm water detention facilities (e.g., dry ponds) used to hold storm water for storm events.

5. Discharge Point – Location where storm water leaves a section of the drainage system to enter another section (e.g., outfall from storm sewer system to open system or roadside culvert to open system).

6. Easement – Storm or drainage real property that contains storm infrastructure or is used to convey storm water.

7. Fitting – Storm water feature that is structurally required at the terminus of a line or at the connection point of two or more lines (e.g., plug).

8. Gravity Main – A sewer line which conveys storm water by difference in elevation.

9. Inlet – Structure with a drop that moves storm water into storm sewer or underground drainage system.

10. Manhole – A device which, for pipe length restrictions, change of flow direction, and/or junction with another main, is placed at the end of a gravity main to allow equipment to diagnose and resolve issues while also providing enough clearance for a person to access.

11. Network Structure – A facility which contains infrastructure elements that directly pump and/or hold storm water for large storm events.

12. Open Drain – Any storm water open system (e.g., channel, ditch).

13.4.01.A continued

13. Underpass – Center point location of road crossing under highway or railroad.

14. Virtual Drainline – Virtual linear feature used to maintain connectivity in the storm infrastructure (primarily used to connect storm sewer outfall locations to open drainage system).

13.4.01.B Storm Water Asset Requirements.

1. As applicable, all storm water asset features must contain the required information as depicted in Table 13.1. This information must be delivered to the City following the guidelines outlined in SECTION 6 of this chapter.

2. For more detailed information regarding GIS data that must be provided for each storm water asset, such as field descriptions, subtypes and domain codes, or data processing workflows, refer to the Geospatial Data Deliverables Properties Guide.

Table 13.1– INFORMATION REQUIRED FOR STORMWATER ASSETS

	Asset													
Information	Abandoned Gravity Main	Abandoned Open Drain	Abandoned Point	Detention	Discharge Point	Easement	Fitting	Gravity Main	Inlet	Manhole	Network Structure	Open Drain	Underpass	Virtual Drainline
Abandon Status	X	X	X											
Active Flag			X	X	X		X	X	X	X				
Address		X	X		X				X	X	X	X	X	
Bank Material				X										
Bed Material		X		X								X		
Channel Name		X										X		
Comments				X										
Company	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Construction Material									X					
Council District	X	X	X	X	X	X	X	X	X	X	X	X	X	
Crossing Type													X	
Data Source Type	X		X		X		X	X	X	X	X			
Depth		X	X	X					X	X		X		
Discharge Type					X									
Downstream Depth								X						
Downstream	X							X						

Information	Asset													
	Abandoned Gravity Main	Abandoned Open Drain	Abandoned Point	Detention	Discharge Point	Easement	Fitting	Gravity Main	Inlet	Manhole	Network Structure	Open Drain	Underpass	Virtual Drainline
Elevation														
Downstream Storm Node	X							X						
Drainage Area	X							X						
Facility ID	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fitting Type							X							
Flood Warning Light													X	
Flow Elevation					X									
Funding Number	X		X	X	X		X	X	X	X	X		X	
Funding Type	X		X	X	X		X	X	X	X	X		X	
Height	X				X			X						
Inlet Type									X					
Install Date	X		X	X	X		X	X	X	X	X		X	
Invert Elevation			X						X	X				
Length	X							X						
Line Type		X										X		X
Location Description				X			X						X	
Main Shape	X							X						
Maintained By	X		X	X	X	X	X	X	X	X	X	X	X	
Manhole Type										X				
Material	X				X			X						
Name				X							X		X	
Number of Crossings													X	
Owned By	X	X	X	X	X	X	X	X	X	X	X	X	X	
Pipe Type	X							X						
Plan Number	X		X	X	X		X	X	X	X	X		X	
Point Type			X											
Pond Area				X										
Pump Station													X	
Rain Gauge													X	
Record Drawing Number	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Rehabilitation Date				X							X	X		
Rim Elevation			X						X	X				
Rotation			X		X		X		X	X	X		X	

Information	Asset													
	Abandoned Gravity Main	Abandoned Open Drain	Abandoned Point	Detention	Discharge Point	Easement	Fitting	Gravity Main	Inlet	Manhole	Network Structure	Open Drain	Underpass	Virtual Drainline
Scada													X	
Side Material		X										X		
Slope	X							X						
Structure Type											X			
Utility Type						X								
UF ID	X	X	X		X	X	X	X	X	X	X	X		
Upstream Depth								X						
Upstream Elevation	X							X						
Upstream Storm Node	X							X						
Volume				X										
Wall Material			X							X				
Watershed				X										
Width	X	X			X	X		X				X		

*For publicly/privately funded projects only

13.4.02 WASTEWATER ASSET INFORMATION

13.4.02.A Wastewater Asset Descriptions.

1. Abandoned Wastewater Line/Point – Any wastewater infrastructure that was installed, used, and maintained, and is no longer in use but was not removed.

2. Casing – A pipe, typically made of steel, which is not designed to convey wastewater, but instead surrounds and protects a sewer line.

3. Cleanout – A device designed to allow access to the line for the diagnosing and resolving of structural or other issues with that line. Typically, these are installed on service leads, though they are rarely used on main lines.

4. Fitting – An appurtenance that is structurally required at the terminus of a line or at the connection point of two or more lines. Excepted from this Feature Class are cleanouts, manholes, network structures, and valves.

5. Force Main – A sewer line which conveys wastewater under pressure.

6. Gravity Main – A sewer line which, due to its slope, conveys wastewater using only gravity.

13.4.02.A continued

7. Manhole – A device which, for pipe length restrictions, change of flow direction, and/or junction with another main, is placed at the end of a gravity main to allow equipment to diagnose and resolve issues while also providing enough clearance for a person to access.

8. Network Structure – A facility which contains infrastructure elements that directly pump and/or treat wastewater.

9. Service Lead – Also called service line, a sewer pipe that connects a private property to a public sewer line.

10. Valve – An appurtenance installed on force mains that controls flow.

13.4.02.B Wastewater Asset Requirements.

1. As applicable, all wastewater asset features must contain the required information as depicted in Table 13.2. This information must be delivered to the City following the guidelines outlined in SECTION 6 of this chapter.

2. For more detailed information regarding GIS data that must be provided for each wastewater asset, such as field descriptions, subtypes and domain codes, or data processing workflows, refer to the Geospatial Data Deliverables Properties Guide.

Table 13.2- INFORMATION REQUIRED FOR WASTEWATER ASSETS

Information	**Asset**								
	Casing	Cleanout	Fitting	Force Main	Gravity Main	Manhole	Network Structure	Service Lead	Valve
Buried Depth		x				x			
Creation Source	*	*	*	*	*	*	*	*	*
Data Source Type	X	X	X	X	X	X	X	X	X
Datum	X	X	X	X	X	X	X	X	X
Datum Year	X	X	X	X	X	X	X	X	X
Diameter	X		X	X	X	X		X	X
Distance to Downstream Manhole		X	*			X		X	
Downstream Direction		X	*			X			
Downstream Invert					X				
Fiscal Year	X	X	X	X	X	X	X	X	X
Flow Elevation		X				X			
GFS Or WBS	*	*	*	*	*	*	*	*	*
GFS or WBS	*	*	*	*	*	*	*	*	*

Information	Asset								
	Casing	Cleanout	Fitting	Force Main	Gravity Main	Manhole	Network Structure	Service Lead	Valve
Number									
ILMS Number	*	*	*	*	*	*	*	*	*
Inlet Elevation						*	X		
Inlet Elevation 2						*			
Inlet Elevation 3						*			
In Service Date	X	X	X	X	X	X	X	X	X
Length	X			X	X			X	
Life Cycle Status	X	X	X	X	X	X	X	X	X
Material	X		X	X	X	X		X	
Notes	*	*	*	*	*	*	*	*	*
Owner	X	X	X	X	X	X	X	X	X
Percent Slope					X			X	
Plan Date	X	X	X	X	X	X	X	X	X
Plan Number	X	X	X	X	X	X	X	X	X
Plan Type	X	X	X	X	X	X	X	X	X
Project Number	*	*	*	*	*	*	*	*	*
Project Type	*	*	*	*	*	*	*	*	*
Record Drawing Number	**	**	**	**	**	**	**	**	**
Rim Elevation						X			
Size of Cover		X				X			
Subtype Code	X	X	X	X	X	X	X	X	X
Type						X			
Upstream Invert					X			X	

*If applicable
**For public/private projects only

13.4.03 WATER ASSET INFORMATION

13.4.03.A Water Asset Descriptions.

1. Abandoned Water Line/Point – Any water infrastructure that was installed, used, and maintained, and is no longer in use but was not removed.

2. Casing – A pipe, typically made of steel, which is not designed to carry water, but instead surrounds and protects a water line.

13.4.03.A continued

3. Control Valve – A valve that controls the flow of water and other fluids. By opening and closing the valve this will regulate how much volume is traveling the piping system.

4. Fitting – An appurtenance that is structurally required at the terminus of a line or at the connection point of two or more lines. Excepted from this Feature Class are control valves, hydrants, meters, pressure reducing stations, sampling stations, and system valves.

5. Hydrant – A structurally independent device used primarily for fire or water quality events.

6. Lateral Service – Also called service line, a water pipe that connects a public water line to a fire service and/or private property.

7. Meter – A device that measures water passing through a point. This also serves as a demarcation between a public ownership from private ownership.

8. Pressure Reducing Station – A facility which contains infrastructure elements that drastically and intentionally reduce water pressure to allow a large diameter main to be tapped by a small diameter main.

9. Pump Pressure Main – A water line which collects raw water from a source to a water treatment facility or distributes treated water from a water treatment facility to end users.

10. Sampling Station – A point at which a sample of water for testing and quality control purposes can be taken directly.

11. System Valve – An appurtenance installed on mains that control flow of water.

13.4.03.B Water Asset Requirements.

1. As applicable, all water asset features must contain the required information as depicted in Table 13.3. The information must be delivered to the City following the guidelines outlined in SECTION 6 of this chapter.

2. For more detailed information regarding GIS data that must be provided for each water asset, such as field descriptions, subtypes and domain codes, or data processing workflows, please see the Geospatial Data Deliverables Properties Guide.

Table 13.3- INFORMATION REQUIRED FOR WATER ASSETS

Information	Asset									
	Casing	Control Valve	Fitting	Hydrant	Lateral Service	Meter	Pressure Reducing Station	Pump Pressure Main	Sampling Station	System Valve
Creation Source	*	*	*	*	*	*	*	*	*	
Data Source Type	X	X	X	X	X	X	X	X	X	X
Diameter	X				X	X		X		X
Fiscal Year	X	X	X	X	X	X	X	X	X	X
GFS or WBS Number	*	*	*	*	*	*	*	*	*	*
GFS or WBS Number	*	*	*	*	*	*	*	*	*	*
Ground Cover								X		
Hydrant Lead Diameter				X						
ILMS Number	*	*	*	*	*	*	*	*	*	*
In Service Date	X	X	X	X	X	X	X	X	X	X
Large Main Diameter			*				*			
Length	X				X			X		
Life Cycle Status	X	X	X	X	X	X	X	X	X	X
Material	X				X			X		
Main Diameter				X		X				
Notes	*	*	*	*	*	*	*	*	*	
Owner	X	X	X	X	X	X	X	X	X	X
Plan Date	X	X	X	X	X	X	X	X	X	X
Plan Number	X	X	X	X	X	X	X	X	X	X
Plan Type	X	X	X	X	X	X	X	X	X	X
Project Number	*	*	*	*	*	*	*	*	*	*
Project Type	*	*	*	*	*	*	*	*	*	*
Record Drawing Number	**	**	**	**	**	**	**	**	**	**
Service Address						X				
Small Main Diameter			*				*			
Subtype Code	X	X	X	X	X	X	X	X	X	X

*If applicable
**For public/private projects only

13.4.04 GEOTECHNICAL AND ENVIRONMENTAL INFORMATION

13.4.04.A Geotechnical and Environmental Feature Class Descriptions.

1. geoBoring (Point) – Soil boring location. Soil borings are drilled to evaluate the soil conditions of a site or project location and to obtain soil samples.

13.4.04.A continued

2. geoBoringTestResults (Table) – Boring log test results stored in a tabular format.

13.4.04.B Geotechnical and Environmental Feature Class Requirements.

1. The boring point features are connected to the associated boring test results through the PROJECTID field. The PROJECTID field is a unique identifier generated by the consultant through the concatenation of the report type, report year, the WBS number and BoreID.

2. The relationship between the geoBoring point and the geoBoring Test Results is a one to many (1:M) relationship with one point being related directly back to many test results where the geoBoring point is the parent and the geoBoring Test Results is the child table. This data will be appended into a larger enterprise dataset maintained by the City where bore IDs are recurring between different reports. The City will create a separate unique identifier for the dataset during the City's internal quality control process, and prior to publishing to the production database.

3. To ensure that the data is distinct, the consultant will provide a project ID which will serve as the interim unique identifier delivered with the data. The PROJECT ID field must be formatted as follows:

4. PROJECT ID Format:

   a. ReportTypeReportYear_WBSNumber_BoreID

      (1) Sample Environmental Report: E2020_S-000035-0100-3_EB1 where by:

         (a) E = Environmental

         (b) 2020 = Report Year in a four digit (YYYY) year format

         (c) Underscore = separator character

         (d) S-000035-0100-3 = WBS Number in alphanumeric format

         (e) EB1 = Bore ID in alphanumeric format

      (2) Sample Geotechnical Report: G2021_ S-000035-0100-3_B1 where by:

         (a) G = Geotechnical

         (b) 2021 = Report Year in a four digit (YYYY) year format

13.4.04.B.4.a.(2) continued

(c) Underscore = separator character

(d) S-000035-0100-3 = WBS Number in alphanumeric format

(e) B1 = Bore ID in alphanumeric format

5. As applicable, all geotechnical and environmental features must contain the required information as depicted in Table 13.4. If utilizing a file geodatabase Feature Class format, the applicable information must be delivered to the City following the guidelines outlined in SECTION 6 of this chapter.

6. For more detailed information regarding GIS data that must be provided for each geotechnical or environmental feature, such as field descriptions, subtypes and domain codes, or data processing workflows, refer to the Geospatial Data Deliverables Properties Guide.

Table 13.4- INFORMATION REQUIRED FOR GEOTECHNICAL AND ENVIRONMENTAL FEATURE CLASSES

FIELD	**Feature Class**	
	geoBoring	geoBoringTestResults
PROJECTID	X	X
WBSNUMBER	X	
PROJECTNAME	X	
REPORTTYPE	X	
CONSULTANTPROJECTNO		X
REPORTSIGNEDDATE	X	
CONSULTANTNAME	X	
BOREID	X	
X*	X	
Y*	X	
LATITUDE**	X	
LONGITUDE**	X	
SURFACEELEV	X	
DEPTH	X	
WATERENCOUNTERED	X	
WATERLEVEL	X	
READINGDATE	X	
WATERLEVELREADING	X	
CONTAMINATION	X	
DRILLEDDATE	X	
SAMPLENO		X
SAMPLEDEPTHTOP		X
SAMPLEDEPTHBTM		X
SAMPLETYPE		X
SPT		X
WATERCONTENT		X
DRYDENSITY		X

FIELD	Feature Class	
	geoBoring	geoBoringTestResults
ATTERBERGLIMITSLL		X
ATTERBERGLIMITSPL		X
ATTERBERGLIMITSPI		X
PERPASSSIEVE200		X
TSFUNCONFCOMPTEST		X
TSFUUTEST		X
TSFCONFININGPRESS		X
TSFTORVANE		X
TSFPOCKETPENETROMETER		X
TYPEOFMATERIAL		X
PID**		X

*Only required for geotechnical borings and is not a requirement for environmental borings.
**Only required for environmental borings and/or test results and is not a requirement for geotechnical borings.

13.4.04.C Alternative Tabular Deliverable Requirements for Geotechnical and Environmental Data.

1. The City's preference is to receive boring locations in a file geodatabase Feature Class and Boring Log Test Results in a file geodatabase table, complying with the standards outlined in SECTION 6 of this chapter. However, Boring and Boring Test Result data may be delivered in a comma delimited (.CSV) text file, or Excel spreadsheet alternatively. The corresponding text file or excel spreadsheet must be named: BoringData_WBS_Number. For tabular data, the City will specify the delivery method during project planning.

2. Tabular Data Schema – Table 13.5 and Table 13.6 outline the geoBoring and geoBoring Test Results Schemas that must be utilized in any Excel or .CSV text file deliverable. The associated list values are described in Table 13.7, Table 13.8, and Table 13.9. Figure 13.1 and Figure 13.2 provide examples of said Excel or .CSV text file deliverables.

Table 13.5 - GEOBORING TABULAR ATTRIBUTE FIELDS

Field Name	Type	Description	List Values
PROJECTID	Text	Unique ID for the project populated by the consultant based on report type, year, the project WBS number, and bore ID. Format is: ReportTypeYear_WBSNumber_BoreID	
WBSNUMBER	Text	City of Houston assigned number for the project	
PROJECTNAME	Text	City of Houston assigned project name	
REPORTTYPE	Text	The report classification content either geotechnical or environmental	geoReportType
REPORTSIGNEDDATE	Date	Date the report was signed	
CONSULTANTNAME	Text	Name of the firm who produced the report	

Field Name	Type	Description	List Values
BOREID	Text	Alphanumeric unique identification number assigned to the boring location	
X*	Numeric	Horizontal coordinate	
Y*	Numeric	Vertical coordinate	
LATITUDE**	Numeric	Geographic coordinate in decimal degrees format measured North and South of the equator.	
LONGITUDE**	Numeric	Geographic coordinate in decimal degrees format measured East and West of the prime meridian.	
SURFACEELEV	Numeric	Vertical measurement of the height of the land surface (Feet)	
DEPTH	Numeric	Total distance from the top of the surface elevation to the bottom of the boring (Feet)	
WATERENCOUNTERED	Text	Measurement in Feet at which water was first encountered at the time of drilling	
WATERLEVEL	Text	Measurement in Feet of the water level 15-20 minutes after water was first encountered	
READINGDATE	Date	Date at which the water level measurement in Feet was read 24 hours or more after drilling completed	
WATERLEVELREADING	Text	The water level measurement in Feet read 24 hours or more after drilling completed	
CONTAMINATION	Numeric	Yes/No Field to flag whether or not contamination was detected	dYesNo
DRILLEDDATE	Date	Date the boring was drilled	

*The field is only required for geotechnical borings and is not a requirement for environmental borings.
**The field is only required for environmental borings and/or test results and is not a requirement for geotechnical borings.

Table 13.6 – GEOBORINGTESTRESULTS TABLE ATTRIBUTE FIELDS

Field Name	Type	Description	List Values
PROJECTID	Text	Unique ID for the project populated by the consultant based on report type, year, the project WBS number, and bore ID. Format is: ReportTypeYear_WBSNumber_BoreID	
WBSNUMBER	Text	City of Houston assigned number for the project	
PROJECTNAME	Text	City of Houston assigned project name	
CONSULTANTNAME	Text	Name of firm who produced the report	
REPORTSIGNEDDATE	Date	Date the report was signed	
BOREID	Text	Alphanumeric unique identification number assigned to the boring location	
SAMPLENO	Text	The unique identification number for the sample	
SAMPLEDEPTHTOP	Numeric	Top depth of the boring in Feet	
SAMPLEDEPTHBTM	Numeric	Bottom depth of the boring in Feet	
SAMPLETYPE	Text	Type of sample taken	geoSampleType
SPT	Numeric	Standard penetration test (SPT) measurement in blows/Feet	
WATERCONTENT	Numeric	Percent water content in sample	
DRYDENSITY	Numeric	Dry density of sample measured in pounds per cubic foot (pcf)	

Field Name	Type	Description	List Values
ATTERBERGLIMITSLL	Numeric	Atterberg limits – Liquid Limit (%)	
ATTERBERGLIMITSPL	Numeric	Atterberg limits – Plastic Limit (%)	
ATTERBERGLIMITSPI	Numeric	Atterberg limits – Plasticity Index (%)	
PERPASSSIEVE200	Numeric	Percent passing sieve 200 (%)	
TSFUNCONFCOMPTEST	Numeric	Shear strength (TSF) unconfined compression test	
TSFUUTEST	Numeric	Shear strength (TSF) triaxial compression (UU) test	
TSFCONFININGPRESS	Numeric	Shear strength (TSF) Confining pressure TSF	
TSFTORVANE	Numeric	Shear strength (TSF) torvane	
TSFPOCKETPENETROMETER	Numeric	Shear strength (TSF) pocket penetrometer	
TYPEOFMATERIAL	Text	Type of soil material. For geotechnical borings refer to ASTM D2487. For environmental borings refer to ASTM D2488.	
PID*	Numeric	Photoionization Detector (PID) value (ppm)	

*The field is only required for environmental borings and/or test results and is not a requirement for geotechnical borings.

Table 13.7 - GEOYESNO LIST

Value	Description
0	No
1	Yes

Table 13.8 - GEOSAMPLETYPE LIST

Value	Description
UD	Undisturbed Sample
SS	Split Spoon Sample
AG	Auger Cuttings
SPT	Standard Penetration Test

Table 13.9 - GEOREPORTTYPE LIST

Value	Description
GEO	Geotechnical
ENV	Environmental

WBS Number	
Project Name	
Report Type (Geo or Env)	
Report Signed Date	
Consultant Name	

Bore ID	X	Y	Depth	Water First Encountered at Time of Drilling	Water Level 15-20 minutes after Water was First Encountered	Water Level Measured 24 hours or more After Drilling Completed		Contamination (Y/N)	Drilled Date
						Reading Date	Water Level Reading		

Figure 13.1- SAMPLE HEADING AND FORMAT FOR GEOBORING EXCEL DATA

SUMMARY OF LABORATORY TEST RESULTS								PROJECT NAME:							
Geotechnical Consultant's Name								COH WBS NUMBER:							
								CONSULTANT PROJECT NUMBER:							
BORING NO.	SAMPLE				SPT (BLOWS/ FT)	WATER CONTENT (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS			PERCENT PASSING SIEVE 200 (%)	SHEAR STRENGTH (TSF)				TYPE OF MATERIAL
	NO.	DEPTH (FT)		TYPE				LL (%)	PL (%)	PI (%)		UNCONFINED COMPRESSION TEST	UU TEST (CONFINING PRESSURE, TSF)	TORVANE	POCKET PENETR-OMETER	
		Top	Bottom													
B-1	1	0.0	0.5	AG		25										Fat Clay
	2	0.5	2.0	UD		23	100	68	24	44	95	1.5		2.0	2.0	Fat Clay
	3	2.0	4.0	UD		22							1.25 (0.4)	1.5	1.5	Fat Clay
	4	4.0	5.5	SS	22	12					35					Silty Sand
B-2	1															
LEGEND	UD = UNDISTURBED SAMPLE, EXTRUDED IN FIELD SS = SPLIT SPOON SAMPLE AG = AUGER CUTTINGS SPT = STANDARD PENETRATION TEST							LL = LIQUID LIMIT PL = PLASTIC LIMIT PI = PLASTICITY INDEX UU = TRIAXIAL COMPRESSION				NOTES:				

FIGURE

Figure 13.2- SAMPLE TEST RESULTS FOR GEOBORINGTESTRESULTS EXCEL DATA

13.4.05 TELECOMMUNICATIONS ASSET INFORMATION

13.4.05.A Telecommunications Asset Descriptions

1. Network Node – An equipment at a fixed location that enables wireless communication between user equipment and a communications network. This includes distributed antenna system nodes.

2. Repeater Pole – A pole on which a repeater antenna (efficient antenna system that receives weak signals and widens transmission coverage) is installed.

3. Fiber Optic Cable – A line containing strands of fiber made of glass or plastic that transmit information quickly over long distances via pulses of light.

13.4.05.B Telecommunications Asset Requirements

1. As applicable, all telecommunications asset features must contain the required information as depicted in Table 13.10. The information must be delivered to the City following the requirements outlined in SECTION 6 of this chapter.

2. For more detailed information regarding GIS data that must be provided for each telecommunications asset, such as field descriptions, subtypes and domain codes, or data processing workflows, refer to the Geospatial Data Deliverables Properties Guide.

Table 13.10 – INFORMATION REQUIRED FOR TELECOMMUNICATIONS ASSETS

Information	**Asset**		
	Network Node	Repeater Pole	Fiber Optic Cable
Cable ID			X
Company Name	X	X	X
Council District	X	X	X
Depth			X
E911 Address	X	X	
From Street			X
ILMS Number	*	*	*
Latitude	X	X	
Length			X
Longitude	X	X	
Material		X	X
Node Name	X		
Node Number	X		
Owner			X
Pole Elevation		X	
Pole ID		X	
Pole Status	X	X	

Information	**Asset**		
	Network Node	Repeater Pole	Fiber Optic Cable
Pole Owner	X	X	
Street Name			X
To Street			X
Zip Code	X	X	

*If applicable

SECTION 5 - DATA QUALITY

13.5.01 TOPOLOGICAL CHECKS

13.5.01.A Appropriate QA/QC standards will be utilized to ensure that the data is topologically correct, accurate, and complete. This shall include:

1. Geometry.

   a. General:

      (1) Point and linear features will be snapped together where appropriate to support networks. Maintain connectivity where all features are connected, and correct flow direction with no duplications, and reversed flow values. Looped systems of uniform size are exempted from this check. Flow direction will be checked for each line using symbology with arrows that point in the direction of digitized flow. Lateral service features must always be drawn towards the meter or hydrant they are serving.

      (2) In instances where two points are constructed on top of each other, digitize one point in the actual location and offset the second point, when applicable per the following tolerances:

         (a) XY Tolerance: 0.0032808333 US Survey Feet

         (b) Z Tolerance: 0.001 US Survey Feet

         (c) M Tolerance: 0.001

      (3) No duplicate features.

      (4) All features must be placed in their correct location, meeting accuracy requirements within this chapter.

   b. Points:

      (1) All point features shall be placed in their correct location, meeting accuracy requirements within this chapter.

   c. Lines:

      (1) No erroneous overshoots, undershoots, dangles, or intersections in the line work.

13.5.01.A.1.c continued

(2) Linear features will not be broken for labeling or aesthetic purposes.

(3) Linear storm water and wastewater features shall be continuous and drawn from upstream to downstream.

2. Attributes.

a. Data Completeness:

(1) Every feature must have each attribute, as applicable, filled with accurate and consistent information as is expected for any submission.

(2) All fields will be checked against the submitted, stamped, and approved plan and profile set for extraneous and erroneous entries.

(3) No null values in required fields.

SECTION 6 - DELIVERABLE SUBMISSION REQUIREMENTS

13.6.01 FORMAT

13.6.01.A All GIS datasets shall be delivered to the City of Houston electronically in an ESRI file geodatabase ArcGIS format with associated Metadata, unless otherwise specified in this chapter. Shapefiles will not be accepted as a submission format.

13.6.01.B For details regarding the digital deliverable submission process please refer to the Geospatial Data Deliverables Properties Guide.

END OF CHAPTER

City of Houston

Design Manual

Chapter 14

FACILITY DESIGN REQUIREMENTS

Chapter 14

FACILITY DESIGN REQUIREMENTS

SECTION 1 - FACILITY DESIGN REQUIREMENTS OVERVIEW

14.01 CHAPTER INCLUDES

A. Incorporation of Houston Public Works Guidelines for water and wastewater related facilities.

14.02 REFERENCES

A. Groundwater Plant Design Guidelines[1].

B. Engineering Design Guidelines Manual for Submersible Lift Stations[2].

C. Design Guidelines Drawings for Submersible Lift Stations.

14.03 DESIGN REQUIREMENTS

A. Conform to design requirements of the latest published edition of each reference document available online.

END OF CHAPTER

[1] Refer to weblink for guidelines: https://www.houstonpermittingcenter.org/media/3061/download

[2] Refer to weblink for guidelines: https://www.houstonpermittingcenter.org/media/3066/download

City of Houston

Design Manual

Chapter 15

TRAFFIC AND SIGNAL DESIGN REQUIREMENTS

Chapter 15
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Chapter 15

TRAFFIC AND SIGNAL DESIGN REQUIREMENTS

SECTION 1 – TRAFFIC AND SIGNAL DESIGN OVERVIEW

15.1.01 CHAPTER INCLUDES

15.1.01.A Criteria for the design of traffic and signal requirements.

15.1.02 REFERENCES

15.1.02.A References listed are the latest edition, version, amendments, and recodifications unless otherwise noted.

1. Refer to the reference lists in Chapter 1 - General Requirements and Chapter 10 - Street Paving Design Requirements.
2. A Policy on Geometric Design of Highways and Streets ("The Green Book"), AASHTO
3. City of Houston Code of Ordinances
    a. Chapter 40 – Streets and Sidewalks
    b. Chapter 42 – Subdivisions, Developments and Platting
    c. Chapter 45 – Traffic
4. City of Houston Construction Code Amendments, latest adopted amendments[1]
5. City of Houston, Infrastructure Design Manual (IDM)
6. City of Houston, Neighborhood Traffic Management Program (NTMP)
7. City of Houston, Standard Details
8. City of Houston, Standard Operations Procedure (SOP) TMG – 905 Left Turn Warrants[2]
9. City of Houston, Standard Specifications

Refer to the weblink for reference:
[1] https://www.houstonpermittingcenter.org/help/codes
[2] This reference can be obtained from Transportation and Drainage Operations

15.1.02.A continued

10. City of Houston Vision Zero High Injury Network (HIN)[3]
11. Highway Capacity Manual (HCM), TRB
12. Highway Safety Improvement Program (HSIP)
13. Houston Bike Plan[4]
14. International Building Code (IBC), edition adopted by City of Houston[5]
15. Major Thoroughfare and Freeway Plan (MTFP)[6]
16. Manual for Assessing Safety Hardware (AASHTO MASH)
17. National Cooperative Highway Research Program (NCHRP), Report 350
18. National Cooperative Highway Research Program (NCHRP), Report 812
19. National Electrical Code (NEC)
20. National Electrical Safety Code (NESC)
21. Roundabout Informational Guide
22. Standard Highway Sign Designs for Texas (SHSD)
23. Texas Manual on Uniform Traffic Control Devices (TMUTCD)
24. Traffic Signal Timing Manual
25. Transit-Oriented Development Map[7]
26. Transportation Impact Analyses for Site Development (An ITE Proposed Recommended Practice), ITE
27. Trip Generation (An ITE Informational Report, Institute of Transportation Engineers, Washington, D.C.)
28. Trip Generation Handbook, ITE
29. Trip Generation Manual

Refer to the weblink for reference:
[3] https://www.houstontx.gov/visionzero/
Refer to the weblink for reference:
[4] https://www.houstonbikeplan.org/
[5] https://www.houstonpermittingcenter.org/building-code-enforcement/code-development#agency-links-416
[6] https://www.houstontx.gov/planning/transportation/MTFP.html
[7] https://houstontx.gov/planning/tod-standards.html

15.1.02.A continued

30. TxDOT Access Management Manual
31. TxDOT CRIS crash database[8]
32. TxDOT Traffic Signal Manual
33. Walkable Places Program[9]

15.1.03 DEFINITIONS

15.1.03.A Access Management - The systematic control of the location, spacing, design and operation of Driveways, Median openings, intersections, bike lanes, and Auxiliary Lanes.

15.1.03.B ADT - The average daily traffic volume. It represents the total two-way traffic on a street for some period less than a year, divided by the total number of days it represents, and includes both weekday and weekend traffic. Usually, ADT is adjusted for day of the week, seasonal variations, and/or vehicle classifications.

15.1.03.C Auxiliary Lane - A lane striped for use as an acceleration lane, deceleration lane, right-turn lane, or left-turn lane, but not for through traffic use.

15.1.03.D Background Conditions – Represents the amount of traffic and geometric changes that will be on the area roadway network without any proposed development during build-out, interim, and the horizon year.

15.1.03.E Battery Back Up/Uninterrupted Power Supply – An uninterruptible power supply/battery backup (UPS/BBU) system provides emergency power to the traffic signal cabinet by supplying power from a separate source (batteries) when utility power is not available. The system may also function as a power conditioner and/or voltage regulation device. UPS/BBU systems consist of an enclosure or cabinet, the batteries, the power inverter/conditioner, a battery charger (usually integral to the inverter), and automatic and manual bypass switches.

15.1.03.F Blue Tile Street Sign - A street sign made of ¾ inch square blue and white colored ceramic tiles embedded in a concrete curb.

15.1.03.G Central Business District - The area bounded by Interstate Highway 45, United States Highway 59, and Interstate Highway 10.

15.1.03.H Connection Spacing - The distance between connections, which is measured along the edge of the traveled way from the closest edge of pavement of the first access connection to the closest edge of pavement of the second access connection.

[8] https://cris.dot.state.tx.us/public/Query/app/home
[9] https://houstontx.gov/planning/wp-program.html

15.1.03.I Corner Clearance - The distance along the edge of the traveled way from the closest edge of pavement of the intersecting public or private street to the closet edge of pavement of the nearest Driveway.

15.1.03.J Courtyard Style Development - As defined in the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting, Section 42-1.

15.1.03.K Design Exception - Any City Engineer approved variation from the design requirements listed in this chapter.

15.1.03.L Development Project - Any public or private project that would modify land use in a way that would require an Access Management Form or Traffic Impact Analysis.

15.1.03.M Driveway - An access connection constructed within the public right-of-way, used to connect a public or private street with adjacent property.

15.1.03.N Driveway Permit – Permit issued by the Building Official based upon the latest version of the International Building Code adopted by the City and its amendments. Driveway Permits for access to freeways, highways, frontage roads, tollways and farm to market roads are not under the jurisdiction of the City of Houston. Driveway approvals from the appropriate agency with jurisdiction is required with building permit application.

15.1.03.O Driveway Radius – The radius of the curb return from the Driveway edge to the street curb.

15.1.03.P Engineer of Record - A Professional Engineer who seals drawings, reports or documents for a project. The engineer or engineering company that will be signing and sealing or otherwise taking responsibility for any study or plan that requires an engineering design.

15.1.03.Q Existing Conditions – Represents the performance of the existing street network and traffic volumes.

15.1.03.R Flashing School Beacon – Speed limit sign beacon used to indicate that the displayed speed limit is in effect. It is used in conjunction with a sign used to indicate the speed limit where a reduced school speed limit has been established.

15.1.03.S Flag Staff Driveway – A Driveway within the flag staff of a flag lot. For flag lot definition refer to City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting, Section 42-1.

15.1.03.T High-Visibility Crosswalk – Crosswalk that is marked with white diagonal lines at 45-degree angle to the line of the crosswalk or with white longitudinal lines parallel to traffic flow, to increase visibility to motorists.

15.1.03.U Intersection Limits - The functional portion of the intersection and shall be defined as the extent or limit of turning bays unless otherwise defined by the City Engineer.

15.1.03.V Joint Access Driveway – A single Driveway serving two abutting lots or parcels.

15.1.03.W Leading Bicycle Interval – A Leading Bicycle Interval is a signal phase that displays a bicycle phase, if provided, prior to the associated vehicle phase. This treatment allows a bicyclist to establish right-of-way in an intersection and can also increase bicyclist visibility.

15.1.03.X Leading Pedestrian Interval – A Leading Pedestrian Interval is a signal phase that displays the pedestrian walk phase prior to the associated vehicle phase. This treatment allows a pedestrian to establish right-of-way in an intersection, and can also aid in pedestrian visibility for drivers, bicyclists, and other system users.

15.1.03.Y Major Activity Center - Those areas designated as Major Activity Centers pursuant to Section 42-273 of the Code of Ordinances of the City of Houston, Texas.

15.1.03.Z Major Thoroughfare – A public street designated as a principal thoroughfare or thoroughfare on the latest edition of the City of Houston's Major Thoroughfare and Freeway Plan.

15.1.03.AA Management District – A district created by the State of Texas to supplement public services such as in public safety, security, business and economic development as well as beautification inside the district boundaries, which are located within the City of Houston limits. This includes downtown and uptown districts.

15.1.03.BB Median - The portion of a divided street separating opposing traffic flows. A Median may be traversable or non-traversable.

15.1.03.CC Mitigation Conditions – Represents the performance of the future street network with the proposed project and with proposed mitigations resulting from the proposed project. Modifications to roadway and intersection features that would minimize the negative impacts to roadway safety and operations that are projected to occur as a result of a Development Project.

15.1.03.DD Multimodal Service Standards (MMSS) – Requirements for travel across all modes that capital projects and private Development Projects shall include in their scopes to benefit the safety and mobility of the public.

15.1.03.EE Multi-unit Residential (MUR) Development – As defined in the City of Houston Code of Ordinances, Chapter 42 – Subdivisions, Developments and Platting, Section 42-1.

15.1.03.FF Permanent Access Easement – A privately maintained and owned street easement approved by the commission that provides for vehicular access to three or more single-family residential units and which shall be either a Type 1 Permanent Access Easement or a Type 2 Permanent Access Easement, each of which is defined in section 15.2.07.

15.1.03.GG Permitted Phase – A traffic signal phase that requires vehicles to yield to conflicting vehicles, bicycle, and pedestrian movements.

15.1.03.HH Projected Conditions – Represents the performance of the street network for a future year, "build scenario", which represents the future street volumes with the proposed project in place. Other than changes in traffic volumes, the Projected Conditions scenario includes the same street network conditions as the Background Conditions scenario.

15.1.03.II Protected Phase – A traffic signal phase that gives vehicles the right-of-way without any conflicting movements.

15.1.03.JJ Protected/Permitted Phase – A combination of traffic signal phases that provides the Protected Phase first, followed by the Permitted Phase, or vice versa.

15.1.03.KK School Advance Warning Assembly – Sign used to warn road users that they are approaching a school area that might include school buildings or grounds, a school crossing, or school related activity.

15.1.03.LL School Crosswalk Warning Assembly – Sign used to warn road users that they are approaching a crossing where schoolchildren cross the roadway if combined with an AHEAD plaque. Sign is used to warn approaching road users of the location of a crossing where schoolchildren cross the roadway if combined with a diagonal downward pointing ARROW.

15.1.03.MM School Speed Limit Assembly – Sign used to indicate the speed limit where a reduced school speed limit has been established.

15.1.03.NN School Zone – School crossing zone, school speed zone, or simply a School Zone means a reduced-speed zone designated on a street by the City to facilitate safe crossing of the street by children going to or leaving a public or private elementary or secondary school during the time the reduced speed limit applies.

15.1.03.OO Shared Access/Shared Driveway - A single Driveway serving two or more adjoining lots or parcels where the shared portion of access extends into the private property and shared access agreement with adjoining property owners is required. Shared Access/Shared Driveways include Flag Staff Driveways, Courtyard Style Development or Multi-unit Residential (MUR) Development Driveways.

15.1.03.PP Sight Distance - The distance visible to the driver of a passenger vehicle measured along the normal travel path of a street from a designated vehicle location and to a specified height above the street when the view is unobstructed by traffic. Refer to AASHTO, Geometric Design of Highways and Streets (current edition), for application to specific design needs such as stopping Sight Distance and other sight requirements.

15.1.03.QQ Slow Streets – Slow Streets is an advisory measure to discourage through traffic on local streets. Temporary devices are placed at intersections to communicate that the street is a slow and shared environment between all road users. The street remains open to all traffic, including emergency vehicles, and thus does not trigger the processes for Speed or Volume Control as outlined in the Neighborhood Traffic Management Program (NTMP).

15.1.03.RR Speed or Volume Control – Speed Control and Volume Control are two tracks of the NTMP which administers requests for traffic calming devices in residential neighborhoods. A Speed Control project is intended to address speeding problems with speed cushions. A Volume Control project is intended to address cut-through traffic and speeding problems within a neighborhood area with various traffic calming devices.

15.1.03.SS Storage Length - The portion of an Auxiliary Lane required to store the number of vehicles expected to accumulate in the lane.

15.1.03.TT Tax Increment Reinvestment Zone (TIRZ) – A political subdivision, which is created by City Council, allowing investments in public improvements to be made and the resulting incremental tax is used to pay for the improvements within the district.

15.1.03.UU TIA Impacted Intersection – Any intersection that has been determined to bear public impacts to roadway safety or mobility by a proposed Development Project and that will require specific mitigation as determined by the criteria of 15.2.03 - Traffic Studies for Site Development.

15.1.03.VV Traffic Circle – A traffic calming element consisting of a physical, circular structure installed in the center of an intersection to require a circular flow within the intersection. Traffic Circles are different from roundabouts, which tend to be larger, integrate path deflection, and utilize yield-on-entry.

15.1.03.WW Traffic Signal Heads – An assembly of one or more signal faces that is provided for controlling traffic movements on one or more approaches.

15.1.03.XX Transit Corridor Street - A Major Thoroughfare designated on the MTFP that METRO has proposed or maintains as a route for a guided rapid transit or fixed guideway transit system.

15.1.03.YY Transit-Oriented Development (TOD) Street – A public street designated as a primary TOD street or secondary TOD street on the transit-oriented development plan.

15.1.03.ZZ Vehicle Level of Service (VLOS) – The City of Houston's specific terminology for all Levels of Service (LOS) computations and thresholds that focus on the LOS of vehicular users. Refer to Highway Capacity Manual for different LOS.

15.1.03.AAA Vulnerable Road Users – Travelers who are most at risk in traffic because they are unprotected by an outside shield, namely pedestrians, bicyclists, and people with disabilities, as they sustain a greater risk of injury in any collision against a vehicle and are therefore highly in need of protection against such collisions.

15.1.03.BBB Walkable Places (WP) Street – A public street designated as a primary WP street or secondary WP street on the WP plan.

15.1.03.CCC Wireless Broadband – Wireless Broadband is a type of telecommunication service that provides high-speed internet access without the need for cables or wires. It uses radio waves or satellite signals to transmit data between devices and networks.

SECTION 2 – TRAFFIC AND SIGNAL DESIGN REQUIREMENTS

15.2.01 MULTIMODAL SERVICE STANDARDS

15.2.01.A To ensure that all roadway projects serve all road users, the City of Houston has defined Multimodal Service Standards (MMSS). All projects impacting the public right-of-way shall comply with all applicable MMSS requirements.

15.2.01.B The Multimodal Service Standards (MMSS) are established in Table 15.1 and Table 15.2. Roadway projects must make every attempt to fully satisfy them, and no project will be approved that lowers any element below existing levels unless doing so still satisfies the requirements for those elements.

15.2.01.C Vehicular Level of Service (VLOS) is not considered a Multimodal Service Standard. Where VLOS can be improved while still satisfying all Multimodal Service Standards, doing so can be beneficial to the driver experience and to vehicular emissions goals. However, VLOS goals are secondary to MMSS.

15.2.01.D Existing roadway features may already satisfy MMSS requirements if they are in good repair.

15.2.01.E MMSS and VLOS shall be checked, documented, and reported for existing and proposed conditions for a project that satisfies any of the following criteria:

1. Is proposed to increase or decrease the number of vehicle lanes along a corridor or at an intersection.

2. Is proposed to reduce the width of pedestrian realm along a corridor or at an intersection.

3. Is required to include this analysis as part of another IDM section or report.

15.2.01.F The MMSS requirements apply to all projects impacting the public right-of-way. Specific applications follow:

1. All intersection and roadway reconstruction projects require compliance with both the site adjacent and TIA Impacted Intersections requirements.

2. All Development Projects that require an Access Management form must comply with site adjacent requirements as required by Code of Ordinances, Chapter 40.

3. Development Projects that require a Traffic Impact Analysis (TIA) must comply with both site adjacent requirements as well as all intersections included in the TIA analysis area (“TIA Impacted Intersections”). Certain requirements apply only to certain categories of traffic impact, as defined in Table 15.4.

15.2.01.G For every applicable road and intersection, the MMSS analysis shall identify the current conditions of the facilities defined in Table 15.1 and identify any deficiencies that must be mitigated.

15.2.01.H Specific MMSS standards are defined in other sections of the IDM; Table 15.1 and Table 15.2 reference the appropriate sections.

Table 15.1 - CORRIDOR MMSS REQUIREMENT APPLICABILITY

Corridor MMSS Requirement Applicability				
Design Element (MMSS Requirement)	**Project Type**			
	Development Project[1] (TIA Category 1)	**Development Project[1] (TIA Category 2)**	**Development Project[1] (TIA Category 3+)**	**Capital Project[2]**
Pedestrian Realm (Ch. 17, Section 3)	Sidewalks and safety/frontage buffers on all site-adjacent public streets, side of street immediately adjacent to development only	All sidewalks and safety/frontage buffers along corridor		
Bicycle Facilities (Ch. 17, Section 4)	N/A	For site frontage ≥ 100-ft: All site-adjacent bicycle facilities required by the Houston Bike Plan, side of street immediately adjacent to development only	All bicycle facilities required by the Houston Bike Plan along the corridor and 100-ft along cross streets	
Bus Stops (Ch. 17, Section 5)	N/A	All bus stops, existing or planned along the frontage of the development	All bus stops, existing or planned along the corridor and within 100-ft of any intersection	

Corridor in Scope:
1) Development Project: Site-adjacent parts of public street
2) Capital Project: Entire corridor within scope of project.

Table 15.2 – INTERSECTION MMSS REQUIREMENT APPLICABILITY

Intersection MMSS Requirement Applicability				
Design Element (MMSS Requirement)	**Project Type**			
	Development Project[1] (TIA Category 1)	**Development Project[1] (TIA Category 2)**	**Development Project[1] (TIA Category 3+)**	**Capital Project[2]**
Sidewalks (17.3.01.C)	All sidewalks at site-adjacent corners of intersections.	All sidewalks at all intersections.	All sidewalks at all intersections AND a minimum 100-ft from the ROW line on each intersecting street.	
Curb Ramps (17.3.02.A)	Curb ramps on site-adjacent corners of intersections and corresponding receiving ramps.	All curb ramps for all legal crossings at all intersections, including all receiving ramps.		
Intersection Corner Radii (Table 10.3)	N/A	All site-adjacent intersection corners.	All corners of all intersections.	
Curb Extensions (17.3.02.C)	N/A	All adjacent midblock crossings and adjacent intersection legs.	All corners of all intersections.	
Bus Stops (Ch. 17, Section 5)	N/A	All bus stops within 100-ft of a site-adjacent intersection.	All bus stops within 100-ft of all intersections.	
Intersection Bicycle Facilities (17.4.03)	N/A	Fully accommodate all existing/future bicycle facilities defined by the Houston Bike Plan at all intersections.		
Pavement Markings (15.2.06)	N/A	All pavement markings within intersection functional areas.		
Pedestrian Push Buttons (15.2.14)	N/A	All pedestrian push buttons at all legal pedestrian crossings at signalized intersections.		
Pedestrian Signal Heads (15.2.14)	N/A	All pedestrian signal heads at all legal pedestrian crossings at signalized intersections.		
Bicyclist Signal Heads (15.2.14 and 17.4.03.H)	N/A	All bicycle signal heads for all approaches to intersection with an existing dedicated bicycle facility.		
Pedestrian Crossing Signal Timing (15.2.14)	N/A	Ensure signal timing incorporates a walk speed of 3 ft/s and look for opportunities to implement lead pedestrian/bicycle interval and actuation-free pedestrian phases.		

Intersections in Scope:
1) Development Project: Site-adjacent intersections and TIA-impacted intersections
2) Capital Project: All intersections within scope of project

15.2.02 TRAFFIC AND DESIGN STUDIES

15.2.02.A GENERAL

1. Traffic and design studies are required to document the approval of changes to public streets, intersections, and traffic control as well as provide justification for the approved changes and alternatives considered. The specific studies required will depend on the scope of the project and must be coordinated with Houston Public Works.

2. Roadway projects associated with private development do not normally need to specifically satisfy the requirements of this section and should instead follow the requirements of Section 15.2.03 - Traffic Studies for Site Development.

3. Traffic and design studies are required for:

    a. New or reconstructed thoroughfare or collector streets;

    b. New or reconstructed local streets that differ from the standard cross sections shown in Tables 10.7 and 10.8;

    c. New or reconstructed intersection of two or more thoroughfare/collector streets;

    d. New, reconstructed, or modified roundabout;

    e. New or reconstructed traffic signal;

    f. New or modified bicycle facility;

    g. Dedicated transit facilities in the road right-of-way;

    h. New or enhanced designated pedestrian or trail crossings; and

    i. Any other project that has the capacity to modify the cross section and/or traffic control along a roadway.

4. One project may require several types of studies to document and justify the project. Project types and associated reports are defined in Table 15.3 - Requirements for Study Modules. The scope of needed studies for a project shall be coordinated with Transportation & Drainage Operations.

5. The studies included in this section do not need to be standalone documents if the required scope items are fully included in another approved document, such as a Traffic Impact Analysis (TIA) or Design Concept Report (DCR).

Table 15.3 – REQUIREMENTS FOR STUDY MODULES

Scope of Project	Study Modules					
	Safety Analysis	Corridor & Access Management Analysis	Intersection Design and Traffic Control Analysis	Intersection VLOS Analysis	Pedestrian Crossing Analysis	Traffic Signal Warrant Analysis
Roadway Construction / Reconstruction	**Y**	**Y**	**Y**	**Y**	**Y**	M
Intersection Construction / Reconstruction	**Y**	N	**Y**	**Y**	N	M
New/Rebuilt Traffic Signal	M	N	**Y**	**Y**	N	**Y**
New/enhanced pedestrian crossings	N	N	M	M	**Y**	M
Road diet / Lane reallocation / Bicycle facilities	**Y**	**Y**	M	**Y**	**Y**	M
Safety studies	**Y**	M	N	N	M	N

Notes:
Y – Study module always required for scope of project
M – Study module may be required by Houston Public Works
N – Study module not usually required unless requested by Houston Public Works

15.2.02.B STANDALONE REPORTS

1. If a project does not require another City-approved study that would cover the scope of studies defined in this section, a standalone report should be prepared to combine all required studies and present combined recommendations. At minimum, the following sections shall be included:

   a. Project Description:

      (1) Fully describe the project and document:

         (a) The funding entity leading the project.

         (b) Background and justification for the project.

         (c) Any public outreach/engagement performed or planned.

         (d) Summary of other projects that are planned, designed, or under construction that would impact the project.

         (e) Timeline for the overall project and for implementation of the recommendations included in the report.

15.2.02.B.1 continued

b. Study Modules:

(1) Provide a section for each included study module. Study modules are defined in Section 15.2.02.C - Roadway Study Modules.

c. Recommendations:

(1) Summarize all approved recommendations from all studies. Provide a timeline for implementation for each recommendation. Provide a map of improvements and, if available, schematic drawings.

15.2.02.C ROADWAY STUDY MODULES

The following modules shall be included as applicable.

1. Safety Analysis

a. The Safety analysis module is used to assess crash history and identify safety concerns along a corridor or at one or more intersections.

(1) Use TxDOT CRIS crash database[10] to assess crash trends over a 5-year period.

(2) Determine if the corridor is on the City of Houston Vision Zero High Injury Network (HIN)[11].

(3) Compute corridor crash rates using crash data and traffic counts. Compute intersection crash rates at signalized locations. Collect new traffic counts if none are currently available. See Section 15.2.04 - Traffic Volumes for requirements for traffic volume data.

(4) Determine whether there are any crash trends or hotspots within the project area.

(5) If the corridor or intersection is on the HIN, identify and describe the crashes that contribute to that designation.

(6) Summarize crash reports by at least these factors:

(a) Year

Refer to the weblink for the updated HIN map:
[10] https://cris.dot.state.tx.us/public/Query/app/home
[11] https://www.houstontx.gov/visionzero/

15.2.02.C.1.a.(6) continued

(b) Severity of crash

(c) Involvement of a pedestrian or bicyclist

(d) Illumination level as a contributing factor

(e) Alcohol as a contributing factor

(f) Speed as a contributing factor

(g) Vehicle movements involved

(h) Highway Safety Improvement Program (HSIP) mitigation codes associated with the crash

(7) Identify any projects that have occurred within the study timeframe that may have addressed a preceding crash problem and assess the impacts of the project on the crash problem.

(8) Provide recommendations to address any identified crash trends or hotspots and use the crash analyses included in this section to specifically support any recommendation.

(9) Where applicable, identify TxDOT mitigation codes defined for the Highway Safety Improvement Program (HSIP) for all recommendations, and calculate the Safety Improvement Index (SII), as defined by TxDOT.

2. Corridor and Access Management Analysis

This module is intended to define features for roadway segments between intersection of public streets. The cross section of the road shall be determined following the steps below, in order. NOTE: The number of general-purpose lanes shall not be the starting point for determination of cross section.

a. Determine walking, biking and transit needs.

(1) Document Existing Condition in relation to the Multimodal Service Standards (MMSS) defined in 15.2.01.

(2) Determine, document and provide recommendations for pedestrian realm dimensions and features as per the Multimodal Service Standard and Chapter 17, Section 3 - Pedestrian Elements Requirements.

15.2.02.C.2.a continued

(3) Describe existing bicycle facilities and determine, document, and provide recommendations for proposed bicycle facilities based on the Houston Bike Plan and by the requirements of Chapter 17, Section 4 - Bikeway Facility Requirements.

(4) Describe existing transit service and infrastructure, and determine, document, and provide recommendations for transit infrastructure, including bus stop locations, enhancements and dedicated transit facilities, according to Chapter 17, Section 5 - Transit Facility Requirements and in coordination with METRO.

b. Determine Access Management needs.

(1) Document existing Access Management characteristics including:

(a) Driveway placement

(b) Driveway dimensions

(c) Presence of physical Median of center turn lane

(d) Median opening locations

(e) Median opening dimensions

(f) Turn lanes at Median openings

(2) Identify and document any crash problems related to existing Access Management conditions and locations.

(3) Document all existing Access Management characteristics that do not satisfy current IDM requirements.

(4) Identify layouts of Access Management characteristics that would fully comply with all IDM requirements.

(5) Make final recommendations for layouts of Access Management characteristics. Identify and justify any recommendations that do not fully comply with IDM requirements. Recommendations must be coordinated with the determination of vehicle capacity needs in Section 15.2.02.C.2.c.

c. Determine vehicle capacity and other vehicular needs.

15.2.02.C.2.c continued

(1) Determine the number of general-purpose lanes and/or parking lanes, depending on the needs and context of the project, that can fit within the remaining right-of-way.

(2) Determine the recommended number of general-purpose and/or parking lanes and, if needed, quantify any additional right-of-way that would be required to accommodate these lanes.

(3) Document Vehicle Level of Service (VLOS) for all existing and proposed conditions at all included intersections utilizing an intersection VLOS analysis (see article 15.2.02.C.4).

d. Summarize all requirements for multimodal facilities along the corridor and provide options for achieving as many of them as possible. Identify impacts on VLOS as well as tradeoffs and alternatives. Provide recommendations for the corridor cross section and Access Management characteristics.

3. Intersection Design and Traffic Control Analysis

This module is used to determine intersection design and traffic control.

a. Document existing traffic control at intersection.

b. Document Existing Conditions at the intersection in relation to the Multimodal Service Standards (MMSS) defined in 15.2.01.

c. Determine and document required pedestrian realm dimensions and features at the intersection as per Chapter 17, Section 17.3.02 - Intersections and Midblock Crossings.

d. Determine required bicycle infrastructure at the intersection according to the Houston Bike Plan and Chapter 17, Section 17.4.03 - Bikeways at Intersections.

e. Determine required transit infrastructure at the intersection, including bus stop locations and enhancements and dedicated transit facilities, according to Chapter 17, Section 5 - Transit Facility Requirements and in coordination with METRO.

f. All new or reconstructed intersections must satisfy all MMSS.

g. Prepare recommendation of proposed traffic control devices.

(1) All new or reconstructed intersections must assess the feasibility of constructing a roundabout. An analysis should be prepared to justify not constructing a roundabout based on the MMSS, other multimodal standards, or traffic demands.

15.2.02.C.3.g continued

(2) All new or reconstructed traffic signals must provide a Traffic Signal Warrant Analysis report that follows the Texas Manual on Uniform Traffic Control Devices. See section 15.2.02.C.6 - Traffic Signal Warrant Analysis (TSWA) below.

(3) Recommend the number and designations of travel lanes and Auxiliary Lanes. The number and types of lanes should not be recommended solely on Existing Conditions; they should be evaluated according to the MMSS and measured traffic demand.

(4) Prepare an intersection VLOS analysis for existing and proposed conditions.

4. Intersection VLOS Analysis

This module is used for traditional capacity analysis at intersections to determine primarily Vehicle Level of Service (VLOS).

a. Collect 13-hour turning movement counts at study intersections utilizing the requirements of section 15.2.04 - Traffic Volumes.

b. Use Vistro or other approved HCM-compatible software or methodology to build capacity analysis models for each identified study scenario.

c. Time periods for analysis:

(1) AM Peak

(2) PM Peak

(3) 4th Highest Hour

(4) Other period as required (e.g., Off-peak, Noon, Weekend, peak hour of generator)

d. Scenarios for analysis will be project-specific, but should generally include:

(1) Existing Conditions

(2) Background Conditions

(3) Projected Conditions

(4) Mitigation Conditions

e. Provide the following figures at a minimum:

15.2.02.C.4.e continued

(1) A chart of the total traffic volumes at the intersection for all available hours to visually communicate the spread of the peak hours of demand.

(2) Turning movements at each analysis intersection for each time period/scenario combination.

f. Provide the following tables at a minimum:

(1) Comparison of VLOS and vehicle delays per vehicle across the scenarios and for each analysis time period. For a given time period, it should be easy to compare VLOS for all scenarios.

5. Pedestrian Crossing Analysis

This module is used to determine where crossings should be provided for pedestrians, bicyclists, and other vulnerable roadway users along a corridor and determine the features of the crossings.

a. Use the methodology defined in Chapter 17, Section 17.3.03 - Corridor Crossing Analysis and Treatments.

6. Traffic Signal Warrant Analysis (TSWA)

This module is required before any new signal may be permitted. It is also used to determine if existing traffic signals should remain or be removed.

a. The City Traffic Engineer must approve the recommendation for a new traffic signal before the signal may be installed.

b. Before a new signal will be approved, a traffic engineer shall conduct a traffic signal warrant analysis for the intersection that is compatible with the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

c. Houston Public Works accepts all warrants defined in the TMUTCD. However, satisfaction of one or more warrants shall not in itself require installation of a traffic control signal.

d. The following warrants are typically reserved for very specific circumstances that are driven by internal Houston Public Works analyses and recommendations:

(1) Warrant 3 – Peak Hour;

(2) Warrant 6 – Coordinated Signal System;

(3) Warrant 8 – Roadway Network; and

15.2.02.C.6.d continued

(4) Warrant 9 – Intersection Near a Grade Crossing.

e. The use of Warrants 3, 6, 8, and 9 for a specific location shall be coordinated with the City Traffic Engineer before the TSWA is conducted.

f. New signals should be spaced at least ¼ mile away from existing or planned signals.

g. The City requires that a minimum of thirteen (13) hours (includes am and pm peak hours) of turning movement counts be collected for a traffic signal warrant analysis.

h. Warrant 7 – Crash Experience: Requires exhaustion of any other feasible crash mitigation options. A TSWA relying on Warrant 7 must document crash mitigation attempts that were previously made and why other mitigation options are not feasible for the location. If crash mitigation is the primary goal of a traffic signal, the requesting party should meet with the City Traffic Engineer first to determine all possible mitigation options.

i. The following may be considered signal-correctable crashes for warrant purposes:

(1) any pedestrian/bicyclist-vehicle crash;

(2) through-through crashes; and

(3) through-left turn crashes.

(4) Rear end crashes, single vehicle crashes, and crashes involving right-turning vehicles are not considered correctable because these crashes may occur with equal or greater frequency after installation of a signal.

j. Right Turn Reductions: If a right turn lane is available or is recommended, all right turning traffic shall be deducted from the hourly approach volumes. If a shared through/right turn lane exists, one half of all right turning traffic on the approach shall be deducted, because right-turning vehicles typically do not require a traffic signal to safely enter another street.

15.2.02.C.6 continued

k. Left Turn Lane Considerations: Engineering judgment is required to determine whether a left turn lane is counted as an additional lane. As a rule of thumb, the Engineer of Record should consider the ratio of left turning traffic to the other traffic. If the left turning volume exceeds twenty (20) percent of the total traffic, the left turn lane should be counted as an additional lane. Exclusive right turn lanes are not to be counted as an additional lane since their volumes are to be deducted from the totals.

l. Traffic volume reductions for high-speed or rural roadways may be utilized as appropriate.

(1) These reductions may only be applied to:

(a) Warrant 1 - Eight Hour Vehicular Volume;

(b) Warrant 2 - Four Hour Vehicular Volume; and

(c) Warrant 4 - Pedestrian Volume.

(2) Warrant 3 - Peak Hour is excluded.

(3) Only major street thresholds shall be reduced. Local experience has shown that reducing the thresholds for Warrant 3 - Peak Hour or reducing minor street thresholds would result in a significant number of local intersections satisfying the warrants that otherwise operate safely without a traffic signal. In short, the warrants become very broad, and engineering judgment is effectively removed from the analysis.

m. If a TSWA finds that a proposed signal is not warranted, conduct an Intersection Design and Traffic Control Analysis to determine appropriate traffic control and intersection design parameters.

n. If a TSWA finds that an existing signal is not warranted, coordinate with Houston Public Works to determine whether or not the signal should be removed, and if so, what traffic control should replace it.

15.2.03 TRAFFIC STUDIES FOR SITE DEVELOPMENT

15.2.03.A APPLICABILITY

1. Two levels of traffic studies are identified and are dependent upon specific site location conditions, adjacent street configurations/capacities and traffic generation rates for proposed development. These studies are referred to as "Access Management Data" and "Traffic Impact Analysis (TIA) ". Figure 15.1 provides an overview of the submittal and review process.

15.2.03.A continued

2. For each proposed development or redevelopment, an Access Management Data Form must be submitted.

    a. The Access Management Data Form provides general property information and an initial estimate of traffic volumes associated with the property.

3. Exceptions to the requirements for the submittal of Access Management Data Form include:

    a. Construction, reconstruction, remodel or additions to a single-family residence.

    b. Remodel of commercial developments with no change in use and/or size.

4. In addition to filing the Access Management Data Form, a Traffic Impact Analysis may be required.

    a. If the proposed development or redevelopment generates 100 or more new peak hour trips (PHT), the Engineer of Record should meet with the City to determine the requirement for a Traffic Impact Analysis.

    b. If after discussion with the City, a Traffic Impact Analysis is required, the extent of the area to be studied will be determined.

    c. If an applicant submits a development plat application or building permit application for new development or redevelopment, the applicant may voluntarily submit a TIA to support the trip generation rates and Access Management needs to the adjacent street system for the proposed project.

5. The City may ask for a technical memorandum in lieu of a full Traffic Impact Analysis (TIA). The technical memo shall be submitted when the proposed development generates 80 vph -120 vph during AM or PM peak hours, utilizing the trip generation rates in the latest edition of the Trip Generation Manual. The technical memo shall address the immediate intersection(s) to the proposed development. The intersection(s) to be included in the technical memorandum shall be decided by the City. The memorandum shall address the studies intersection(s) in terms of:

    a. Existing traffic counts (turning movements and 24-hour counts)

    b. Existing signal timing

    c. The intersection geometric layout including:

        (1) Number of lanes for each approach

15.2.03.A.5.c continued

(2) Lane width

(3) Medians widths and Median openings locations

(4) Existing Driveways location near the proposed development

(5) Signage and lane marking

(6) Type and location of bicycle facilities

(7) Summary of existing Multimodal Service Standards (MMSS) as defined in section 15.2.01.

d. Existing operation performance using PTV Vistro or other HCM compatible software packages

e. Number of trips generated by the proposed development

f. The impact of the proposed development on the intersection(s) traffic operation performance under the Existing Conditions (using Vistro or other HCM compatible software packages)

g. The proposed mitigation measures including but not limited to:

(1) Addressing deficiencies in existing Multimodal Service Standards (MMSS)

(2) Changing lane usage and marking

(3) Changing geometric and/or layout

(4) Changing traffic control type

(5) Adding lanes

(a) Note: Any mitigation must fully comply with the requirements of the Multimodal Service Standards (MMSS) defined in 15.2.01.

h. The impact of the proposed mitigation measures on the intersection traffic operation performance (using Vistro or other HCM compatible software packages).

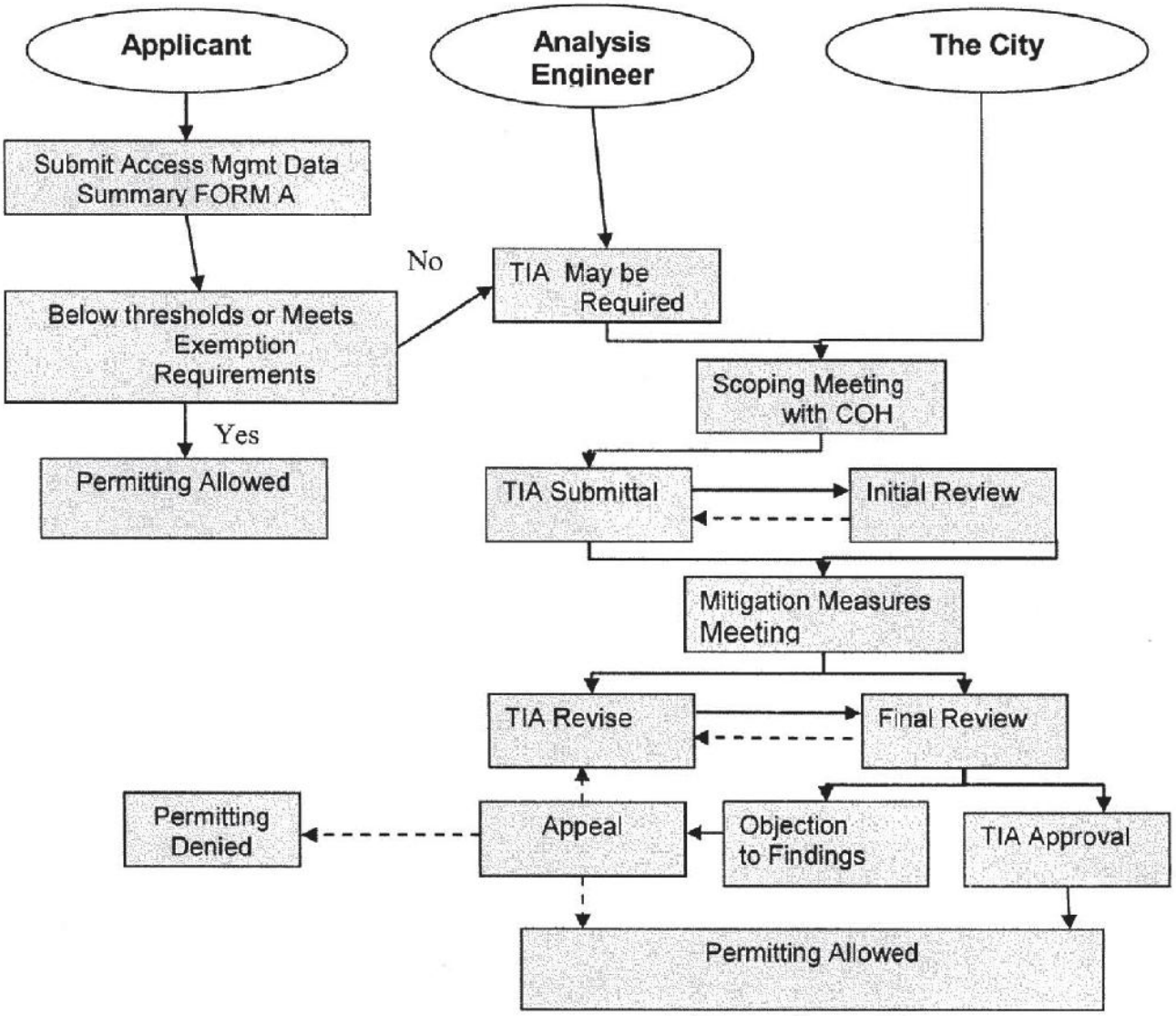


Figure 15.1 – OVERVIEW OF TRAFFIC IMPACT ANALYSIS PROCESS

ACCESS MANAGEMENT DATA FORM

HOUSTON PUBLIC WORKS

City of Houston
Access Form

Project Name: _____ **Project Number:** _____

Critical Item:

An Access Form is required for all commercial developments with the exception of developments with no change in use and/or size. Alterations to roadway access points **may result in significant site plan revisions.** For this reason, Access Forms should be submitted prior to or during plat submittal. If platting is not required, this form shall be approved prior to submitting plans for permitting.

Background:

This Access Form provides general property information and initial estimates of traffic volumes associated with the property. Chapter 15 of the City of Houston Infrastructure Design Manual (IDM) requires all commercial properties to submit an Access Form and a Traffic Impact Analysis (TIA) (if applicable). Exceptions to the submittal of an Access Form are:

a) Construction, reconstruction, remodel or additions to a single family residence.
b) Remodel of commercial developments with no change in use and/or size.

Furthermore, existing driveways in the right of way are not grandfathered.

Instructions:

This Access Form must be completely filled and submitted to PWEACCESSFORM@HOUSTONTX.GOV for review. It **must** be accompanied by a dimensioned site plan layout with driveway locations indicating the extent of the access which the commercial property has or (is planned) to access public streets. On-site traffic related features (loading docks, emergency lanes, and driveway entrance/exits) must be depicted on the site plan.

ACCESS MANAGEMENT DATA FORM

Access Form

Project Name: _____ **Project Number:** _____

Project Address: _____

Applicant: _____

Telephone: _____ Email: _____

☐ I have read and understand all items on page 1 of this Access Form (Check mark and initials are required to start review)	**Initials:** _____

EXISTING DEVELOPMENT (IF FUNCTIONAL):

Tract Number: _____ Tract Size: _____

Building Sq. Ft.	Land Use Description & I.T.E Code	Trip Rate		Peak Hour Trips		Average Daily Traffic Rate	Average Daily Traffic
		AM	PM	AM	PM		
Total							

PROPOSED DEVELOPMENT (NEW ADDED TRIPS):

Tract Number: _____ Tract Size: _____

NET NEW ADDED TRIPS:	

Building Sq. Ft.	Land Use Description & I.T.E Code	Trip Rate		Peak Hour Trips		Average Daily Traffic Rate	Average Daily Traffic
		AM	PM	AM	PM		
Total							

ABUTTING ROADWAYS:

Street Name	Number of Driveways	R.O.W Width	Pavement Width

ACCESS MANAGEMENT DATA FORM

Access Form

Project Name: _____ **Project Number:** _____

FOR OFFICE USE ONLY:

☐ The Office of City Engineer (OCE) has reviewed the Access Form provided for this project. At this time, the OCE has no objection to permitting for driveway access on the basis of vehicle trips generated by this development. **(Please provide a copy of this form with your permit documents.)**

However, this statement of no objection does not supersede requirements to comply with geometric design standards, codes and ordinances pertaining to median opening/modifications, driveways, auxiliary lane and other roadway improvements. All geometric design modifications must be approved by the Office of the City Engineer.

Reviewed by: _____Date: _____

☐ At this time, a Technical Memorandum is required in lieu of a full Traffic Impact Analysis (TIA). The technical memo shall be submitted when the proposed development generates 80 vph -120 vph during AM or PM peak hours, utilizing the trip generation rates in the latest edition of the Traffic Generation Manual.

(If additional concerns arise through the review of a Technical Memorandum, the City of Houston may request a full Traffic Impact Study.)

☐ A Traffic Impact Analysis is required. The Analysis Engineer should meet with the City to determine the scope for a Traffic Impact study and the extent of the study area.

	Traffic Impact Category	Site Traffic Thresholds New Peak Hour Trips (PHT) On Adjacent Street
○	Category I	PHT < 100
○	Category II	100 to 499
○	Category III	500 to 999
○	Category IV	PHT ≥ 1000

15.2.03.B TRAFFIC IMPACT ANALYSIS GUIDELINES (TIA)

1. General

   a. Authorization to Perform a TIA:

      (1) A TIA shall be prepared by an individual, group, firm, or corporation having demonstrated professional emphasis and experience in traffic engineering, and the preparation of similar analysis, hereinafter referred to as the Engineer of Record. The TIA document shall bear the seal and signature of a Texas Licensed Professional Engineer specializing in the branch of civil engineering. The responsibility for assessing the traffic impacts associated with a proposed development/redevelopment, hereinafter referred to as the "Development," rests with the applicant and the Engineer of Record, while the City shall serve as the review and approval authority.

   b. Purpose and Intent of TIA Guidelines:

      (1) The purpose of the TIA is to identify the adequacy of the existing street right-of-way to accommodate any changes in trips generated from a proposed development/redevelopment (as a stand-alone development or a stage of a master plan). If impacts are identified, potential mitigation measures (on-site or off-site) can be proposed and evaluated. The traffic impact analysis will be used to make a determination as to whether Driveway(s) being considered are necessary to provide reasonable access to the private property consistent with the safety and convenience of the public.

   c. Goals of a TIA Completed Within the City of Houston:

      (1) To identify any and all potential adverse traffic impacts to the existing area street system, the surrounding community and to additional proposed developments.

      (2) To identify transportation improvements with an aim to cost effectively mitigate identified adverse traffic impacts to mobility within the study area/analysis area.

      (3) To assist public and private sector entities to identify methods to facilitate multimodal access to the site, including by walking, bicycling, and transit, by utilizing the Multimodal Service Standards (MMSSs) defined in 15.2.01.

15.2.03.B.1.c continued

(4) To assist public and private sector entities in identifying and resolving issues related to the location of Driveways, Median openings, turn lanes, traffic signals, and other transportation facilities.

d. Document Limitations:

(1) While this section (15.2.03) contains guidelines and requirements necessary to complete a TIA for the City, the City does not intend this section to be a sole reference for the preparation of a TIA. For more specific information regarding the various aspects of TIA preparation, the City suggests that the reader obtain and refer to the Institute of Transportation Engineer's (ITE) current edition of Transportation Impact Analyses for Site Development (An ITE Proposed Recommended Practice).

2. The Traffic Impact Analysis Process

a. It is a goal of the City that these guidelines will allow for the maximization of efficiency and safety associated with area development/redevelopment.

b. The TIA process should begin as early as possible, as early as initial development planning and plat preparation. Early TIA preparation can help align site architectural design and layout with requirements for Driveway Permitting and off-site improvements. Further changes to the development, site plan, and Driveway layout are expected for an early submittal and can be accommodated in the TIA review process.

c. If a TIA is required or the applicant chooses to prepare a TIA, the completed TIA may be submitted at any time prior to or during the plat submittal. If platting is not required, a TIA shall be approved prior to submitting plans for permitting. TIA review may result in significant site plan revisions. The final site plan approval shall not be issued without the TIA approval.

d. The TIA report shall bear the seal and signature of a Texas Licensed Professional Engineer specializing in the branch of civil engineering. The responsibility for assessing the traffic impacts associated with a proposed development or redevelopment rests with the applicant and the Engineer of Record, while the City shall serve as the review and approval authority.

15.2.03.B.2 continued

e. A TIA determines traffic impacts of a development/redevelopment on the surrounding street system. The City will use this information to assist in establishing immediate transportation infrastructure needs and potential transportation improvements. If the development/redevelopment is a stage of a future larger development (master plan), the TIA should include the impact of the overall development (all stages).

f. Prior to submitting an application for development platting or a building permit the applicant may be required to submit a revised TIA and obtain approval by the City if any changes have been made to the development (site plan) or original TIA assumptions related to:

(1) Land-use (revisions required only for an increase in trips),

(2) Increase in the trip generation variable(s) (revisions required only for an increase in trips),

(3) Intersection and street design, and

(4) Access connections placement and design assumptions.

3. The Proposal of Scope and Initial Trip Generation Estimate

a. Using proposed development redevelopment, or master plan attributes (type, size, etc.), determine a corresponding traffic impact category for the development by calculating the highest number of estimated new peak hour trips generated for an adjacent street (See Table 15.4).

Table 15.4 - TRAFFIC IMPACT CATEGORIES

Traffic Impact Category	Site Traffic Thresholds New Peak Hour Trips (PHT) on Adjacent Street
Category I	PHT < 100
Category II	100 to 499
Category III	500 to 999
Category IV	PHT ≥ 1000

b. The City requires that the Engineer of Record generate site traffic using the methodologies found in the current edition of the ITE publication.

c. Using the resulting traffic impact category and the boundaries and horizons guidelines in Table 15.5, the Engineer of Record shall prepare and submit to the City Engineer a proposed scope for the TIA.

15.2.03.B.3 continued

d. It is also a goal of the proposed scope to minimize deliverables. It is mandatory that, regardless of traffic impact category (II, III, or IV), the Engineer of Record holds a preliminary scoping meeting with the City Traffic Engineer.

e. An approved proposal of scope ensures that the submittal of a TIA will allow the City to evaluate the overall traffic impact of the development on area transportation infrastructure.

4. Preparing the TIA

a. The TIA shall be prepared according to the requirements detailed in the Traffic Impact Analysis Preparation Overview Figure 15.2.

Table 15.5 - BOUNDARIES AND HORIZONS GUIDELINES

	Requirements	Category I	Category II	Category III	Category IV
General	Access Management Data Form	X	X	X	X
	Scoping Meeting with the City Traffic Engineer		X	X	X
	Proposed Scope		X	X	X
Horizon	Opening Year		X	X	X
	Full Build-Out Year(1)			X	X
Limits(3)	Analysis Area (From boundaries of development)(2)		¼ Mile	½ Mile	½ or 1 Mile
	All Site Access Driveways		X	X	X
	All Site Access Private Street Intersections		X	X	X
	All Adjacent Signalized Intersections		X	X	X
	All Adjacent Major Unsignalized Intersections		X	X	X
	All Analysis Area Signalized Intersections			X	X
	All Analysis Area Major Unsignalized Intersections			X	X

(1) Including the full implementation of master plan.
(2) Category II, III and IV studies should extend to first signalized intersection (minimum) even if outside of boundary and include any critical intersections as defined by the City.
(3) Shall be defined as the limits of the master plan.

5. TIA Submission and Review

a. All TIA submittals should be emailed to the Office of the City Engineer.

15.2.03.B.5 continued

b. The applicant shall submit one electronic copy of the TIA including all appendices (paper copies are not necessary unless requested by the City).

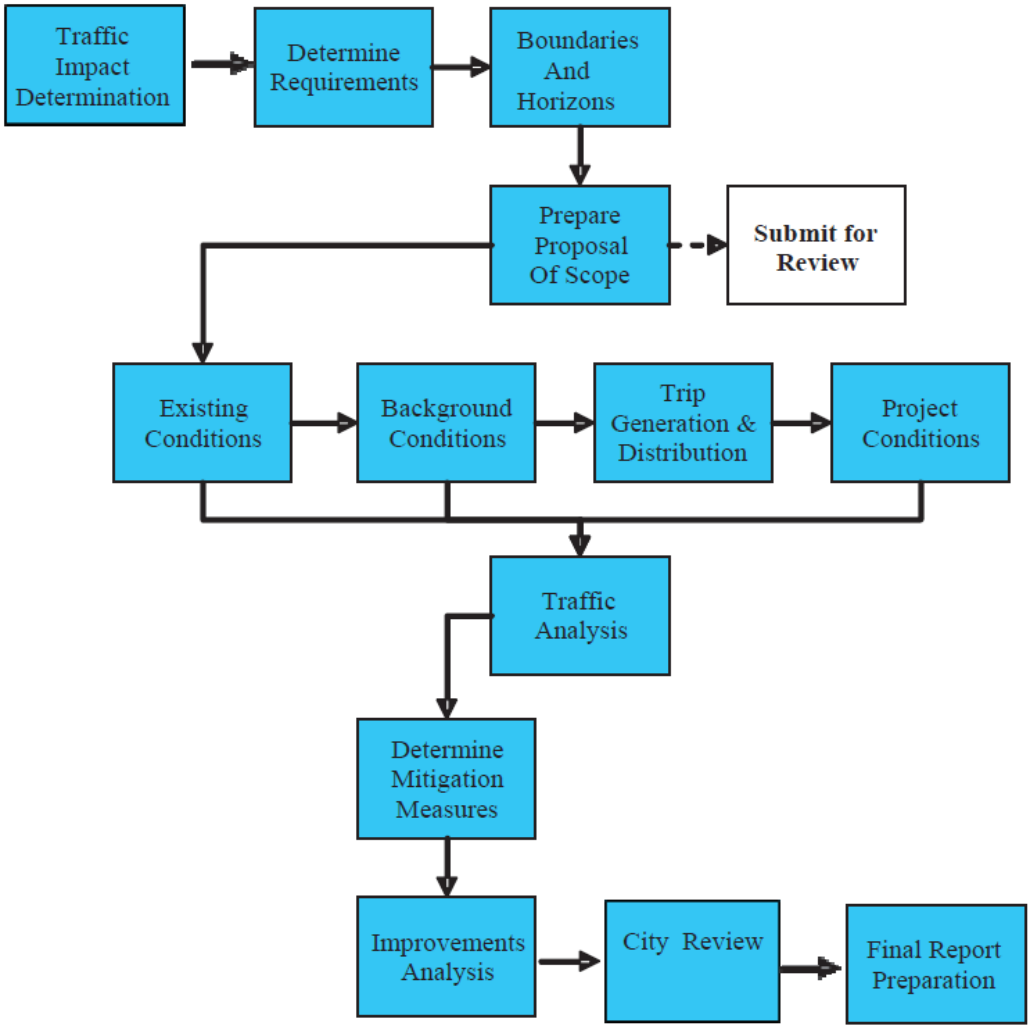


Figure 15.2 – TRAFFIC IMPACT ANALYSIS PREPARATION OVERVIEW

15.2.03.B.5 continued

c. The City will make an initial review of the TIA to determine if the Engineer of Record completed the TIA in accordance with the technical requirements and within the submission requirements of the analysis as outlined in this manual or as established at the preliminary scoping meeting or proposal of scope. If the City finds deviations from the technical requirements and/or the submission requirements of the study, the City will terminate the initial review until the Engineer of Record has addressed said deficiencies. At such a time when the City identifies deficiencies, the City will send a notice of deficiencies to the Engineer of Record and applicant. Submittal should include, if available, electronics copies of traffic counts (in Excel and pdf formats) and other collected data (i.e., queuing, delay studies, etc.) as well as any traffic analysis models used and referenced in the TIA.

d. All TIA submittals should include either an interim seal or a final seal, which is signed by a Licensed Professional Engineer in the State of Texas.

e. When the applicant submits a final TIA that meets the technical and submission requirements established in this document or at the preliminary scoping meeting or proposal of scope, the City will conduct a final review of the TIA.

f. Following the City's completion of the final review, the City will provide to the Engineer of Record and applicant written objection to the findings or adequacy of the proposed mitigation measures to address impacts. If no objections are noted, the City will interpose no objection to permitting for the proposed development. If the applicant disagrees with the objections made by the City, the applicant may write an appeal to the Director of Public Works.

g. Approval of a TIA will remain valid for a maximum of three years (from date of final TIA approval). Validity of an approved TIA beyond three years will be allowed by the City Engineer so long as the phased development is proceeding according to the approved plan and the schedule contained within such approved plan. The applicant may be required to update traffic impact data to address changes within the area and will meet with the City Engineer prior to the expiration of the three-year period to determine if an updated TIA is required.

6. Mitigation Measures Requirements

a. The TIA shall have identified significant adverse vehicular traffic impacts in order to trigger the need for mitigation. The need for mitigation is determined by using the qualitative measure Vehicle Level of Service (VLOS). The threshold of significance for transportation facilities on the area street system is VLOS D.

15.2.03.B.6 continued

b. Approval of TIAs will not be withheld if the City agrees that no feasible mitigation options exist.

c. Traffic signal retiming is not considered an acceptable mitigation measure unless it is first approved by the City of Houston Traffic Signal Operations. Typically, an individual intersection cannot be re-optimized in the future if it is a part of coordinated street network. This may only be possible if the entire street network is re-timed to allow for system wide signal progression. If signal retiming is approved by the City as a mitigation measure, it should be included in the Mitigation Conditions.

d. Mitigation Requirements:

(1) The following conditions must be assessed to determine mitigation:

(a) Existing Conditions

(b) Background Conditions

(c) Projected Conditions

(d) Mitigation Conditions

(2) VLOS shall be prepared for all analysis intersections for Existing Conditions, Background Conditions, Projected Conditions, and Mitigation Conditions.

(3) Mitigation Process:

(a) The mitigation process is shown in Figure 15.3.

(b) Each analysis intersection within the TIA scope shall follow this mitigation process.

(c) Mitigation Conditions:

(i) If the VLOS decreases from the Background Conditions, and if the Projected Conditions VLOS is E or F, then mitigation may be required.

(ii) If the Projected Conditions VLOS is higher than or unchanged from the Background Conditions VLOS, or if the Projected Conditions VLOS is D or higher, no mitigation shall be required.

(d) The intersection shall first be brought up to all standards that bring it into compliance with the Multimodal Service Standards (MMSS).

15.2.03.B.6.d.(3) continued

(e) Identify mitigation options that would improve the Projected Conditions VLOS to the Background Conditions VLOS. If the MMSS can be maintained and if the mitigation is feasible, then it should be implemented. No mitigation will be approved that does not comply with MMSS requirements.

(f) Private developers will not be required to acquire right-of-way from a third party to satisfy mitigation requirements. However, right-of-way dedication or easements may be required.

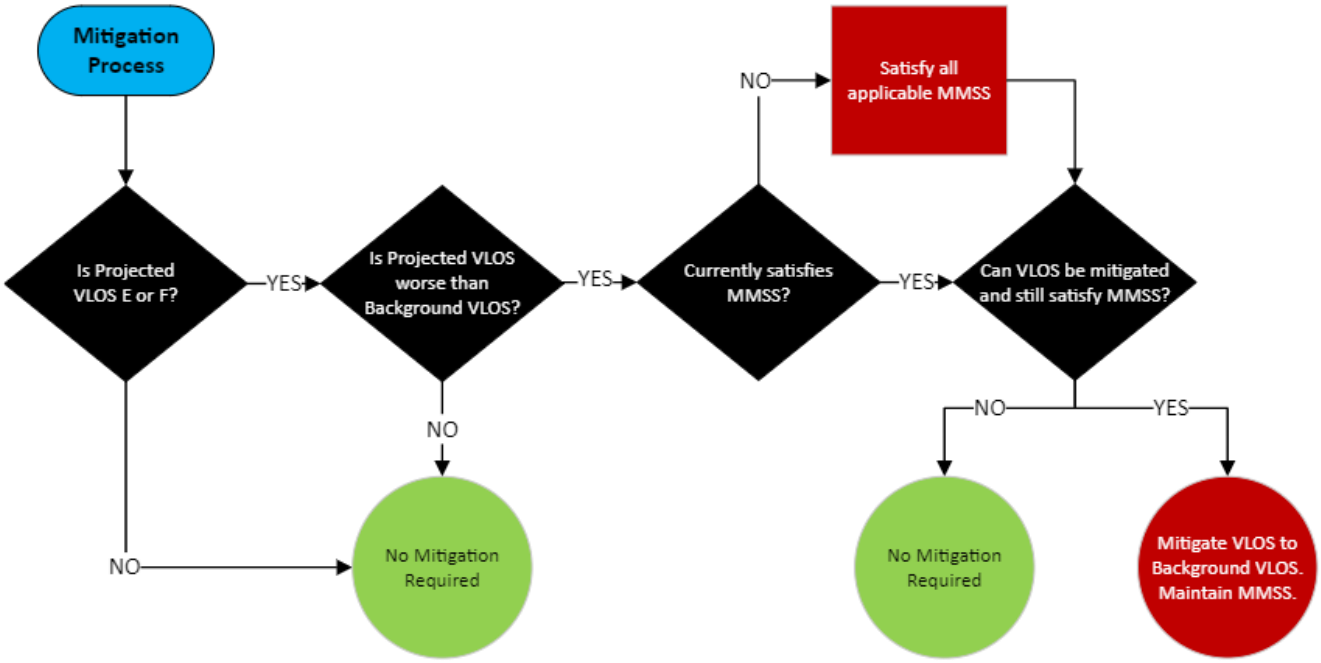


Figure 15.3 – TIA MITIGATION PROCESS

7. Traffic Impact Analysis Submission Requirements

a. The Engineer of Record must identify all of the required data and information in the appropriate sections of the report.

b. Text contained in the document shall be comprehensive and complete.

c. The report shall have an electronic copy of final submittals including all appendices.

d. The report shall contain a table of contents, lists of figures and list of tables. A typical TIA report outline is shown in the following sections.

I. Executive Summary

15.2.03.B.7.d.I continued

(a) Site Location & Analysis Area

(b) Development Description

(c) Conclusions

(d) Recommendations

II. Introduction

(a) A statement about the purpose and objectives of the analysis.

(b) A description of the existing and expected land use and intensity.

(1) *If residential, number and type of dwelling units.*

(2) *If commercial or industrial, square footage and type.*

(3) *If redevelopment, what is the expected trip generation differential.*

(c) A vicinity map identifying major industrial and site access intersections and other approved projects near the development.

(d) A site plan for the development.

(e) A description of development phasing and estimate year each phase will begin and end.

III. Area Conditions

(a) A description of the analysis area.

(b) A description of existing and future land uses within the analysis area. The description should include current land use, densities and occupancy, anticipated development, undeveloped properties, and current master plans.

(1) If residential, number and type of dwelling units.

(2) If commercial or industrial, square footage and type.

(c) A combination of narratives, tables and figures detailing area street system characteristics within the analysis area including:

(1) Quantify and summarize the existing facility compliance with the Multimodal Service Standards (MMSS) identified in 15.2.01.

(2) Programmed street improvements in the area (City of Houston 5 year Capital Improvement Plan)

15.2.03.B.7.d.III.(c) continued

(3) Additional streets that may be impacted

(4) Functional Street Classifications (based upon Major Thoroughfare and Freeway Plan)

(5) Posted Speed Limits

(6) Distance, and alignments from existing streets, Driveways, and/or Median openings to development access (need to assess Access Management Standards)

(7) Traffic control devices (traffic signals and stop signs)

(8) Signal locations and timings (offsets need to be shown if in coordination)

(9) Intersection layout, lane usage, and street configuration

(10) Street right-of-way widths

(11) Lane widths

(12) Current traffic volumes within the past 1 year to have been captured on a typical Tuesday, Wednesday, or Thursday for all streets in the analysis. Any traffic volumes older than 1 year may not be acceptable and will need to be justified. The Engineer of Record should also make every reasonable effort to count traffic that accurately reflects a true "peak period' for the area, which includes any potential seasonal variations (i.e. schools, churches, etc.). Depending on the type of development, it may also be necessary to capture volumes on a typical weekend.

i. 24-hour counts at major intersection and site access intersections

ii. Turning movement counts (peak hours) with pedestrian and bicycle movements

(13) Pedestrian Infrastructure

i. Existing Facilities, with identification of any deficiencies as per Chapter 17, Section 3 - Pedestrian Elements Requirements.

(14) Bicycle Infrastructure

i. Existing facilities, with identification of any deficiencies as per Chapter 17, Section 4 - Bikeway Facility Requirements.

15.2.03.B.7.d.III.(c).(14) continued

ii. Planned facilities on the Houston Bike Plan

(15) Transit Service

i. Existing routes and service headways

ii. Planned transit facilities

iii. All bus stops, bus pads, bus shelters

iv. Ridership (where applicable/when available)

(16) Crash Analysis

i. Identify whether any street or intersection in the scope of the TIA is on the City of Houston Vision Zero High Injury Network (HIN).

ii. Use TxDOT CRIS database to identify crash types and locations for three (3) years, and summarize: type of crash, severity of crash, and inclusion of a pedestrian or bicyclist.

iii. Identify any crash hotspots along any roadway or at any intersection included in the scope of the TIA.

iv. Identify any improvements to mitigate any identified crash trends or hotspots.

(17) Existing Sight Distances – Intersection and stopping Sight Distances, vertical and horizontal clearances. Refer to Chapter 10, Section 10.3.02.C. - Intersection Sight Distance.

IV. Required Table(s)

(a) Twenty-four hour approach volumes at major and site access intersections.

(b) Peak hour approach volumes at major and site access intersections.

V. Required Figure(s)

(a) Major and site access intersection lane configuration diagrams with existing twenty-four hour approach volumes. Preferably overlaid onto aerial photography.

(b) Major and site access intersection lane configuration diagrams with existing AM and PM peak hour turning movement volumes. Preferably overlaid onto aerial photography.

15.2.03.B.7.d.V continued

(c) The Engineer of Record may also use photographs (identifying location from where it was taken as well as the date and time stamp) to document Existing Conditions.

VI. Projected Vehicular Traffic

(a) Sufficient details of calculations so that all calculations can be verified.

(b) Site generated traffic volumes (24-hour and peak periods) by corresponding development phase or year.

(c) Trip Generation - List of trip generation rates and/or sources of rates used for the study.

(d) Trip Distribution and Assignment - The gravity model or other acceptable trip distribution model used to estimate trip distribution. The Engineer of Record can complete this task either manually or with applicable computer models.

(1) Background traffic volumes (24-hour and peak periods) by corresponding development phase or year.

(e) Traffic volumes should account for all approved developments in the analysis area as well as area growth beyond the analysis area. Contact the City for information about surrounding developments.

(1) Pass-by and diverted traffic volume reduction rates, if applicable.

(2) Pedestrian, bicycle and transit reduction rates, and supporting evidence, if applicable.

(3) Internal capture reduction rates, if applicable.

(4) Total project traffic volumes (24-hour and peak periods) by corresponding development phase or year. Future traffic as may be required for a development with multiple phases should also be included.

(f) Required Table(s)

(1) Pass-by trip, internal capture, pedestrian, bicycles, and transit reduction rates used, if applicable.

(2) Twenty-four hour approach volumes for background, pass-by, site generated, and total project traffic conditions at major and site access intersections and any additional transportation facilities specified by the City.

15.2.03.B.7.d.VI.(f) continued

(3) Peak hour approach volumes for background, pass-by, site generated, and

(4) total project traffic conditions at major and site access intersections and any additional transportation facilities specified by the City.

(g) Required Figure(s)

(1) Twenty-four hour, and peak hour approach volumes for background, pass-by, site generated, and total project traffic conditions overlaid onto major and site access intersections lane configuration diagrams. Preferably overlaid onto aerial photography.

(2) Peak hour turning movement volumes for background, pass-by, site generated, and total project traffic conditions overlaid onto major and site access intersections lane configuration diagrams. Preferably overlaid onto aerial photography.

(3) Distribution and assignment rates for pass-by and site generated traffic volumes overlaid onto major and site access intersections lane configuration diagrams. Preferably overlaid onto aerial photography.

VII. Traffic Analysis

Analyze existing, background and project traffic conditions VLOS and delay at all major and site access intersections and determine MOEs of any additional transportation facilities within the analysis area as necessary or as specified by the City.

(a) Analysis must utilize existing traffic volumes.

(b) Analysis must utilize total projected traffic volumes which include site generated traffic and the background traffic to complete analyses for the required study limits and horizons as they correspond to the predetermined TIA category.

(c) Analysis may be prepared manually or by using various software programs such as Highway Capacity Software, Vistro or as approved by the City.

(d) Analysis must utilize the capacity analysis methodology found in the current edition of the Highway Capacity Manual, or control delay calculations from Vistro or other software as approved by the City, and/or delay calculations from micro-simulation of the complete street network (no individual intersections) to determine VLOS.

15.2.03.B.7.d.VII continued

(e) Determination of necessary or specified MOEs should be completed using state- of-the-practice engineering methods.

(f) In addition to VLOS and delay, the Engineer of Record should identify critical movements regarding capacity and potential locations of queue spillback.

(g) The Engineer of Record should perform a signal warrant analysis for unsignalized intersections (engineering judgment) using the signal warrant guidelines. Additionally, as part of the improvements analysis the Engineer of Record should analyze any unsignalized intersections warranting a signal as a signalized intersection and discuss within the TIA report.

(h) Tables of existing, background and project traffic conditions VLOS and delay for each major and site access intersection and MOEs for any additional transportation facilities specified by the City, include critical movements and queue spillbacks.

VIII. Additional Information

(a) Site circulation and off-site parking requirements.

(b) Potential parking impact to adjacent neighborhoods and neighborhood parking

(c) Evaluation of potential need for traffic calming including bulb out, chicanes, roundabouts, or those elements found in Section 15.2.11 of this chapter.

(d) Others (If applicable)

(1) Crash analysis

(2) Traffic control needs

(3) Transit (bus and rail)

(4) Pedestrian and bicycle access

(5) Delivery and service vehicles

(6) Transportation demand management.

IX. Transportation Improvements Analysis (Mitigation Measures)

(a) A description of enhancements needed to bring all impacted roadways and intersections up to MMSS requirements.

(b) A description and justification of transportation modifications to accommodate projected traffic conditions

15.2.03.B.7.d.IX continued

(c) VLOS and delay evaluation and comparison including review of critical movements and queue spillbacks

(d) MOE comparison for any additional transportation facilities specified by the City

(e) Table(s)

(1) VLOS and delay comparisons for improvements including critical movements and queue spillback

(2) MOE comparisons for any additional transportation facilities improvements

(f) Figure(s)

(1) Concept schematics of improvements including corresponding VLOS and delay values.

X. Site Improvement Analysis

(a) A description of site circulation and recommendations for improvement.

(b) A description of on-site parking and recommendations for improvement including shared parking, if applicable

(c) A description of expected delivery and service vehicle operation and facility use and recommendations for improvement.

(d) A description of expected site passenger loading characteristics related to bus stop/transit and recommendations for improvement.

(e) A description of adherence to related Access Management concepts as can be found in the City's set of Access Management Standards including Driveway design, access spacing, and turning movement treatments.

XI. Conclusions and Recommendations

(a) Traffic Impacts

(b) Adjacent transportation improvements for each horizon year addressing, at a minimum, the following:

(1) Recommended MMSS modifications

(2) Bicycle facility implementation/improvements

(3) Pedestrian and transit facility implementation/improvements

15.2.03.B.7.d.XI.(b) continued

(4) Additional capacity (left, right, or through lanes), if compatible with MMSS requirements

(5) Traffic control device(s) (modification or installation)

(6) Need for acceleration or deceleration lanes

(7) Critical movements

(8) Length of storage bays

(9) Implementation schedule

(c) Off site transportation improvements

(1) Modification to existing traffic control device(s)

(2) Additional traffic control device(s)

(3) Additional capacity at major intersections

(4) Additional street capacity

(5) Other

(d) Site transportation improvements

(1) Access Management

(2) Site circulation and parking

(e) Mitigation Measures

(1) The TIA report shall identify the mitigation measures needed as a result of any traffic impacts of the proposed development or redevelopment. The TIA report should also identify who or what exactly caused the need for each mitigation measure. This information will be used when the applicant meets with the City Engineer about the implementation and cost appropriations for mitigations measures.

XII. Appendices

Appendices shall be titled appropriately in Adobe PDF file format. General figures and tables required by the TIA process should generally not be included as an appendix and should instead be included near the referencing text in the main document.

(a) Basic trip generation worksheet

(b) Capacity analysis worksheets or modeling software output

15.2.03.B.7.d.XII continued

(c) Traffic volumes (24-hour and peak hour turning movement counts)

(d) Selected photographs

15.2.03.C TECHNICAL NOTES

1. Background Trip Determination

   a. Background or non-site traffic forecasts are necessary to determine the impact of the development in horizon years such as the projected year of opening, year of full build-out and five years after full build-out. Background traffic consists of all trips that do not begin or end in the analysis area and all attraction and production trips from existing development within the analysis area. Trips generated from existing development within the analysis area are important as the proposed development may influence existing traffic patterns and potentially generate new trips for existing developments. Background traffic volumes should also include trips generated from other proposed developments within the analysis area. The Engineer of Record should check with the City to ensure that all approved developments have been included in background traffic determination.

2. Methodologies for Background Traffic Determination

   a. There are three basic methodologies used to determine background traffic volumes: build-out, area transportation planning, and trending. Each of these methodologies has strengths and weaknesses. Some methods may be more appropriate depending on the category of the development. The Engineer of Record may use any of the three aforementioned methods to determine background traffic volumes. The City anticipates that the majority of background traffic calculations will be completed using trending methods. For this reason, the City provides the following information on trending.

15.2.03.C.2 continued

b. Trending or the use of growth rates is a common method used to generate background traffic. This method is particularly useful for smaller developments and studies having shorter horizon periods (5 to 10 years). City of Houston traffic volumes have typically grown between one and two percent per year. Although these growth rates are typical for the whole of the City, there are some areas that may have higher and lower rates of growth. The Engineer of Record may find higher growth rates in outlying areas of the City having lower development density, and lower growth rates in older more mature areas of the City that have little or no year-to-year changes in traffic. In general, the City of Houston experiences a growth rate of one percent for all trending analyses. It is a requirement and the responsibility of the Engineer of Record to apply appropriate growth rates as they correspond to different areas of the city. The Engineer of Record should provide and justify an expected area growth rate in the proposal of scope for approval by the City. Where feasible, growth rates should be calculated from historical counts.

3. Site Trip Generation

   a. The City requires that the Engineer of Record generate site traffic and general trip generation rates using the methodologies found in the current edition of the ITE publication, Trip Generation Handbook.

   b. The ITE publication suggests using rates from local studies as a preferred method for generating site traffic. If the Engineer of Record utilizes local studies to determine appropriate rates, it is a requirement and the responsibility of the Engineer of Record to reference these studies in the TIA report. In addition, the Engineer of Record must make available copies of the referenced studies if requested by the City. If local rates are not available, the Engineer of Record shall use equations and rates from the current edition of the ITE Trip Generation report as long as it follows the ITE recommended procedure. Otherwise, Engineer of Record should consult with the City and local data may need to be collected.

4. Pass-by Trips/Internal Capture

   a. The City Traffic Engineer shall approve all pass-by and internal capture reduction for use in the TIA.

15.2.03.C.4 continued

b. The added pass-by trip will have little impact on through movement traffic operations or be part of a potential change in travel demand requiring adjacent transportation infrastructure improvements. However, pass-by trips can affect left- and right- turning movement frequency and may require installation of turn lanes or other forms of mitigation (i.e., exclusive phasing, timing optimization, capacity increase). The Engineer of Record should redistribute pass-by trips from the through movement to the appropriate left- or right- turning movement for analysis purposes. The Engineer of Record should provide and justify an expected reduction rate for pass-by trips in the proposal of scope for approval by the City.

c. Development access connections should still carry pass-by trips and the Engineer of Record should consider those trips in calculating the total number of trips generated by the proposed development and for necessary adjacent street improvements due to these trips. The City also recommends that the Engineer of Record account for pass-by trips in the trip assignment step to ensure appropriate left and right turning movement volumes as these added turning vehicles may require the need for the installation of new or additional storage at existing left- and right-turn lanes.

d. Internal capture is the application of a percent reduction in generated trips (Driveway trips) and is typically applicable to projects such as shopping centers with out-lots and urban mixed-use developments.

5. Generating Trips for Redevelopment

a. For proposed redevelopment, the City allows the Engineer of Record to subtract trips generated by the existing development from those the new development will generate. Existing trips are preferably derived from traffic counts.

b. If an applicant proposes changes to only a portion of an existing development, the City allows the Engineer of Record to subtract any trips associated with that portion of the existing development from the trip that the proposed redevelopment will generate.

6. Site Trip Distribution and Assignment

a. Site traffic distribution and assignment are very subjective tasks and requires the Engineer of Record to exercise engineering judgment and to call on past experiences in transportation planning.

b. Trip Distribution

15.2.03.C.6.b continued

(1) Trip distribution efforts, in general, take into consideration the development as a whole. Determining how generated traffic will access the proposed development can vary greatly and depends on several factors:

(a) Type of development

(b) Size of the development

(c) Where the development will draw or attract traffic from

(d) Competing developments in the area

(e) Surrounding land uses

(f) Condition and capacity of the surrounding street system

c. The City recommends the Engineer of Record refer to, or utilize previously determined trip distribution models, planning software, or other recognized and substantiated methods to distribute traffic.

d. It is a requirement and the responsibility of the Engineer of Record to document the methodologies or references utilized in completing the task of trip distribution in the TIA report. The Engineer of Record will also be responsible to provide copies of referenced studies or models if requested by the City.

7. Trip Assignment

a. Assigning trips determines the amount of traffic on routes within the street network and analysis area. The Engineer of Record should assign trips after considering several area and street network characteristics such as logical routings, left-turn movements at unsignalized intersections and access connections, available capacity and existing travel times. The Engineer of Record should consider traffic conditions for each horizon year and adjust trip assignments accordingly. The Engineer of Record may also find it necessary to prepare different sets of trip assignments for site generated trips. This may especially be useful if there are a significant number of pass-by trips. It is a requirement and the responsibility of the Engineer of Record to detail and explain assumptions in the narrative portion of the TIA report.

8. Traffic Analysis

15.2.03.C.8 continued

a. Capacity analyses shall be performed on the transportation facilities within the determined analysis area. The Engineer of Record shall use the methodology of the HCM to complete any capacity analysis. The analyses may be prepared manually or by using various available software programs such as HCS, Vistro, or as approved by the City. In addition to capacity analyses, the Engineer of Record should consider other factors including safety, circulation, traffic control needs, transit, neighborhood traffic impacts, pedestrian and bicycle access, delivery and service vehicles and transportation demand management.

b. For each analysis horizon, the Engineer of Record shall utilize the total project traffic volume which includes site generated traffic and the background traffic. Background traffic shall include traffic from other proposed developments within the analysis area and horizon. The Engineer of Record shall also complete capacity analyses for Existing and Background Conditions in order to provide VLOS comparisons.

c. The analysis and site plan of the development are an iterative process required for each horizon year. The purpose is to show the relationship between the site, its circulation, and plan along with the existing area street system. Accomplishing this allows the Engineer of Record to better determine deficiencies and develop alternatives for consideration. The Engineer of Record should define and identify impacts, deficiencies, and need for improvement. The analysis of Existing Conditions is essential in order to determine pre-development deficiencies and need for improvements.

d. The Engineer of Record shall tabulate and report VLOS and delay for the transportation facilities within the determined analysis area. The Engineer of Record should tabulate overall intersection VLOS and delay for each approach and individual movements. Left turning movements and, in many cases, the approach VLOS may be lower at stop-controlled facilities. Intersection capacity analysis shall include analysis of queue spillbacks and capacity of left and right turn lanes. The VLOS for turning movements at all access connections (Driveways and turning lanes) at the project site shall also be analyzed.

e. If the applicant is proposing a traffic signal at an intersection or access connections, the Engineer of Record shall prepare a Traffic Signal Warrant Analysis (TSWA) to include with the TIA.

f. All capacity analysis worksheets and modeling software outputs for the Existing Conditions and horizon years shall be included in the TIA report as an appendix. The City may also require the actual model to be submitted in electronic form.

15.2.03.C continued

9. Site Access and Off-Site Improvements

    a. The Engineer of Record should identify needs and deficiencies using the previously prepared analyses. In addition, the Engineer of Record should develop alternatives to address these needs and should address both on- and off-site improvements, if applicable.

    b. Make recommendations for all site-adjacent streets and intersections to fully comply with the Multimodal Service Standards (MMSS) as defined in section 15.2.01.

    c. Mitigation measures can include, but are not limited to, Median openings, turn lanes, bicycle/pedestrian/transit amenities, traffic calming and traffic signals. The Engineer of Record shall analyze proposed mitigation measures for capacity and other factors. The Engineer of Record shall base capacity improvements on the VLOS, however all Multimodal Service Standards (MMSS) must be satisfied before VLOS improvements will be considered.

10. Previously Proposed Transportation Improvements

    a. The Engineer of Record can factor proposed network improvements into the analysis and can use them as mitigation measures. For example, if the applicant schedules a development to open in three years, and the City has a capital project that will widen the street before that time, the Engineer of Record can consider the proposed capital improvement in the analysis.

11. Phased Developments

    a. Phased developments often present a challenge for the applicant. In many cases, phase I of the development is well defined while additional phases are vague and may change with market conditions.

    b. It is acceptable to the City for an applicant to submit a TIA for all phases of the development including proposed improvements at the start of a project. However, if future phases of the development change, generating more or less traffic, or if the site and/or Driveway layout changes, it will be necessary for an Engineer of Record to update the existing TIA or prepare a new one. If the applicant only submits to the City the first phase of the development, the applicant should be aware that conditions may change potentially requiring additional on- and off-site improvements. If a development is to be completed in phases, the TIA can also propose phasing of mitigation. However, the Engineer of Record must analyze any mitigation measures proposed for the appropriate horizon year.

12. On-Site Planning

15.2.03.C.12 continued

a. An integral component of any TIA should include basic site planning. This includes the identification of access connections (e.g., transit connections to existing bicycle and pedestrian facilities), internal circulation, service and delivery access connections and service bays including the use of turning templates as appropriate, and the identification of optimal building locations.

b. Access connections operate as intersections and the City treats them as such. They should have an appropriate number of lanes, adequate storage "ready access to existing transit facilities," pedestrian facilities and appropriate signing and pavement markings. Adequate storage for a larger development's access connections is often a concern, and if not designed properly, will operate inefficiently creating the potential for traffic to back up onto the street system. Shared Access between adjoining properties is desirable and should be pursued wherever possible, particularly where street frontages are short or internal volumes will be low. Driveways should be located near the property line if possible, or the applicant should make cross access agreements with adjoining property owners.

c. On-site circulation and street design should be consistent with off-site streets. The area street system has shaped driver behavior and expectations; violating these expectations provides potential for safety problems.

d. Consistency between off-site and on-site signage and pavement markings is desirable for managing drivers' expectations. To the extent practical, use of Texas Manual on Uniform Traffic Control Devices (TMUTCD) approved signs and pavement markings is recommended. Site access connections shall conform to City of Houston Access Management Standards and the applicant and the Engineer of Record should consider the following principles:

(1) Locating proposed traffic signals to provide for progression along the intersecting street.

(2) Providing the minimum number of access connections that can adequately serve all anticipated traffic traveling to the site.

(3) Providing adequate capacity/storage at access connections to ensure that traffic accessing the site does not spill back onto adjacent streets.

(4) Intersecting two-way Driveways with streets as close to perpendicular as possible.

15.2.03.C.12.d continued

(5) Providing adequate capacity/storage at internal intersections, especially those adjacent to public street access connections, to ensure that traffic within the site does not spill back onto adjacent streets.

(6) Providing adequate Sight Distance and appropriate safety measures at all access connections and internal intersections.

(7) Locate site Driveways across from existing public streets, Driveways or existing Median break locations, i.e., avoid offset Driveways or access connections.

e. The Engineer of Record should base Storage Lengths at access connections on the City of Houston Design Manual and Access Management Standards. For smaller developments, the Engineer of Record should design parking and access connections to allow vehicles to align themselves perpendicularly to the adjacent street system. For larger developments, the Engineer of Record should provide adequate storage to ensure that exiting traffic does not hinder internal circulation. The Engineer of Record should estimate potential on-site queuing and provide adequate stacking spaces to prevent impacts on adjacent streets as well as bicycle/pedestrian facilities.

15.2.03.D TRAFFIC ANALISYS IN MAJOR ACTIVITY CENTERS

The City Engineer, together with the Planning and Development Department, may cooperate with Management Districts, development authorities or other public or private organizations to prepare a transportation plan within a Major Activity Center. While the City may provide oversight, the preparation of the plan is not the responsibility of the City.

1. Transportation Plan and Traffic Analysis

a. The horizon year projections can be used to generate trips for the Major Activity Center study area. A Traffic Impact Analysis can be prepared using this transportation plan identifying impacts and mitigation measures. A plan can be included for how mitigation measures are implemented and these can be incorporated into transportation plans and capital improvement programs within a Major Activity Center.

b. It may be necessary for the transportation plan and traffic analysis to be updated once every three years.

c. Any proposed development within the transportation plan and traffic analysis study area that will produce the same or less PHT than a use described in the transportation plan shall be exempt from preparing a TIA.

15.2.03.D.1 continued

d. Any proposed development within the transportation plan and traffic analysis study area that will produce more PHT that described in the transportation plan shall be required to amend the plan or submit a separate standalone TIA.

2. Developments within a Major Activity Center without a transportation plan and associated traffic analysis will follow the traffic study requirements in this chapter.

3. Developments within a Major Activity Center will always have the option of preparing a separate TIA specifically for their development.

15.2.04 TRAFFIC VOLUMES

15.2.04.A The City of Houston, Houston Public Works collects and stores a broad range of traffic data to assist the Engineers of Record in maintaining and designing safe and cost effective facilities. The traffic data collection efforts include traffic volume and vehicle classification and speed data surveys, utilizing road tubes, permanent loop sensors, or other devices.

15.2.04.B The City of Houston uploads and stores historical traffic counts on the City GeoLink portal. [12]

15.2.04.C Traffic volumes from other sources can be used with authorization of the City Traffic Engineer.

15.2.04.D TRAFFIC STUDIES

1. New traffic volumes must be collected for all traffic studies if existing counts are more than 1 year old if located in an area experiencing high growth or more than 2 years old in all other areas.

2. Counts must be conducted between Tuesday and Thursday when school is in session. They must not be collected on holidays or the day before or after a holiday or when special events may disrupt typical traffic flows.

3. Summer counts may not be used unless authorized by the City Traffic Engineer.

4. General peak hour counts should be conducted between 7-9 am and 4-6 pm. If there is a peak hour generator (such as a bus stop or school) that may affect the designated peak times, this must be identified and approved by the City Traffic Engineer prior to use.

5. ADT and approach counts should include vehicle speeds and a calculated 85th-percentile speed as well as vehicle classifications broken into at least three categories based on size or number of axles.

[12] https://geohub.houstontx.gov

15.2.04.D continued

6. Turning movement counts (TMC) should be 13 hours and should include pedestrians and bicycles.

15.2.04.E ADJUSTMENT FACTORS

1. Seasonal Factors. If requested, traffic volumes shall be adjusted to reflect the seasonal changes in traffic volumes.

2. Peak Hour Factor (PHF). The hourly volume during the analysis hour divided by the peak 15-minute flow rate within the analysis hour. Hourly counts used in traffic analyses must use a PHF adjustment, which is computed by dividing the measured hourly volume by the PHF. PHF for the entire intersection will be applied to all vehicle movement volumes unless otherwise directed by the City Traffic Engineer.

$$PHF = \frac{HourlyVolume}{4V_{15}}$$

15.2.04.F GROWTH FACTOR

1. The City of Houston may require traffic counts to be projected out to future conditions. When Background Conditions and/or future conditions are required for a project assessment, the projection methodology must follow the requirements of this section.

2. The Engineer of Record must recommend a methodology for determining Background and/or future conditions. Linear growth rates are the most common method, but other methods may be acceptable.

3. If a growth rate is used to determine the Background Conditions and/or future conditions, the Engineer of Record shall recommend a growth rate. The City of Houston considers 1-2% to be a typical range of growth rates within most of the City, and the Engineer of Record shall provide justification for using a lower or greater rate.

4. Justification of a growth rate should be based on historical traffic counts in the vicinity of the project and/or knowledge of future land-use changes.

15.2.05 TRAFFIC SIGNS

15.2.05.A GENERAL

15.2.05.A continued

1. This section of the Design Manual contains the criteria and formats to be used in designing and preparing plans for the installation and refurbishing of traffic signs in the City of Houston. The intent is to establish standard procedures and requirements that will be used by the Engineer of Record when designing signing for City of Houston projects. All design shall also be in accordance with the Standard Highway Sign Designs (SHSD) for Texas and with the Texas Manual of Uniform Traffic Control Devices (TMUTCD).

2. This document provides the Engineer of Record with:

   a. the design requirements and guidelines for ensuring uniformity in sign types, mounting, size, and placement; and

   b. the required format of plan sheets to allow ease of review, minimization of construction errors, and facilitation of maintenance.

15.2.05.B DESIGN REQUIREMENTS

1. Description of Design/Review Process

   a. Project Initiation

      (1) Determine requirements of other agencies. If the project falls under TxDOT's jurisdiction, verify TxDOT's signing requirements and if discrepancies exist between the City's requirements and TxDOT's, the Engineer of Record shall meet with the City Traffic Engineer to reconcile any differences.

      (2) The Engineer of Record shall meet with the City of Houston prior to beginning the signing design to discuss the project in detail. At this meeting, typical and any specialty signing within the project limits will be discussed. The meeting regarding traffic signing will generally occur as part of other project initiation meetings and will not require a separate meeting.

      (3) Any special signs, sign toppers, custom signs and non-standard signs must be identified and approved by the City Traffic Engineer prior to use.

   b. Collect Engineering Data

      (1) Collect all data required to develop a base map of Existing Conditions which can be used for the design process. Typically, traffic signing design will be included as part of a roadway, intersection, or traffic signal design project, and base maps for traffic signing design can be generated from the topographic survey and/or other design sheets.

15.2.05.B.1.b continued

(2) The Engineer of Record shall visit the project site to inventory and identify physical features that may impact traffic signing designs.

(3) The Engineer of Record shall perform an inventory of existing signing. The inventory shall include but is not limited to the following:

(a) Sign size, sign material, and general condition of the sign

(b) Sign type and legend

(c) Posted speed limit(s)

(d) Any specialty signs

(e) Sign post and foundation type

(f) Identify signs that will need to be relocated or replaced.

(g) Any obstructions or geometric features that may interfere with the installation or visibility of signs.

c. Develop Base Map of Existing Conditions

(1) The Engineer of Record shall develop a base map showing all the applicable data collected. The base map or drawing will be used to show the traffic signing design.

(2) The base map shall include but is not limited to the following information:

(a) All roadway curb and gutter or edges of pavement

(b) Roadway stations and centerline

(c) Right-of-way, easements and street names

(d) Driveways and intersections

(e) Sidewalks, bus stops, pads, and shelters

(f) Other features deemed pertinent

d. Plans and Drawings

(1) General

15.2.05.B.1.d.(1) continued

(a) All traffic signing design shall be prepared on design sheet size required by the Project Manager. On the traffic signing plans; proposed pavement markings shall be shown as a background information without callouts. Refer to Section 15.2.06, Traffic Pavement Markings, for details regarding the design of pavement markings.

(b) All full-size designs shall be prepared at a scale of 1-inch equals 40 feet. If other design scales are needed, approval from the City Project Manager is needed before beginning design.

(c) All Drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.

(d) On projects where the Engineer of Record finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's Project Manager.

(2) General Notes

(a) General notes shown on City of Houston Standard Detail 01554-01 should appear on all traffic sign design sheets. Additional notes may be added by the Engineer of Record as may be necessary to properly clarify the intent of the design.

(b) The general notes in short include but are not limited to the following items:

(i) Prior to start of construction, all existing signs within the area of construction shall be inventoried and documented jointly by the City Inspector and the contractor. This document will be jointly signed by both parties reflecting the sign type, sign size, sign condition, sign location, reflectivity adequacy, etc. The contractor is held accountable for these signs throughout the project and at the project's completion.

(ii) The contractor will be responsible for safeguarding existing signs so that they either continue to remain visible and upright in the field or they are collected and stored in a secure area when temporary signs are used in lieu of the existing signs.

15.2.05.B.1.d.(2).(b) continued

(iii) The contractor will be responsible for re-installing existing signs that have been removed and stored by the contractor if required per construction plans. The contractor will provide and install signs that were documented missing prior to the start of work.

(iv) The contractor shall replace any signs that are lost or damaged during construction. All signs shall meet City standards.

(v) The contractor shall install all permanent signs, posts and hardware as shown on the plans.

(3) Ground Mounted Signs

(a) All ground mounted signs, unless noted otherwise, shall be mounted at a height of seven (7) feet measured from the bottom of the sign to the top of curb or top of roadway at edge of pavement and shall be a minimum of twenty-four (24) inches from the edge of pavement or curb.

(b) All ground mounted signs shall use perforated square metal tubing 1- 3/4" by 1-3/4". Special permission from the City Traffic Engineer will be required to use any other metal sign post.

(c) Refer to City of Houston Standard Details 01554-01 and 01554-02 for additional design requirements.

(4) Street Name Signs

(a) New street name shall be approved by the Planning and Development Department.

(b) Street name signs shall include block numbers per the Standard Details.

(c) Ground-mounted street name signs shall have a height of nine (9) inches. The length shall be thirty (30) inches minimum and forty-eight (48) inches maximum (in 1-inch increments). Sign plates longer than forty-eight (48) inches must be approved by the City Traffic Engineer.

(d) Refer to City of Houston Standard Detail 01554-03 (Street Name Sign and Sign Mounting) for additional requirements related to ground mounted street name signs. Refer to Chapter 15, Section 15.2.14 - Traffic Signals of this manual for overhead mounted street name signs.

15.2.05.B.1.d.(4) continued

(e) Customized street name signs require separate approval from the City Traffic Engineer. This includes ground mounted signs, overhead street name signs, and sign toppers. Interested parties should contact the Traffic Hotline at 832-395-3000 to apply.

(5) Ground Mounted Sign Sizes

(a) All "STOP" and "YIELD" signs installed in the City of Houston shall be a minimum of thirty-six (36) inches for vehicular traffic and eighteen (18) inches for non-motorized traffic.

(b) Refer to City of Houston Standard Detail 01554-06 (Ground mounted sign sizes) for dimensions of typically used sign plates and dimension of attachment holes.

(6) Sign Placement

(a) The placement of all signs shall be in conformance with the latest edition of the Texas Manual of Uniform Traffic Control Devices (TMUTCD).

(b) Refer to City of Houston Standard Detail 01554-07 (Typical Sign Placement) for typical sign placement details and street name signs at typical intersections.

(c) Refer to traffic signal details for additional information regarding typical placement and location for signs mounted on mast arms.

(7) City of Houston Approved Signs

(a) City of Houston Standard Detail 01554-08 and 01554-09 provide lists of regulatory, warning, construction work, bicycle, and school signs with corresponding sign nomenclature, and dimension.

(b) The Engineer of Record shall use the signs listed on City of Houston Standard Details 01554-08 and 01554-09. Special permission from the City Traffic Engineer will be required to adjust the sign dimensions and/or use additional signs approved by TMUTCD. Note that this does not apply to special signs and guide signs specifically tailored for a specific location.

(c) Guide signs for the following entities may be permitted within the City right-of-way. These entities may be required to install and maintain their own signs:

15.2.05.B.1.d.(7).(c) continued

(i) Public airports with a minimum of 15 regularly scheduled flights daily.

(ii) College and university campuses with a minimum of 500 off-street parking spaces.

(iii) Recreation and cultural interest facilities with minimum annual attendance of 100,000 visitors.

(iv) Hospitals with designated trauma facilities.

(v) Contact Transportation and Drainage Operations for submittal and approval requirements.

(8) Sign Summary Sheet

The Engineer of Record shall include a sign summary sheet as part of the signing design. The format of the sign summary sheet is shown by City of Houston Standard Detail 01554-10 (summary of signs). The sign summary table shall include the following information: plan sheet number, sign number, sign nomenclature, sign text, dimensions, post type, number of posts, sign area (square footage only for special signs), and sign post size.

15.2.05.C BLUE TILE STREET SIGNS

1. The following are the requirements for the preservation and installation of Blue Tile Street Signs embedded in street curbs:

   a. Coordinate, prepare and submit a preservation action plan to the Planning and Development Department Historic Preservation Division that is in accordance with these requirements:

      (1) Conduct community engagement to understand the local history and community needs for Blue Tile Street Sign preservation.

      (2) Gather input from City of Houston City Council Member's office, neighborhood civic groups, Tax Increment Reinvestment Zones (TIRZ), Management District, and Preservation Houston[13] and any other stakeholders identified by the City.

Refer to the weblink for reference:
[13] https://preservationhouston.org/

15.2.05.C.1 continued

b. For Capital Improvement Projects, include Blue Tile Street Sign preservation action plan in the Preliminary Engineer Report (PER) submitted to the City.

c. For street maintenance projects, preserve Blue Tile Street Signs according to these requirements.

d. Existing Curbs Without Blue Tile Street Signs.

(1) City of Houston does not install Blue Tile Street Signs where they did not exist previously.

(2) For public requests to install Blue Tile Street Signs where they did not exist previously:

(a) Coordinate with the Office of the City Engineer (OCE) for any public/third party installation.

e. Existing Curbs with Blue Tile Street Signs.

(1) Proposed curb reconstruction is not City funded

(a) Coordinate with the Office of the City Engineer (OCE) for any public/third party installation or restoration of Blue Tile Street Signs that is not part of a City funded comprehensive street reconstruction.

(2) City funded proposed reconstruction does not include street and curb:

(a) The presence of Blue Tile Street Signs in disrepair does not initiate a City funded reconstruction of existing curb.

(b) Coordinate with the Office of the City Engineer (OCE) for any public/third party installation or restoration of Blue Tile Street Signs that is not part of a City funded comprehensive street reconstruction.

(3) City funded proposed reconstruction does include street and curb:

(a) Reuse and Salvageability:

(i) Identify existing Blue Tile Street Signs that are salvageable, unsalvageable, and signs that will remain in place.

(ii) Existing curb with embedded sign determined to be in salvageable condition and identified for reinstallation must be approved by the City Engineer.

15.2.05.C.1.e.(3).(a) continued

(iii) Signs considered to be in salvageable condition must meet the following conditions:

- Minor cracks and chips in curbs are acceptable.
- Existing roadway paving does not cover part of the tiles, such that all letters are visible and legible.
- Removal of sign will not significantly damage the sign or irreparably damage the curb the sign is embedded in.

(iv) Existing Blue Tile Street Signs that are damaged beyond repair, determined to be unsalvageable or unacceptable for reinstallation by City Engineer, will be marked for disposal as demolition debris in the contract documents.

(b) Existing Blue Tile Street Signs that are damaged beyond repair, determined to be unsalvageable or unacceptable for reinstallation by the City Engineer will be replaced with a proposed Blue Tile Street Sign.

(c) Design and construct proposed Blue Tile Street Signs to replicate existing Blue Tile Street Signs.

(d) Blue Tile Street Signs must not disrupt the use of City infrastructure and must not block any ADA ramps or storm sewer inlets.

(e) Remove and reinstall existing Blue Tile Street Signs that can remain in the curb at the existing location.

(i) Existing Blue Tile Street Signs that are not affected by construction will remain in place.

(f) Existing Blue Tile Street Signs that cannot remain in place or located in the curb at the existing location, but can be removed and reinstalled in the proposed curb near the existing location:

(i) Relocate the existing Blue Tile Street Sign within thirty (30) feet from the edge of pavement of the cross street.

(g) Existing Blue Tile Street Signs that can be removed and cannot be reinstalled in the proposed curb near the existing location, and are in salvageable condition:

15.2.05.C.1.e.(3).(g) continued

(i) A proposed Blue Tile Street Sign will be installed as a replacement of the existing Blue Tile Street Sign. Locate the proposed sign within thirty (30) feet of the edge of pavement of the cross street.

(ii) In addition to 15.2.05.C.1.e.(3).(g).(i), if the community wants to repurpose the existing signs in a different capacity, such as embedment into the neighborhood sidewalk, direction to the contractor must be communicated in the contract documents.

(iii) If signs cannot be repurposed according to 15.2.05.C.1.e.(3).(g).(ii), remove existing Blue Tile Street Signs and deliver for disposition, as determined through community engagement, to any of the following:

- Local stakeholder;
- Artist who commits to repurposing the tiles;
- City of Houston Building Material Reuse Warehouse.

(h) Label Blue Tile Street Signs on plans with an identification number (ID).

(i) Provide a Blue Tiles Street Sign table on each drawing sheet with the following information:

(i) ID number

(ii) Station

(iii) Offset location

(iv) Sign data (name and block number)

(v) Sign length

(vi) Condition (salvageable or unsalvageable)

(vii) Work direction (remove and reinstall; remove and replace; remove, deliver for disposition and replace; remove, repurpose, and replace; dispose as demolition debris, and replace; existing to remain in place)

(j) Sign length will include an additional 6-inches of curb beyond the extents of each end of the tiled sign.

15.2.05.C.1.e.(3) continued

(k) Provide any details required for construction of signs.

15.2.06 TRAFFIC PAVEMENT MARKINGS

15.2.06.A GENERAL

1. This section of the design manual contains the criteria and formats to be used in designing and preparing plans for the installation of pavement markings in the City of Houston. The intent is to establish standard procedures and requirements that will be used by the Engineer of Record when designing pavement markings for City of Houston projects. All design shall also be in accordance with the Texas Manual of Uniform Traffic Control Devices (TMUTCD).

2. This document provides the Engineer of Record with:

    a. The design requirements and guidelines for ensuring uniformity in pavement marking materials, arrangement, and details; and

    b. The required format of plan sheets to allow ease of review, minimization of construction errors, and facilitation of maintenance.

15.2.06.B DESIGN REQUIREMENTS

1. Description of Design/Review Process

    a. Project Initiation

        (1) Determine requirements of other agencies. If the project falls under TxDOT's jurisdiction, verify TxDOT's pavement marking requirements and if discrepancies exist between the City's requirements and TxDOT's, the Engineer of Record shall meet with the City Traffic Engineer to reconcile any differences.

        (2) The Engineer of Record shall meet with the City of Houston prior to beginning the pavement marking design to discuss the project in detail. At this meeting, typical and any specialty pavement markings within the project limits will be discussed. The meeting regarding pavement marking generally occurs as part of other project initiation meetings and will not require a separate meeting.

    b. Collect Engineering Data

15.2.06.B.1.b continued

(1) Collect all data required to develop a base map of Existing Conditions which can be used for the design process. Typically, pavement marking design will be included as part of a roadway, intersection, or traffic signal design project and base maps for traffic pavement marking design can be generated from the topographic survey and/or other design sheets.

(2) The Engineer of Record shall visit the project site to inventory and identify physical features that may impact pavement marking design.

(3) The Engineer of Record shall perform an inventory of existing pavement markings. The inventory shall include but is not limited to the following:

(a) Lane width, pavement marking material, and general condition of the markings

(b) Posted speed limit(s)

(c) Any special pavement markings such as rail crossings, School Zone, bicycle facilities, etc., and

(d) Existing lane configurations and lane assignments.

c. Develop Base Map of Existing Conditions

(1) The Engineer of Record shall develop a base map showing all the applicable data collected. The base map or drawing will be used to show the pavement marking design.

(2) The base map shall include but is not limited to the following information:

(a) All roadway curb and gutter or edges of pavement

(b) Roadway stations and centerline

(c) Right-of-way

(d) Driveways and intersections

(e) Sidewalks, bus stops, pads, and shelters

(f) Other features deemed pertinent

15.2.06.B.1.c continued

(3) Before traffic signals are located on the base map, the pavement markings (existing or proposed) should be located to act as a guide in the location of signal heads and detector loops. Pavement markings shall conform to the Standard Specifications and Detail Sheets as well as meet the guidelines in section 15.2.06.B.2.

2. Pavement Marking Materials

   a. Preformed plastic pavement markings, as specified in the Standard Specifications, shall be used for all lane lines, island markings, cross hatching, arrows and legends.

   b. Preformed plastic pavement markings, as specified in the Standard Specifications, shall be used for all pedestrian crosswalks and stop bars.

3. Lane Lines

   a. Lane lines shall be aligned with corresponding lane lines on the opposite side of the intersection.

   b. Lane lines shall terminate at the stop or at the curb return (on uncontrolled approaches).

4. Crosswalks

   a. Crosswalks shall be installed across all approaches except where pedestrians are prohibited from crossing. They shall provide access to all corners of an intersection. Marked crosswalks shall be installed for all legal pedestrian crossings at signalized intersections. Marked crosswalks may be installed at other legal crossing locations to be evaluated and approved by the City.

   b. Crosswalks shall be ten feet wide. See the City of Houston Standard Detail for crosswalk configuration.

   c. Crosswalks should match up with ADA accessible ramps where possible.

   d. No transverse marking shall be placed within 18" of the curb or raised Median.

   e. High-Visibility Crosswalks shall be used only in exceptional scenarios at signalized and non-signalized crossings on collectors and Major Thoroughfares requiring extra emphasis such as immediately adjacent school facilities, rail stations, transit centers, and/or any other consideration evaluated and approved by the City.

5. Stop Lines

15.2.06.B.5 continued

a. Stop lines shall be placed at all signalized locations.

b. The stop lines shall be 24” wide and extend from a point 18” from the curb to the solid double yellow line (or a point 18” from the raised Median). It shall be located in accordance with City Standards.

6. Turn Arrows and Legends

a. City of Houston only uses Arrows or Onlys in exclusive turn lanes.

b. Plans and Drawings

(1) General

(a) All pavement markings design shall be prepared on design sheet size required by the Project Manager. Traffic signing and pavement markings shall be shown on different plan sheets. Refer to Section 15.2.05, Traffic Signs, for details regarding the design of traffic signs.

(b) All full size designs shall be prepared at a scale of one (1) inch equals forty (40) feet excluding notes and detail sheets. If other design scales are needed, approval from the City Project Manager is needed before beginning design.

(c) All Drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.

(d) On projects where the Engineer of Record finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's project manager.

(e) All changes to pavement marking lines and symbols shall be labeled by station callouts to the nearest whole number (##+##).

(f) Existing pavement markings to remain and proposed items such as right-of-way lines, edge of pavement, and curbs shall be delineated at lighter weight/shade than proposed pavement markings on pavement marking design sheets.

15.2.06.B.6.b.(1) continued

(g) At a minimum, lane widths between lane markings and face of curb/edge of pavements shall be provided every 500 feet using the center of the pavement markings as a reference point.

(h) General notes and quantities of pavement markings and sheet shall be prepared for every design project. In addition, line style designation methodology shown on City of Houston Standard Detail 02760-01 shall be used to call out pavement marking line types on all design sheets.

(2) General Notes

General Notes shown in City of Houston Standard Detail 02760-01 should appear on all pavement marking design sheets. Additional notes may be added by the Engineer of Record as may be necessary to properly clarify the intent of the design.

(a) With the general notes a table showing bid items and quantities shall be provided.

(b) Every type of pavement marking line width, pattern, and width combination shall be assigned specific bid item with quantity in linear feet (LF). For example, lane lines (WB4) will have total LF quantity and unique bid item number.

(c) Every symbol and text type shall be assigned a bid item with quantity as Each (EA). For example, white single arrow will have total count quantity and unique bid item number.

(d) Every type of raised pavement marker (RPM) shall be assigned a bid item with quantity as Each (EA). For example, Type I-C "C" RRPM will have total count quantity and unique bid item number.

(3) Left/Right-Turn "Only" and Arrow Spacing (Refer to City of Houston Standard Detail 02760-02)

(4) Pavement Marking Words (Refer to City of Houston Standard Detail 02760-03)

(5) Pavement Marking Symbols and Arrows (Refer to City of Houston Standard Detail 02760-04)

15.2.06.B.6.b continued

(6) Standard Pavement Markings with Reflective Raised Pavement Markers for Position Guidance (Refer to City of Houston Standard Detail 02760-05)

(7) Use of Reflective Chip Seal Marker for Temporary Markings (Refer to City of Houston Standard Detail 02760-06)

(a) On some long-term temporary pavement markings plan, the Engineer of Record may select use of raised pavement marker buttons instead of chip seal marker. In such cases the Engineer of Record has to provide special temporary pavement marking RPM button arrangements for each line type and use of reflective raised pavement markers.

(8) Pavement marking for accessible parking (refer to City of Houston Standard Detail 02760-07)

(a) Note that angled parking on public streets requires City Council approval before implementation per City of Houston Code of Ordinances.

(9) Railroad Crossing Pavement Markings (Refer to City of Houston Standard Detail 02760-08)

(10) Bicycle Facilities Pavement Markings (Refer to City of Houston Standard Detail 02760-09)

(11) Crosswalks Pavement Markings (Refer to City of Houston Standard Detail 02760-12)

(a) High-Visibility Crosswalks should only be used where documented need is identified such as designated school crossings.

(12) Right- and Left-Turn Lanes (Refer to City of Houston Standard Details 02760-13 and 02760-14)

(13) Two-Way Left-Turn Lanes (Refer to City of Houston Standard Details 02760-15 and 02760-16)

15.2.07 ACCESS MANAGEMENT STANDARDS

15.2.07.A GENERAL

15.2.07.A continued

1. The overall purpose of implementing the City of Houston Access Management Standards is to ensure safety and enhance the functionality of City streets. This goal will be accomplished through preservation and improvement of operational efficiency and safety. "Access Management" is the systematic control and proactive management of the location, spacing, design, and operation of Driveways, Medians, Auxiliary Lanes, and intersections to improve the balance between access and mobility while preserving street safety and efficiency.

15.2.07.B APPLICABILITY

1. The Access Management Standards contained in this section are applicable to any new development, addition, or redevelopment, all or a portion, which is located within the defined corporate city limits of the City of Houston, Texas.

2. The requirements contained within this section are design standards and will serve as a basis for development plat approvals and building permits. These standards should be used in conjunction with the Houston City Code of Ordinances and other requirements set forth in the Infrastructure Design Manual.

3. Requirements for Access Management Design Techniques - Additional references/ resources are available in Chapter 40 - Streets and Sidewalks of the City of Houston Municipal Code of Ordinances[14] and the latest Houston Amendments to the International Building Code[15].

15.2.07.C ACCESS MANAGEMENT DESIGN

1. Driveways

   a. Proposed and redeveloped Driveways should be located and designed to provide safe and efficient access between property lines and the edge of the roadway. The Driveway should not create a traffic hazard for drivers utilizing the Driveways , or other road users including bicyclists and pedestrians.

   b. Driveway design considers the effect of vehicles to/from developed property on the movement of traffic and the safety of traveling public on abutting streets.

   c. Driveway design characteristics are based on proposed development classification (see Table 15.6).

   d. Driveway placement criteria is shown in

[14] https://library.municode.com/tx/houston/codes/code_of_ordinances?nodeId=COOR_CH40STSI
[15] https://www.houstonpermittingcenter.org/building-code-enforcement/code-development#agency-links-416

15.2.07.C.1 continued

e. Table 15.7 and

f. Table 15.8.

g. Driveway width is measured at the beginning of the Driveway Radii tangents within the Driveway (see Figure 15.4). Driveway Radius is the rounded edge of a Driveway that accommodates entry and exit by turning vehicles; however, radii should be as small as feasible to ensure a safer crossing for pedestrians and bicyclists. Design standards for minimum Driveway width and radius can be found in Table 15.6.

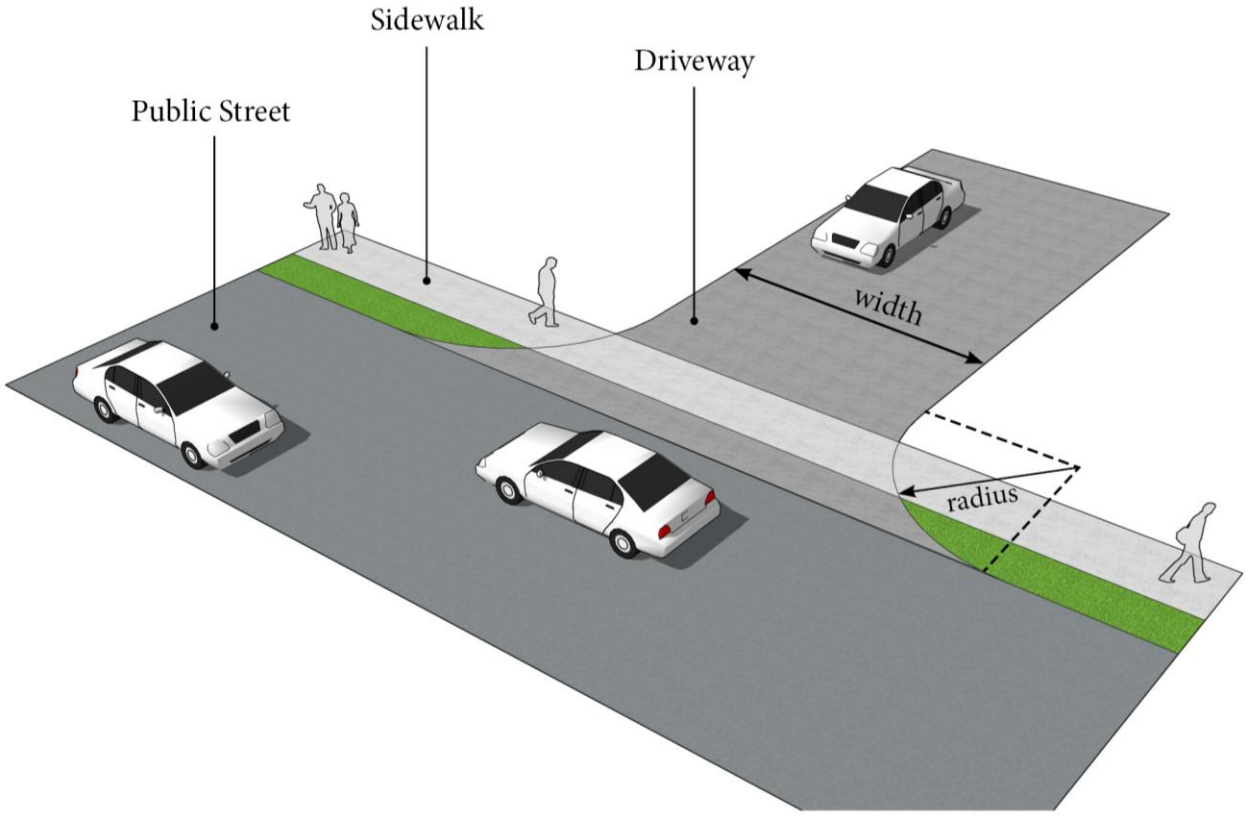


Figure 15.4 - DRIVEWAY RADIUS AND WIDTH

15.2.07.C.1 continued

Table 15.6 - DRIVEWAY DESIGN CRITERIA

Driveway Design Criteria [1][2]												
Traffic Type	Type A Driveway (For Single Family Residential Houses or Duplexes)				Type B Driveway (Shared Access/Shared Driveway)				Type C Driveway (Commercial Driveway)			
	Width (ft)		Radius (ft)		Width (ft)		Radius (ft)		Width (ft)		Radius (ft)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
One-Way	10	12	4	10	12[5]	16[5]	4[5]	10[5]	15	20	10	20
Two-Way	10[3]	24[4]	4	10	16[6]	24	4	10	24	35	10	20

(1) See article 15.2.07.C.1.f for Driveways that require a vehicle swept path analysis.
(2) See 15.2.07.C.1.g.(1) and 15.2.07.C.1.g.(2) for Type 1 PAE and Type 2 PAE requirements.
(3) The minimum width for Joint Access Driveway is 12 ft.
(4) Refer to Chapter 42 of the Code of Ordinances for driveway widths for narrow lots.
(5) Only MURs and Courtyard Style Developments on corner lots can have one-way driveways.
(6) Refer to Chapter 42, Section 42-146 of the Code of Ordinances for exceptions to the minimum driveway width for Shared Driveways.

h. Vehicle Swept Path Analysis Requirements.

(1) Vehicle swept path analysis is required for all commercial Driveways and Driveways connecting to existing alleys or streets that are less than fifteen (15) feet in width.

(2) Minimum Driveway width and radius shall not be less than required in Table 15.6.

(3) Design and Control Vehicles used for analysis are as follows:

(a) Type A and Type B Driveways

(i) Design Vehicle – P

(ii) Control Vehicle – P

(b) Type C Driveways

(i) Design Vehicle – WB40

(ii) Control Vehicle – WB62

(4) Driveway width and radius must be rounded up to the nearest whole foot.

i. Permanent Access Easements (PAE) Design Criteria.

15.2.07.C.1.g continued

(1) Type 1 Permanent Access Easements (Type 1 PAE).

(a) According to Section 42-1 of the Code of Ordinances, Type 1 PAE is a Permanent Access Easement at least fifty (50) feet in width that is designed and constructed like a public street in accordance with this design manual and contains one or more public utilities in an unpaved portion of the easement.

(b) For undivided streets, provide a minimum face to face pavement width of twenty-six (26) feet pursuant to Table 10.7 and Figure 10.3 of this manual.

(c) For divided streets, refer to Table 10.8 and Figure 10.4 of this manual for the minimum face to face pavement width requirements.

(2) Type 2 Permanent Access Easements (Type 2 PAE).

(a) According to Section 42-1 of the Code of Ordinances, Type 2 PAE is a Permanent Access Easement at least twenty-eight (28) feet in width that is designed and constructed like a private street serving a development that has no public utilities other than a public water line, connected to one or more fire hydrants, that provides no domestic water services. All private utilities within a Type 2 Permanent Access Easement must be designed to public utility standards outlined in the Infrastructure Design Manual.

(b) All Type 2 PAEs shall have a minimum face to face pavement width of twenty-eight (28) feet.

(c) Type 2 PAEs shall not connect to an alley.

(d) Curb Radii:

(i) For Type 2 PAEs that connect to a public street or a Type 1 PAE shall meet the standard intersection curb radii requirements for local streets in Chapter 10, Table 10.3.

(ii) Type 2 PAEs that connect to a Type 2 PAE shall comply with Section 42-129 of the City of Houston Code of Ordinances.

(e) Exception: Type 2 PAEs that are designed as turnarounds must meet fire code requirements. See Figure 10.11 of this manual for requirements.

15.2.07.C.1 continued

j. General Driveway Design Criteria.

(1) Driveway Categories.

(a) Type A Driveway is a Driveway for a single-family residential house or a duplex, or a Joint Access Driveway serving two abutting single-family residential lots or parcels taking direct access from a street.

(b) Type B Driveway is either a Shared Access/Shared Driveway (Flag Staff Driveways, Courtyard Style Development, or Multi-unit Residential (MUR) Development Driveways), or a Driveway constructed on an access easement other than a Permanent Access Easement.

(c) Type C Driveway is a Driveway for commercial developments or for non-single family residential developments (other than Multi-unit Residential Development) taking direct access from a public street.

(2) Outside of the right-of-way, the Shared Access/Shared Driveway and private drive width must meet the corresponding Chapter 42 of the Code of Ordinances and plat requirements.

(3) For Driveways that connect to roadways that are less than 18-feet in width, refer to street widening requirements in Section 10.3.03.J. Steet widening requirements will not apply to removal and replacement of single-family residential or duplex home Driveways.

(4) One-way Driveways must intersect streets between 45 and 90 degrees.

(5) Angled one-way drives are permitted only on one-way streets and divided streets with no Median opening.

(6) Two-way Driveways must intersect city streets at approximately 90 degrees.

(7) Where situations permit, AASHTO design vehicles may be used to justify Driveway Radii.

(8) No Driveway Radius shall encroach on abutting property or corner radius.

15.2.07.C.1.h continued

(9) Driveways shall not be permitted within limits of any intersection. (Design Exception shall be required for Major Thoroughfare locations with existing esplanades and streets used for residential access.) Intersection Limits are defined by Driveway offsets as defined in

(10) Table 15.8.

(11) For one-way Driveways, the entry Driveway shall precede exit Driveways (in direction of adjacent travel lane).

(12) All Type A Driveways must remain tangential, uniform in throat width, and unobstructed from the roadway to the property line on private property.

(13) All Type B Driveways must remain tangential, uniform in throat width, and unobstructed for a minimum of eight (8) feet past the property line on private property.

(14) Type C Driveways must remain tangential, uniform in throat width, and unobstructed for a minimum of twenty (20) feet past the property line on private property.

(15) Where present or projected traffic operations indicate needs for alternative Driveway geometrics, additional consideration may be given.

(16) For alley access requirements, refer to Ch. 10, Subsection 10.3.03.G.2.

(17) Where Driveways are installed or altered on roadways with bicycle facilities (refer to Chapter 17, article 17.1.04.B), the bicycle facility shall be incorporated into the proposal and the new configuration of the bicycle facility must be approved by the City of Houston. The proposed bicycle facility design must meet all City of Houston standards (refer to IDM Chapter 17), including but not limited to restoring the bicycle facility to the same or better level of safety and comfort for Vulnerable Road Users (refer to Chapter 17, article 17.1.04.SS). The City of Houston approved design must be implemented before construction can be considered complete.

(18) Refer to Chapter 42 of Code of Ordinances for requirements for alley access or Shared Access for new developments proposing narrow lots as defined in Chapter 42 of the Code of Ordinances.

(19) For narrow lots with an individual Driveway, the maximum Driveway width allowed is twelve (12) feet and must meet Chapter 42 requirements of the Code of Ordinances.

15.2.07.C.2 continued

2. Loading Docks/Wells/Berths

   a. Back in loading is not permitted on Driveways and accesses to loading docks/ wells/berths from an adjacent Major Thoroughfare.

   b. Where Driveways are used to access trash receptacles and loading docks, the Driveways and adjacent areas on the property must be designed to provide appropriate maneuverability and storage for the vehicle and no part of the vehicle shall protrude over the property line or obstruct any public street or sidewalk in whole or in part.

   c. Driveways or accesses to loading docks/wells/berths/trash receptacles shall be a minimum of twenty (20) feet from another Driveway on the same property or as defined in

   d. Table 15.8.

   e. Driveways to utility and infrastructure facilities such as lift stations, cell towers etc. must be designed to prevent obstructions to adjacent public streets or sidewalks, in whole or in part.

3. Driveway and Corner Clearance Spacing

   a. General Driveway Spacing Criteria

      (1) The distance between connections from Driveway to street is measured from the closest edge of the Driveway to the property line. See Figure 15.5.

      (2) The distance from Driveway to Driveway is measured from the closest edge of the first Driveway to the closest edge of the second Driveway. See Figure 15.5.

      (3) A pair of one-way Driveways (entry and exit) should be considered as a two-way Driveway for Driveway spacing purposes.

      (4) Spacing between one-way Driveways requires the entry precedes the exit in the direction off the adjacent travel lane.

      (5) For the special situation of multiple entry Driveways placed on one-way street and exit Driveways placed on a different street, two same street Driveways should be considered as a one-way pair.

      (6) Driveways on a street without a Median should align with Driveways on the opposite side of the street, when possible.

15.2.07.C.3 continued

(7) Driveway should be placed at a minimum offset distance of seventy-five (75) ft from the Median nose or align the Driveway with the Median opening.

(8) Bicycle and Pedestrian Pathways at Driveways: With the City of Houston's focus on safety for all modes of travel and an increasing multimodal environment, standards for bicycle lanes/paths and sidewalks where they intersect Driveways have been provided. These can be found in Chapter 17, Sections 17.3.01 and 17.4.02 of the IDM.

b. Type A and Type B Driveway Spacing – See Figure 15.5 for Type A and Type B Driveway spacing definitions and

c. Table 15.7 for Type A and Type B Driveway spacing criteria.

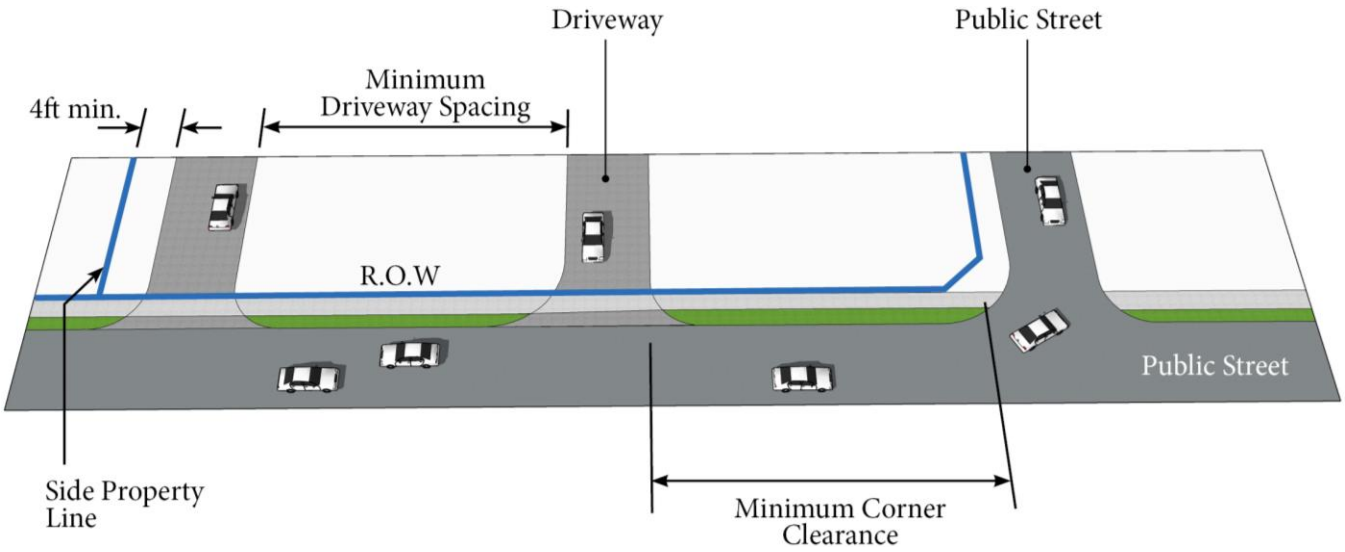


Figure 15.5 – TYPE A & TYPE B DRIVEWAY SPACING

15.2.07.C.3
continued

Table 15.7 – TYPE A & TYPE B DRIVEWAY PLACEMENT CRITERIA

Table 15.7 – Type A & Type B Driveway Placement Criteria				
Driveway Type	**Between adjacent Driveways within the same property**	**Between adjacent street ROW**	**Between side property line**	**Maximum number of Driveways**
	Spacing (Minimum dimension in ft)			
Type A	20 (1)	20	4 (5)	2 (6)
Type B *(≤ 20 lots)*	30	30	4 (5)	N/A
Type B *(> 20 lots)*	40	40		
(1) 10-ft minimum between pair of one-way Driveways.				
(2) All proposed access connections must be placed to achieve adequate intersection Sight Distance for safe and efficient departure from the proposed location (comply with AASHTO standard)				
(3) Driveway Radius cannot extend beyond property line.				
(4) Driveway Radius cannot extend into public street or other Driveway curb radius.				
(5) When spacing of Driveways result in a roadside ditch that is less than 8-ft long (e.g., less than 8-ft between culverts), options shall be considered to address maintenance challenges and may include replacement of the short roadside ditch with a long run culvert and a junction box*, which will require a submittal of plans and profiles to the Office of City Engineer.				
(6) Unless prohibited by Chapter 42 of the Code of Ordinances.				
* No gravel, no sand, no bricks, no alternative material except new sod around the junction box in the open space in right-of-way between the Driveways.				

d. Type C Driveway Spacing - See Figure 15.6 for Type C Driveway spacing definitions and

e. Table 15.8 for Type C Driveway placement criteria.

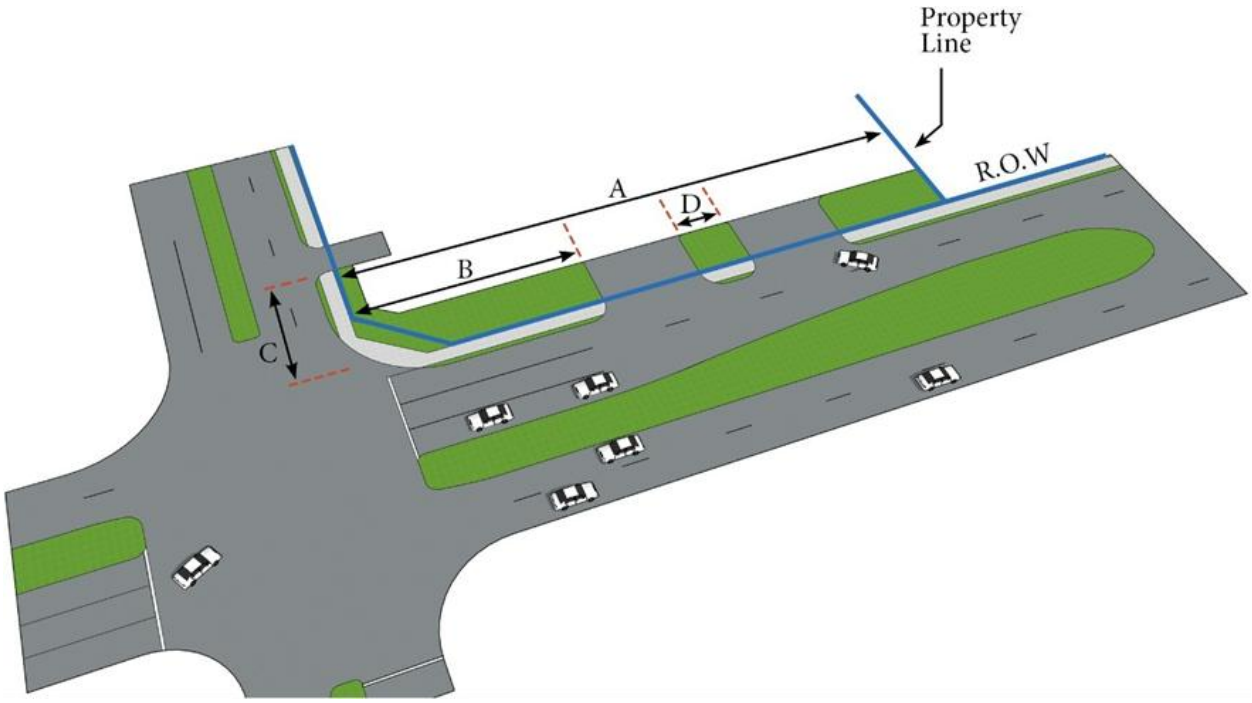


Figure 15.6 – TYPE C DRIVEWAY PLACEMENT

15.2.07.C continued

Table 15.8 – TYPE C DRIVEWAY PLACEMENT CRITERIA

Table 15. 8 Type C Driveway Placement Criteria (1)				
A	**Maximum Number of Driveways**	**B**	**C**	**D**
Frontage(2)		**Minimum Driveway Offset (Major Thoroughfares)**	**Minimum Driveway Offset(8) (Local Streets)**	**Minimum Spacing Between Adjacent Driveways within the Same Property**
Up to 170 feet	1	100 feet	60 feet	N/A
170 to 250 feet	2	100 feet	60 feet	40 feet
250 to 450 feet	3	100 feet	60 feet	40 feet
> 450 feet	1 additional / 250' frontage	100 feet	60 feet	40 feet

(1) Applicable to Driveways designed for commercial traffic (auto, truck, and bus access).
(2) Where the development frontage is equal to or greater than the distance to first Median opening, at least one Driveway will be aligned with the existing and/or future location of the Median opening.
(3) For CBD or locations unable to comply, approval of the City Engineer required.
(4) All proposed access connections must be placed to achieve adequate intersection Sight Distance for safe and efficient departure from the proposed access connection (comply with AASHTO standard).
(5) The minimum Driveway offset for all Major Thoroughfare shall be 100 feet.
(6) Driveway Radius cannot extend beyond property line.
(7) Driveway Radius cannot extend into public street or other Driveway curb radius.
(8) Minimum offset will be 100' along bus routes.

4. Medians

   a. Median design involves mainly Median type, opening, and length. Installing Medians provides the potential for safer street operation, increased capacity, and improved aesthetics.

   b. Median Openings: Median openings allow vehicles to cross opposing traffic lanes at designated locations. Requirements for Median openings can be found in Chapter 10, section 10.3.03.E of this manual.

   c. Minimum Median Lengths: The minimum lengths of Medians between openings are determined by the functional classification of the street and the type of interruption (thoroughfare, collector, local street, private Driveway, etc.) of the adjacent openings. Requirements can be found in Chapter 10, section 10.3.03.E of this Manual.

15.2.07.C.4 continued

d. Mid-block Crossings: With the City of Houston's focus on safety for all modes of travel and an increasing multimodal environment, pedestrian safety is being prioritized. Mid-block crossings provide designated areas for pedestrians to cross the street between where vehicular intersections occur. Existing roadway Median may be considered a pedestrian refuge island as long as it is improved to meet the requirements of Chapter 17, section 17.3.02.D.

5. Treatments for Turning Movements

a. Turn lanes provide a refuge area for left and right turning vehicles. Turn lanes may be placed at intersection approaches, Driveway approaches, and Median openings to remove turning vehicles from the through lanes, thus reducing congestion and improving traffic operations, capacity, and safety.

b. Dedicated Left-Turn Lanes

(1) Left-turn lanes shall be considered in the following situations:

(a) To existing and new conditions subject to City of Houston Standard Operating Procedure (SOP) TMG – 905 Left Turn Warrants[16] and approval of the City Traffic Engineer or the City Engineer;

(b) All signalized intersection approaches along planned or existing streets having a classification of collector or higher;

(c) All unsignalized intersections and Driveways along divided streets having a classification of collector or higher;

(d) All unsignalized intersections and Driveways along undivided streets having a classification of thoroughfare or higher;

(e) All developments in excess of five acres located within 500 feet of the intersection of two or more thoroughfare facilities;

(f) New public or private school construction;

(g) Shopping centers and other traffic generators with a lease space in excess of one hundred thousand square feet; and

(h) Places of worship.

[16] This reference can be obtained from Transportation and Drainage Operations

15.2.07.C.5.b continued

(2) Request not to install dedicated left-turn lanes shall be guided by a traffic study and requires approval from the City Traffic Engineer or the City Engineer.

(3) Dual left-turn and dual right-turn lanes should be designed for the SU-30 in the inside lane and the standard design vehicle in the outside lane.

c. Dedicated Right-Turn Lanes

(1) The use of dedicated right-turn lanes should always be guided by a traffic study. This will be based on TxDOT's Access Management Manual Chapter 2, Section 3, Table 2-3 - Auxiliary Lane Thresholds.

6. Minimum Turning Treatment Storage Length

a. Storage Length, as shown in Figure 15.7, is an important design element that ensures the provision of sufficient turn lane storage capacity to reduce instances of spillback. Left- and right-turn lane Storage Lengths must not be less than the minimum requirements outlined in Chapter 10, Section 3 – Geometric Design Requirements of this Manual.

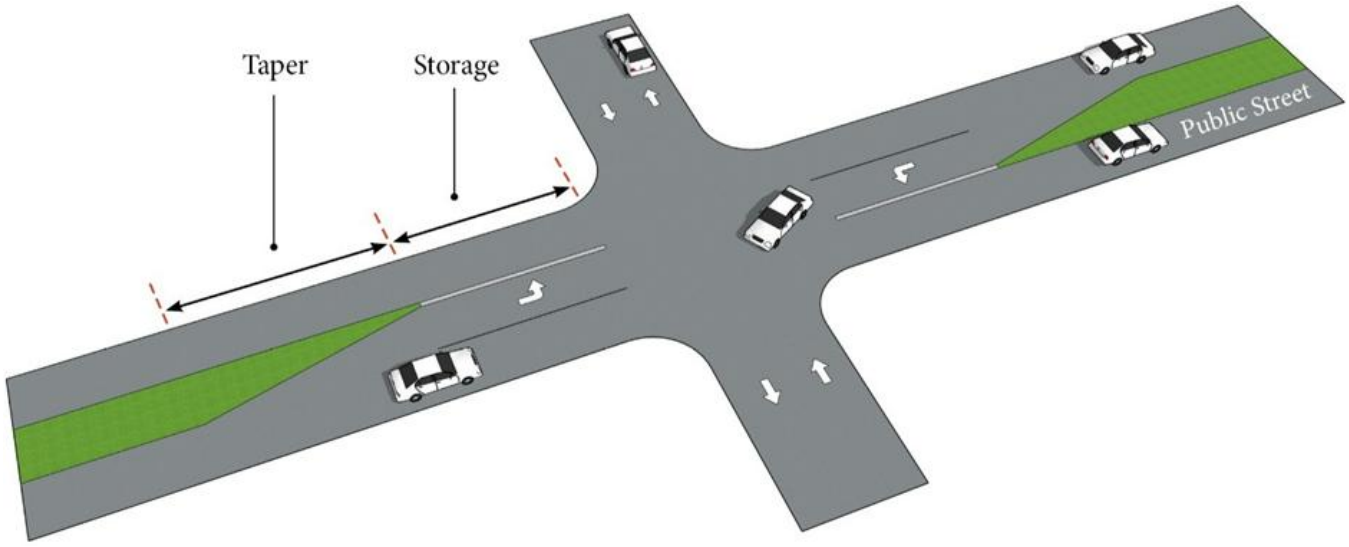


Figure 15.7 – TURN LANE DETAILS

15.2.07.C.6 continued

b. Calculating Required Storage Length (Single Lane)

The required Storage Length for both left- and right-turn lanes can be obtained using traffic modeling software such as the latest version of the HCM Software (HCS) or Vistro. The 95th percentile queue length is a widely accepted value for Storage Length. The following methods may be used to determine Storage Length.

(1) Signalized Storage Length: For signalized intersections, the Storage Length should be determined based on results from computer analysis software.

(2) Unsignalized Storage Length: Equation 1 is used to calculate unsignalized Storage Length.

$$L=(V/30)(2)(S) \qquad \text{(Equation 1)}$$

Where:
L = Storage Length in feet
$V/30$ = turning volume in a two-minute interval
2 = a factor that provides for storage of all left-turning vehicles on most cycles
S = queue Storage Length, in feet per vehicle

c. See Left Turn Bay Plan in Chapter 10 of the IDM Figure 10.8 - Median Nose and Left Turn Bay.

15.2.08 TRAFFIC CONTROL PLAN

15.2.08.A GENERAL

1. This section of the Design Manual contains general guidelines and instructions to be used in determining appropriate construction sequencing and preparation of traffic control plans. The intent is to establish standard procedures and requirements that will be used by the Engineer of Record when preparing traffic control plans for City of Houston projects. In turn consistent application of lane closures and minimal inconvenience to the traveling public will reduce frustration due to negative impacts of construction activities and improve safety because of uniformity of lane/sidewalk closure techniques. All design shall also be in accordance with the latest version of the Texas Manual on Uniform Traffic Control Devices (TMUTCD).

2. This document provides the Engineer of Record with:

   a. requirements and guidelines for ensuring uniformity in lane/sidewalk closure techniques; and

   b. the required format of plan sheets to allow ease of review, minimization of construction errors, and facilitation of maintenance of traffic control setup by the contractor.

15.2.08.B DESIGN REQUIREMENTS

1. Description of Design/Review Process

   a. Project Initiation

      (1) Determine requirements of other agencies. If the project falls under TxDOT's jurisdiction, verify TxDOT's traffic control requirements and approval process is needed. The Engineer of Record shall meet with appropriate TxDOT personnel to determine how to prepare the traffic control setup. After the meeting the Engineer of Record shall meet with City of Houston Project Manager/City Traffic Engineer to discuss traffic control plans per TxDOT requirements and come up with an action plan to prepare construction sequencing and traffic control plans. This task could be handled via phone/e-mail correspondence.

      (2) The Engineer of Record shall meet with the City of Houston prior to beginning the construction sequencing and traffic control plans to discuss the project in detail. At this meeting, typical and any conditions that need to be considered in preparation of construction sequencing and traffic control plans will be discussed. The meeting regarding traffic control plans will generally occur as part of other project initiation meetings and design review meetings. Based on the discretion of the City Traffic Engineer and/or City of Houston Project Manager a special meeting may be organized to discuss specifics of the project in regards to construction sequencing and traffic control setup.

2. Data Collection

   a. Collect all data required to produce construction sequencing plans and traffic control plans. Typically, at this stage of the design process proposed improvements and goals of the project have been developed. Therefore, existing topographic survey and/or improvement design sheets will be used as the base file to produce construction sequencing plans.

   b. The Engineer of Record shall visit the project site to inventory and identify physical features that may impact construction sequencing and traffic control plans such as access Driveways to special adjacent properties that may require special considerations in preparing traffic control plans such as schools, police stations, fire stations, churches, properties with only one access point, and relatively high demand commercial developments.

3. Plans and Drawings

15.2.08.B.3 continued

a. General

(1) Construction sequencing and traffic control plans shall be shown on different plan sheets.

(2) All full-size designs for construction sequencing and traffic control plans shall be prepared at any standard scale as long as the notes and callouts meet Chapter 3 requirements of this manual.

(3) All Drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.

(4) On projects where the Engineer of Record finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's project manager.

(5) Construction sequencing plan should include all aspects of the improvement project such as removal of existing features such as curb, pavement, signs, implementation of temporary pavement to facilitate traffic, implementation of temporary signal locations, and installation of all proposed elements of the project.

(6) Each phase of construction sequencing plan shall have separate traffic control plan including associated detour routes and signal modification plans as necessary. The Engineer of Record should look into using standard lane closures to reduce the number of plan sheets from phase to phase. In addition, if simple signal head adjustments are need for signal modification of different phases, the Engineer of Record is encouraged to only use one signal modification plan for different phases.

(7) Each phase of construction sequencing plan shall make every effort to leave existing sidewalk accessible to pedestrians while project related improvement activities commence forward. Complete sidewalk closure must be minimized as much as possible.

15.2.08.B.3.a continued

(8) Lane closures on Major Thoroughfares according to the latest classifications by the Planning and Development Department; existing directional vehicular movements shall be maintained throughout the duration of the construction project. There may be special construction activities that may require limitations of movements on Major Thoroughfares. These situations must be approved by the City Traffic Engineer. Typically, such approvals are associated with peak period restrictions and/or special traffic control plan and requirement of extensive advertisement to the traveling public especially to stake holders substantially impacted in the vicinity.

b. Travelway.

(1) Provide 11-foot travel lanes on traffic control plans outside the Central Business District (CBD), and a minimum 10-foot wide travel lanes within the CBD. Any deviation will have to be approved by the City Traffic Engineer.

(2) The Contractor shall provide at a minimum two traversable lanes within the CBD. Any deviation will have to be approved by the City Traffic Engineer.

c. Pedestrian, Bicycle, and Transit Facilities.

(1) Any project that impacts pedestrian, bicycle, and/ or transit facilities must provide approved temporary traffic control measures for the impacted road users. Refer to Chapter 17, Section 17.2.03 - Pedestrian and Bicycle Temporary Traffic Control for requirements for traffic control impacting pedestrian and bicycle facilities. If a transit stop is present, provide an accessible and comfortable pedestrian route to access the transit stop.

(2) For the safety of bike drivers, place steady burn lights on drums at lane closures in the following conditions:

(a) On tangents and tapers in the work zone area shifting bike lane traffic.

(b) At bike lane closures.

(c) Around bike hazards such as potholes and steel plate trench coverings.

(d) At parking lane closures that are adjacent to a bike lane.

d. Open Trench.

15.2.08.B.3.d continued

(1) Trench walls should not be three feet from the edge of the traveled way at any stage of the construction.

(2) Traffic control devices shall be in place before starting any excavation.

e. Barriers.

(1) For vertical drop-off greater than one foot along roadway, low profile concrete barriers with appropriate end protections must be installed.

(2) Water Filled Barriers:

(a) Water filled barriers can be used as instructed by the Engineer of Record and approved by City for projects where space is limited and heavy equipment to place concrete barrier is not feasible.

(b) Place and install water filled barrier units as shown on the plans and per manufacturer's design instructions and specifications on roadways with posted speed limit of 45mph or less.

f. General Notes.

(1) The following General Notes should be included on the traffic control plan. Additional notes may be added by the Engineer of Record as may be necessary to properly clarify the intent of the design. The contractor shall provide and install traffic control devices in conformance with Part VI of Texas Manual on Uniform Traffic Control Devices (TMUTCD) latest edition with revisions during the entire construction period.

(2) All signs and traffic control devices shall conform to the latest version of the TMUTCD.

(3) No lanes shall be closed during the hours of 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM Monday thru Friday without approval of the City Traffic Engineer.

(4) No work shall be performed in residential areas from 7:00 PM to 7:00 AM.

(5) Contractor shall maintain approved number of through lanes of traffic in each direction during construction working hours. Traffic control plans shall include one-way and/or detour plans. Contractor shall maintain ADA compliant pedestrian access to bus stops and adequate bus access to the bus stops.

15.2.08.B.3.f continued

(6) Contractor shall maintain traffic lanes and detours according to traffic control plans during working hours.

(7) Contractor shall cover open pavement excavations for minor utility work with anchored steel plates during non-working hours, and open lanes for normal traffic flow when feasible.

(8) If the contractor chooses to use a different method of "Traffic Control Plans" during the construction than what is outlined in the contract drawings, the contractor shall be responsible to prepare and submit an alternate set of traffic control plans to the City of Houston Project Manager for approval ten working days prior to implementation. These plans shall be drawn to scale on reproducible mylars and shall be sealed by a Licensed Engineer in the State of Texas. Office of City Engineer, Mobility Permits Section representative approval is required to accept the proposed changes.

(9) Contractor shall secure lane/sidewalk/bicycle facility closure permits from Office of City Engineer before implementing the traffic control plan.[17] The application must be submitted at least ten business days prior to the implementation of the traffic control plan and/or beginning construction work. The contractor shall provide traffic control plans, construction sequencing, and construction schedule with the application.

(10) Contractor shall have approved traffic control plan and permit at the job site for inspection at all times.

(11) During pavement surface restoration projects; the contractor shall not open closed lanes until the pavement surface has cured enough to allow vehicular traffic according to City of Houston Standard Specifications.

(12) The contractor is responsible for scheduling and coordinating all construction activities with stake holders in the vicinity including emergency response agencies such as Houston Police Department, Houston Fire Department, and Metropolitan Transit Authority.

(13) Contractor shall be responsible for issuing all work directives to all sub-contractors, utility companies, and all other entities performing construction work associated with the project.

[17] Refer to Mobility Permit System weblink at https://geohub.houstontx.gov for permit requirements[18] Source: National Academies of Sciences, Engineering, and Medicine. 2015. Signal Timing

15.2.08.B.3.f continued

(14) Nothing in these notes or plans shall relieve the contractor of the responsibility for job site conditions during the course of construction of the project; including safety of all modes of transportation, persons, and property, and that this requirement shall apply continuously and not be limited to working hours.

(15) The Office of City Engineer (Mobility Permits Group) per the direction of the City Traffic Engineer have the right to demand the installation of additional traffic control devices or modifications to these plans and notes, as deemed necessary to promote the safe and orderly flow of traffic, including pedestrians and bicycles, through the construction work zone. The contractor shall comply with these additional requests or modifications with due diligence.

(16) All existing traffic control signs and pavement markings shall be maintained in visible locations during construction unless prior written approval is obtained from City of Houston Project Manager. The contractor shall restore or replace (at the discretion of the City Traffic Engineer) any pavement marking or signing damaged during construction operations, including raised pavement markers (RPMs).

(17) When entering or leaving roadways carrying public traffic, the contractor's equipment, whether empty or loaded shall in all cases yield to public traffic with the assistance of contractor provided certified flagger/peace officer.

(18) Access to Driveways adjacent to the construction work zone shall be maintained at all times as much as possible. Additional cones and/or delineators may be required to delineate the Driveway access route through the construction work zone. A minimum of one travel lane shall be maintained across the Driveways, unless prior written approval is obtained from City of Houston Project Manager.

(19) Spillage resulting from hauling operations along or across any public traveled way shall be removed immediately by the contractor.

(20) The contractor shall submit an application for temporary parking restrictions if there are parking meters located at the proposed lane closures from Parking Management Division (832-393-8690) at least ten business days before implementation of lane closures. In addition, temporary no parking signs shall be posted 24 hours prior to commencement of work.

15.2.08.B.3.f continued

(21) Additional off duty police officers/flaggers may be requested to direct traffic when lanes are blocked at the discretion of the City Project Manager even if they are not specifically identified on the project plans.

(22) The contractor shall replace within 72 hours, all traffic signal loop detectors damaged during construction.

(23) In general, a solar powered flashing arrow board shall be required on all Major Thoroughfare lane closures. Exceptions to flashing arrow boards and/or implementation on residential lane closures shall be approved by the City Traffic Engineer.

(24) Approved traffic control plan shall be in place before starting any excavation.

(25) Water filled barriers can be used as instructed by the Engineer and approved by the City for projects where space is limited and heavy equipment to place concrete barriers is not feasible. Water filled barriers shall not be used on roadways with a posted speed limit more than 45 mph.

(26) Water filled barriers must be installed and maintained per the manufacturer's requirements and routinely inspected for defects.

(27) If water filled barrier is provided, use environmentally safe anti-freezing agent in the water when it is applicable per manufacturer specifications and recover agent when the barrier is drained.

(28) Dispose of water and agent properly. Do not drain water filled barrier into or across existing travel lane.

(29) Provide barrier units that are capable of being lifted and moved when filled if draining is not possible.

(30) Provide water filled barrier that acts as its own free standing, non-redirective end treatment.

(31) When water filled barriers are used to channelize pedestrians, they must have a continuous detectable bottom for users of long canes and the top of the unit shall not be less than 32 inches in height.

(32) Any closure of a pedestrian or bicycle facility shall require the shortest detour that maintains the safety of pedestrian and/or bicyclists.

15.2.08.B.3 continued

g. General Notes and Channelization Spacing (Refer to City of Houston Standard Detail 01555-01)

h. General Lane Closure Guidance (Refer to City of Houston Standard Detail 01555-02)

i. General Detour Guidance (Refer to City of Houston Standard Detail 01555-03)

j. Long Term Major Street Lane Closure (Refer to City of Houston Standard Detail 01555-04)

k. Long Term Minor Street Lane Closure (Refer to City of Houston Standard Detail 01555-05)

l. Short Term Minor Street Intersection Lane Closures (Refer to City of Houston Standard Details 01555-06 through 01555-12)

15.2.09 MINIMUM VERTICAL CLEARANCE

15.2.09.A GENERAL

1. This section of the design manual contains the requirements for minimum vertical clearances for structures, utilities and traffic control devices.

15.2.09.B MINIMUM VERTICAL CLEARANCE GUIDANCE

1. Pedestrian Sky Bridges

   a. Refer to Chapter 18, Encroachments, for sky bridge clearance requirements.

2. Overhead Traffic Signal Devices

   a. See Section 15.2.14 – Traffic Signals and Standard Detail 02582-01 for minimum clearance requirements for overhead traffic signal devices.

3. Traffic Signs

   a. See Section 15.2.14 - Traffic Signals and TMUTCD for overhead sign installation requirements.

4. Vehicular Bridge

   a. The desirable clearance for the lowest point of the structure in the public right of way is 17.5 feet over the entire roadway width. If a clearance is less than 17.5 feet, it must contain appropriate signs, and it requires approval of the City Engineer and the City Traffic Engineer. Absolute minimum clearance is 14.5 feet.

15.2.09.B continued

5. Building Structures Over Public Right-of-Way

    a. The bottom of the lowest point of the structure in public right-of-way should be a minimum of 18.5 feet over the entire roadway width.

6. Railroad Overpass Clearances

    a. Highway structures over railroads are referred to as railroad overpasses. Vertical clearance for new structures over railroad tracks must be 23'-6" feet minimum measured from the top of rail to the lowest obstruction under the highway structure. In cases where electric powered trains are involved, additional vertical clearance may be required.

7. Railroad Underpass

    a. Prior to resurfacing under railroads, approval must be obtained from the railroad company.

8. Obtain approval from Office of City Engineer for exception or deviations from these requirements.

15.2.10 SCHOOL ZONES

15.2.10.A GENERAL

1. School Zones are segments of roadway within the vicinity of a school that are designed to identify an area where students cross or are likely to cross that roadway.

2. School speed zones are used to indicate where a reduced speed zone for a school area has been established in accordance with law based upon an engineering study.

3. Safe and accessible routes for students to walk and bike to school are vital to achieving the City of Houston's commitment to Vision Zero. The City of Houston, Houston Public Works, Transportation and Drainage Operations works with school principals or their designated representatives to develop a plan for creating safe School Zones which prioritize pedestrian and bicycle safety.

    a. The City of Houston does not respond specifically to community requests related to School Zones. The City of Houston will present requests to the principal or his/her designated representative for consideration.

    b. The detailed School Zone Policy and application can be obtained at https://www.houstonpublicworks.org/multi-modal-safety-and-design.

15.2.10.B DESIGN REQUIREMENTS

1. Figure 15.8 displays an example layout of a School Zone, including school speed zone.

2. Newly designated School Zones are installed at elementary, middle/junior, or high school and shall consist of:

   a. Advanced warning notice indicated by School Advance Warning Assemblies consisting of Advance School Warning sign (S1-1) above an AHEAD sign (W16-9p).

   b. Reduced speed limits indicated by School Speed Limit Assemblies. The School Zone begins at first posted School Speed Limit Assembly ("Zone Beginning" in Figure 15.8).

      (1) School Speed Limit Assemblies may be a SCHOOL sign (S4-3) on top of a 20 mph SPEED LIMIT sign (R2-1) above a sign with the effective times of the school speed zone (S4-1).

      (2) School Speed Limit Assemblies may be a 20 mph SCHOOL SPEED LIMIT WHEN FLASHING sign (S5-1) with a Flashing School Beacon.

         (a) Flashing School Beacons shall be installed on designated Major Thoroughfares or collectors and on streets with an average daily traffic count of 5,000 vehicles or greater.

         (b) For the design of Flashing School Beacons, see City of Houston Standard Detail No. 16712-03.

   c. Additional School Speed Limit Assemblies or Flashing School Beacons ("Zone Continuation" in Figure 15.8) that are installed typically every 300 to 500-ft spacing depending on length of zone and intersecting roadway.

   d. School Crosswalk Warning Assemblies consisting of School Crossing sign (S1-1) on top of a Diagonal Arrow plaque (W16-7p) installed only on uncontrolled leg(s) of an intersection and at designated midblock crossings.

   e. High-Visibility Crosswalk markings at intersections and designated midblock crossings. See Chapter 15, Section 15.2.06.B.4 - Crosswalks and Chapter 17, Section 17.3.03 - Corridor Crossing Analysis and Treatments for additional guidance on midblock crossing specifications.

   f. End School Zone signs (S5-2) marked with a standard SPEED LIMIT sign (R2-1) showing the speed limit for the section of roadway.

15.2.10.B
continued

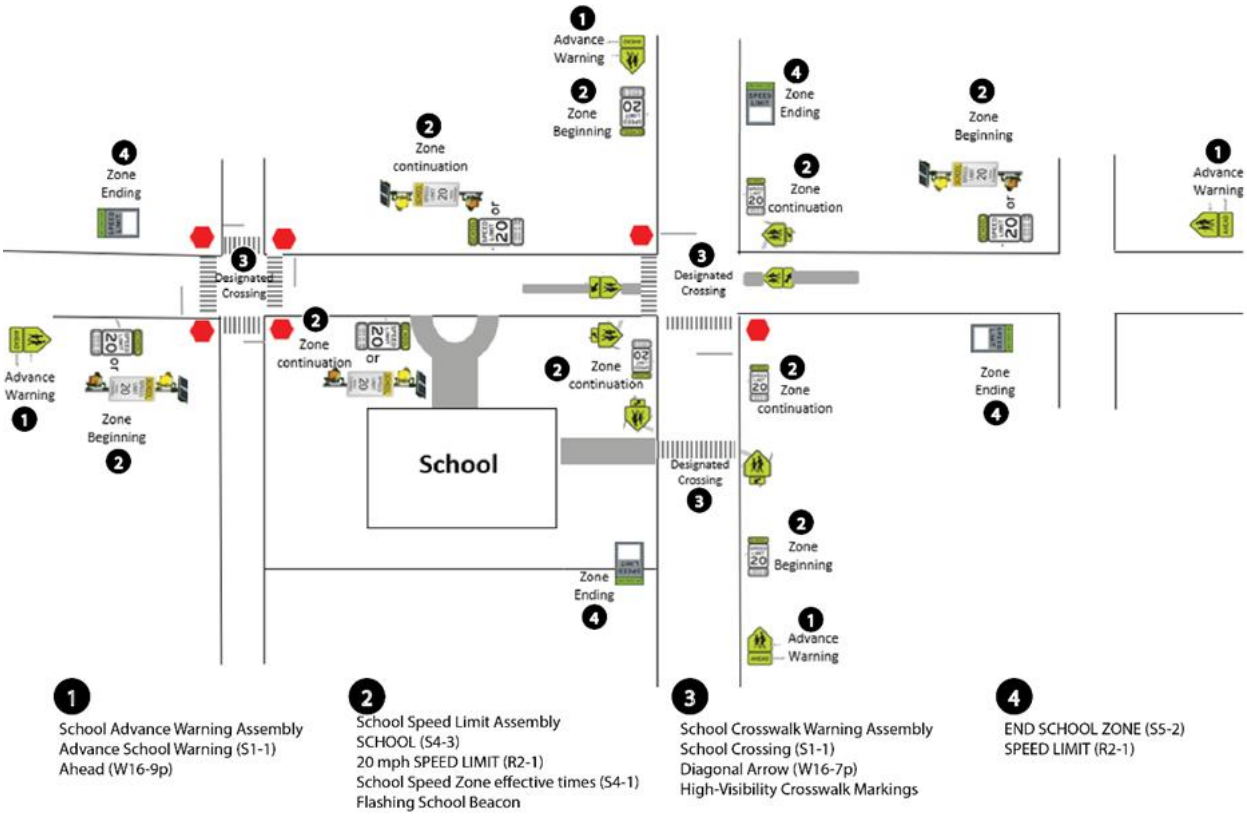


Figure 15.8 – EXAMPLE SCHOOL ZONE

3. Existing School Zones may be redesigned and, if so, shall consist of:

   a. A meeting with the City of Houston, Houston Public Works, Transportation and Drainage Operations to discuss issues with the existing School Zone design. This meeting may occur as part of other project initiation meetings and will not require a separate meeting.

   b. Data identifying existing School Zone items including School Zone beacons, designated school crossings, designated or proposed bikeways and school start time and dismissal time. Typically, School Zone information will be included as part of the general existing condition data collection effort as defined by School Zone policy.

   c. The Engineer of Record shall prepare a plan to maintain existing School Zones in safe operational manner if school is in session during construction and replace existing School Zones as implemented previously before start of construction.

      (1) Complete replacement, modification, or additions may be required by City of Houston to meet the current standards.

15.2.10.B.3.c continued

(2) Any obstructions to pedestrian and bicycle facilities shall follow Chapter 17, section 17.2.03 - Pedestrian and Bicycle Temporary Traffic Control.

15.2.10.C EXISTING SCHOOL ZONES DURING CONSTRUCTION

1. It is the responsibility of the contractor performing the work to accommodate safe movement of school related activities during the entire duration of the construction period.

2. The contractor may need to relocate school beacons, School Zone signs temporarily during construction before implementation of School Zone equipment per design plans at the contractor's expense. Coordinate relocation of flashing beacons and signage with City staff and school principal.

15.2.11 TRAFFIC CALMING

15.2.11.A GENERAL

1. All proposed traffic calming must utilize the Neighborhood Traffic Management Program (NTMP).

2. NTMP is intended to address traffic safety by combining a robust and defined community outreach approach with a toolbox of street safety elements collectively known as traffic calming. Traffic calming devices are self-enforcing, reduce and manage cut-through traffic and ensure safe and prudent vehicle speeds.

3. Traffic calming devices can be installed on a temporary or a permanent basis. Traffic calming devices may be implemented as part of newly constructed and reconstructed streets or as part of retrofit and rehabilitation projects.

4. Reconstruction and rehabilitation projects for minor collectors and residential streets should consider public requests for traffic calming devices, especially where there is a NTMP project on the waiting list.

15.2.11.B DEVICES

1. Types of traffic calming include but are not limited to speed cushions, Traffic Circles, partial/full closures, diverters, and chicanes. Below are brief descriptions of the three common traffic calming devices.

    a. Speed cushions

15.2.11.B.1.a continued

(1) Speed cushions are speed humps with wheel cutouts at designated widths to allow for large vehicles to pass unaffected, while reducing passenger car speeds. Speed cushions allow emergency vehicles to pass their wheels on either side of the raised area.

(2) Speed cushions must meet design standards identified in City of Houston standard detail No. 13501-01 and specifications in Section 13501.

b. Traffic Circles

(1) Traffic Circles are a circular physical structure installed in the center of an intersection to require a circular flow within the intersection.

(2) Traffic Circles can encourage slower speeds by forcing slight path diversions for drivers making a through movement or left turn, and by creating a visual break on a straight path to catch a driver's attention. Traffic Circles are not the same as roundabouts, which are considered a full traffic control device.

(3) Traffic Circles may be installed on a temporary or permanent basis and a variety of materials may be considered to designate a Traffic Circle, such as pavement markings, curbs, flex posts, and mountable concrete islands. Specific materials shall be reviewed and approved by Transportation and Drainage Operations.

c. Chicanes

(1) Chicanes create a horizontal diversion of traffic from a straight travel path.

(2) Chicanes should provide a relatively abrupt taper that shifts travel to have a calming effect on vehicle speeds. They can be created by shifting parking from one side of the street to the other (if there is only space for one side of parking) or by extending the curb.

(3) Chicanes may be demarcated from the existing roadbed using curbs (pre-cast, cast-in-place, or similar), bollards, planters, or other delineation along with pavement markings and striping.

(4) Chicane design and specific materials are subject to review and approval by Transportation and Drainage Operations.

2. All proposed traffic calming measures shall have to go through the NTMP process before implementation.

15.2.11.B.2 continued

a. The requestor can also contact the NTMP group at NTMP@Houstontx.gov or 832-395-3000 for additional assistance.

b. The City of Houston, Houston Public Works, Transportation & Drainage Operations administers the Neighborhood Traffic Management Program (NTMP) per the requirements of City of Houston Code of Ordinances Chapter 45, Article XV.

3. Slow Streets is an advisory measure to discourage through traffic on local streets. Temporary devices are placed at intersections to communicate that the street is a slow and shared environment between all road users. The street remains open to all traffic, including emergency vehicles, and thus does not trigger the processes for Speed or Volume Control as outlined in the NTMP.

15.2.12 STREET EXTENSIONS AND CLOSURES

15.2.12.A STREET EXTENSIONS

1. For streets that will be extended, the traffic study will recommend appropriate posted speed limit and parking restrictions that are consistent with the existing street segments at both ends.

2. For street extensions that occur in phases, the design will include installations of appropriate pavement markings and warning signs (e.g., speed reduction signs, no outlet.) to ensure safe traffic operations and street transition until the full extensions are completed.

15.2.12.B COMPLETE STREET CLOSURE

1. A street can permanently be closed by a private entity after the City relinquishes the street right-of-way and access easement. The City Joint Referral Committee (JRC) reviews and approves all abandonment and sale of street, alley, or easement. Information about the JRC can be found here:

   https://www.publicworks.houstontx.gov/joint-referral-committee.

2. A local, residential street can be closed for traffic calming purposes. Requests for such closure are administered by the Neighborhood Traffic Calming Program (NTMP).

3. Temporary complete street closure is strongly discouraged. If such closures are required and demonstrated to minimize construction impacts and improve public safety, closure permit can be obtained from the Mobility Permit Section. Temporary closure to serve a special event will require a permit from the Mayor's Office. Below are general requirements for temporary, construction-related street closures.

   a. Planned full street closures require a mobility permit from the Office of City Engineer, Mobility Unit.

15.2.12.B.3 continued

b. Purpose and anticipated duration of the proposed full street closure must accompany the mobility permit application.

c. Traffic Control and Detour Plan must be sealed by a Texas licensed Professional Engineer.

d. Public notification. Change message signs (CMS) must be displayed a minimum of 7 days in advance of the proposed full street closure.

4. Slow Streets is an advisory measure to discourage through traffic on local streets. Temporary devices are placed at intersections to communicate that the street is a slow and shared environment between all road users. The street remains open to all traffic, including emergency vehicles, and thus does not trigger the processes for Speed or Volume Control as outlined in the NTMP.

15.2.13 STREETLIGHT DESIGN REQUIREMENTS

15.2.13.A DESIGN REQUIREMENTS - CAPITAL IMPROVEMENT PROJECTS

1. The following design requirements are applicable within the City street rights-of-way and are intended for lights owned and installed by CenterPoint Energy. The Engineer of Record is to contact the City prior to implementing the below criteria to determine ownership and design methodology. This recommended practice is applicable to all capital improvement projects, including but not limited to street, bridge, water, wastewater, and storm sewer projects. The Engineer of Record will be responsible for designing the street lighting layout associated with each project by following the guidelines listed below. Note that the below criteria are solely for the use of the standard cobra style light fixtures on cobra poles. Areas requiring or requesting decorative type lighting will need direction from the City's Streetlight Section on developing a streetlight design and cost.

   a. It is the City's practice to upgrade the street lighting along all roadways to current recommended levels as part of capital improvement projects.

   b. Areas without wood power poles are considered candidates for metal pole streetlights. The Engineer of Record will prepare the lighting layout, spacing the streetlights at a distance of approximately 200' +/- 20' for Driveway/utility conflicts. Typically, a streetlight placed 3-4 ft. behind back of curb will illuminate two lanes. Roadway sections that are four or more lanes should be illuminated from both sides. For sections less than four lanes, stagger the streetlights along both sides of the roadway, maintaining the 200' +/- 20' spacing. The design should also include any existing street lighting. Proposed and existing street lights should be called out by station numbers. Generally, begin layouts at intersections and work away.

15.2.13.A.1 continued

c. The design must identify which of the existing streetlights will require relocating or temporary removal during the construction phase. Plans shall be submitted to the Transportation & Drainage Operations for review/approval. Upon approval, the City will submit the approved layout to CenterPoint Energy for a conduit/pullbox layout and cost estimate for the temporary removal/re-installation of the existing streetlights. These costs will then be forwarded to the Project Manager and included as a line item in the bidding documents for cash allowance to pay CenterPoint. Note that CenterPoint will require payment prior to providing service.

d. When overhead power and wood pole street lighting exist in an area, the design should utilize existing wooden utility poles for any additional streetlights while maintaining a 175' +/- 15' spacing. Mixing of wood and metal pole streetlights along local streets in neighborhoods is generally not allowed and shall require prior approval from the City.

e. Along thoroughfares and collectors with four or more lanes, wood poles may exist along only one side of the roadway. In these instances, it is acceptable to have wood pole streetlights along one side while having metal pole streetlights along the other.

f. Upon completion of the project it is the contractor's responsibility to notify the Streetlight Section in writing that the conduit has been installed & inspected and meets CenterPoint's specifications before the authorization for new/re-installed metal pole streetlights can proceed.

g. Locations of existing and proposed streetlights (station numbers) need to be shown. Do not show lighting outside of the public roadway right-of-way.

h. Pole number for existing streetlights must be shown. This is a 6-digit number that is stenciled approximately 6' above grade on the street side of the light.

i. Depict type of existing and proposed streetlights (metal pole or wood pole) - note: wood poles are never installed for the sole purpose of street lighting).

j. All metal pole streetlights that could potentially be impacted by construction activities shall be removed and reinstalled. The removal and reinstallation will be completed by CenterPoint. The cost for this service will be included in the project as cash allowance to pay CenterPoint.

15.2.13.A.1 continued

k. The proposed locations of new streetlights should not necessarily be based on the existing light locations. The layout should be created from scratch, following the spacing criteria described above.

l. When removing/replacing lights in residential areas, it is generally preferable to replace lights in the same location, unless relocation is necessary to meet the lighting and spacing criteria.

m. In residential area, show parcel boundaries (property lines).

n. In residential areas, place lights on property lines and at property corners 2' off the radius of the curve (refer to the CenterPoint Energy streetlight staking detail).

o. No lights should be placed at a 45-degree angle at the intersections

p. Do not place proposed lights under heavy tree canopy (typical mounting height of a streetlight pole is 26'). Field verify to ensure appropriate clearance. Where tree canopy is unavoidable, plans must specify that tree canopy will need to be trimmed a minimum 5' radius around the projected streetlight pole mounting height (all trimming to be part of project cost, CNP will not trim trees nor install lights in heavy tree canopy).

q. Do not place proposed lights in any wheelchair ramps or sidewalks.

r. If decorative lighting is requested by the neighborhood, the Engineer of Record will submit the standard layout to the City. CenterPoint will prepare a separate decorative lighting layout. The City will review both layouts and determine which layout will be implemented.

s. Based on the City approved layout, CenterPoint will prepare a conduit layout, which the Engineer of Record will incorporate into the design. The contractor is responsible for the conduit installation. CenterPoint will be responsible for installing and energizing the streetlights. Payment to CenterPoint will be included in the project as a cash allowance item.

t. If temporary lighting is required, design and installation will be completed by CNP. Cost for this service will be included in the project as cash allowance from the contractor to CNP.

15.2.13.B DESIGN REQUIREMENTS - CITIZEN REQUEST

15.2.13.B continued

1. The primary purpose of street lighting is to illuminate the roadway. Streetlights are not intended for providing security lighting, pedestrian lighting, parking lots lighting or any other private property lighting. A street segment must be within the City limits in order to be eligible for streetlights. All streetlights are installed, owned and maintained by Center Point Energy. However, the City must approve for any street light installation that is within the City right-of-way. Once it is installed, the City pays for the operating and maintenance cost of the street light.

2. Street light types - The City of Houston standard street light type includes Light Emitting Diode (LED) in a cobra style light fixture mounted on wooden pole or metal pole.

    a. Wood Pole Lights: The City will authorize for street light installation on wooden utility poles wherever possible.

    b. Metal Pole Lights: If an area does not have existing wooden pole with overhead power lines, then a metal pole streetlight powered by underground lines will be installed. There may be a cost associated with this type of installation.

    c. Wattage: Various wattages will be installed depending on the road to be illuminated. 45-watt LED fixtures will be installed on local roadways and 95-watt LED fixtures on collector type roadways. 115-watt LED fixtures are typically installed along Major Thoroughfares. LED streetlights technology continues to advance. Increased efficiencies will change the applicable wattages and the Engineer of Record should refer to the latest City specification for roadway lighting.

3. Street light spacing requirements. Metal pole streetlights are typically installed approximately 200 feet apart (+/- 20') with 10 feet for property line adjustment. Streetlights are typically installed on public right-of-way avoiding obstructions such as trees, manhole, and inlets. Spacing for streetlights on wooden utility poles may vary depending on the existing location of the wood poles. However, spacing will normally be 150 to 200 feet apart for adequate roadway illumination.

15.2.13.B continued

4. Streetlight(s) can be requested by application. A Street Light Survey Request Form is available by calling the City of Houston at 311. This application must be completely filled out and submitted to the City by mail or by fax. Upon receipt of the application, the City will conduct a street light survey and provide a written response in approximately 6 - 8 weeks thereafter. If the City determines that streetlight is feasible as a result of the survey, the City will authorize Center Point Energy for street light installation. Streetlights deemed necessary along Major Thoroughfares will incur an installation cost by CenterPoint Energy. Funding for the installation cost will be processed and paid by the City. CenterPoint Energy will schedule the installation once it receives payment. Timelines for the installation will vary depending on the City's ability to fund the request.

5. Cost for streetlights. Typically, there is no charge to the applicant for any streetlight that can be installed on an existing wooden pole, or any streetlight (wooden or metal) that is installed on a roadway that is classified as a Major Thoroughfare per the City of Houston. However, there is a charge for the installation of a new streetlight on a metal pole on city local roads. There may be an additional charge by CNP for local roads that require a high level of illumination. Per Section 40-3 of the City Code of Ordinances, the applicant is required to pay for the first year's operating cost prior to authorizing the installation of the streetlight. This is a one-time charge to the applicant. The cost may vary but average around $200.00 per streetlight.

6. Enhanced streetlight. The street light program also offers enhanced streetlights upon request. Locations and types of enhanced streetlights must meet the following requirements:

    a. Locations of enhanced streetlights must be within a current Management District, Tax Increment Reinvestment Zone (TIRZ), recognized by City of Houston.

    b. Enhanced streetlight must be approved by the Street Light Program coordinator coordinated with City's other capital improvement project.

15.2.14 TRAFFIC SIGNALS

Requirements for reviewed and approved plans not constructed within a 2-year period.

15.2.14.A GENERAL

15.2.14.A continued

1. This document presents the criteria and formats to be used in designing improvements and preparing plans for traffic signal work in the City of Houston. It will also outline general requirements and guidelines to be followed by the Engineer of Record of traffic signals for the City of Houston. This section is not intended to replace sound engineering judgment or the standards of engineering practice. The Engineer of Record shall also follow the guidelines published in the Texas Manual on Uniform Traffic Control Devices and in documents from the Institute of Transportation Engineers.

2. These design guidelines are applicable to both new traffic signal construction and to the modification of existing traffic signals. If any portion of a traffic signal installation is being modified, the City requires the entire signal be upgraded to current standards. Permission to deviate from these standards must be received prior to submission on construction drawings for review and approval.

3. The document provides the Engineer of Record with:

    a. The analysis requirements for determining what improvements should be recommended,

    b. The design requirements and guidelines for ensuring uniformity in type and location of equipment, operational features, and intersection layout; and

    c. The required format of plans and contract documents to allow for minimization of construction errors and facilitation of maintenance.

4. New signals must be approved by the City Traffic Engineer before they may be permitted. Any new or reconstructed signal shall follow the requirements of section 15.2.02 - Traffic and Design Studies to satisfy warrants and identify design criteria for all travel modes, including pedestrian, bicyclists, transit users, and motorists.

15.2.14.B DESIGN REQUIREMENTS

1. Description of Design/Review Process

    a. Solicit Information from Other Agencies

        (1) Determine Requirements of Other Agencies & Property Owners.

15.2.14.B.1.a.(1) continued

(a) Verify with TxDOT their requirements if the intersection or street approaches fall under their jurisdiction. If discrepancies exist between the City's requirements and TxDOT's, the Engineer of Record shall meet with the City Traffic Engineer to reconcile any differences. If access to private property (residential, industrial, or commercial, etc.) is involved, the Engineer of Record shall contact the property owner involved, determine how the access will be affected, and coordinate with the City any differences which may exist.

(2) Contact appropriate electrical utility for power hook-up and illumination requirements.

(a) The Engineer of Record shall verify with the electric utility involved in the project the power hook-up requirements. The Engineer of Record shall work with the utility to determine the service location during design and this location shall be indicated on the plans. The Engineer of Record shall note who is responsible for each component of a service hook-up, including the conduit and cable run from the load center to the power source, the conduit riser on the power pole and the actual splice into the power system. The responsibilities shall be clearly stated in the project plans.

(3) Contact the Railroads and verify their requirements regarding traffic signal pre-emption or crossing of tracks with conduit runs.

(a) If railroad pre-emption is required in compliance with MUTCD guidelines, contact should be made with the railroad's manager of telecommunications and signals, and the City of Houston's signal operations representative early in the design process to determine their needs or requirements. If railroad right-of-way must be crossed with conduit runs, the Engineer of Record shall determine the railroad's requirements for conduit type, size, depth, construction methods and restrictions.

b. Collect Engineering Data.

(1) Collect all data required to develop a base map of Existing Conditions which can be used for the design process and operational evaluation.

15.2.14.B.1.b continued

(2) Topographic Features: On each approach where advance detection or street improvements are anticipated, detailed information on topographic features should be collected for the area within 500 feet of the intersection. Otherwise, the topographic information is only required for the distance anticipated for the detection zone setbacks and for poles, traffic signal controllers, and related underground conduits.

(a) Widths and alignments of streets, lanes, and shoulders

(b) Median widths and lengths

(c) Curve radii

(d) Tapers

(e) Turn lanes

(f) Driveways & sidewalks

(g) Pavement type

(h) Existing pavement markings and raised channelization

(i) Grades

(j) Sight Distance obstructions

(k) Parking conditions

(l) Right-of-way lines and easements

(m) Building lines

(n) Angle of intersecting streets

(o) Trees and shrubs

(p) Railings and barriers

(q) ADA accessible curb ramps

(r) Street furniture

(s) Drainage features

(t) Traffic signal equipment:

(i) Pole locations

(ii) Signal head locations and types

15.2.14.B.1.b.(2).(t) continued

(iii) Controller cabinet location

(iv) Pull boxes (location and size), and conduits

(v) Detector locations

(vi) Service location (existing and potential)

(vii) Existing signal communications system and associated infrastructure

(viii) Emergency and/or railroad preemption systems

(u) Existing illumination (location and type)

(v) Existing signs

(w) Existing pavement markings

(x) Overhead utilities (horizontal and vertical clearances)

(y) Underground utilities

(i) Special attention should be given to obtaining a precise location of utilities. The Engineer of Record shall request utility information from all utilities within the survey area. Field location should be requested for all utilities including traffic signal cables, conduits and detectors. Accurate horizontal and vertical clearance information shall be obtained for overhead utility lines including the sag of the cables between supports.

(3) Operational Data (If the Location has an Existing Traffic Signal):

(a) Phasing and timings

(b) Signal displays

(c) Type of controller and cabinet

(d) Detection methodology

(e) Traffic Signal Communications System Features

(4) Traffic Data (If Required by the City):

(a) Counts and projected volumes (24-hour approach and turning movements in am, pm, and noon peaks)

15.2.14.B.1.b.(4) continued

(b) Speed limit and speed study

(c) Accident history and diagrams (if available)

(d) Pedestrian volume and patterns

(5) Miscellaneous Data:

(a) Bus stops and routes

(b) Adjacent land uses

(c) Proximity of railroad crossings

(d) Proximity of emergency vehicle sources

(e) Other construction in progress in the area

(f) Adjacent street and drainage structures

(6) It may be possible to obtain information on existing topographic features from existing plans or maps. This data may be used for reference, but all plan preparation shall be based on field survey unless pre-approved by the City. Operational data and traffic data may be available from the City but may need to be supplemented by studies conducted by the Engineer of Record.

c. Develop Base Map of Existing Conditions.

(1) The Engineer of Record shall develop a base map showing all the applicable data collected. This map will be used as a base for showing all phases of the traffic signal design work and all geometric design work.

(2) Directional Orientation: All plan sheets shall have the intersection oriented with North to the top of the sheet or to the right of the sheet (if required to provide significantly better utilization of space).

(3) Scale: Traffic signal plans should be drawn a 1" = 20' scale at full size. Break lines may be used to show advanced detection of other features away for the intersection. Blown up details at a larger scale shall be used to illustrate areas with numerous conflicts or many items to be shown in a compact area such as intersection corners.

15.2.14.B.1.c continued

(4) Existing Conditions: The traffic signal base maps shall be printed using CSI Standards resulting in a lighter tone for Existing Conditions. The plan shall include, but not be limited to, the following information:

(a) Right-of-way, easements and street names

(b) Curbs and Medians

(c) Lane lines and channelization

(d) Sidewalks

(e) Utilities (underground and overhead):

(i) Electric

(ii) Gas

(iii) Telephone

(iv) Communications & Cable TV

(v) Traffic and Illumination

(vi) Sanitary Sewer

(vii) Storm Sewer

(viii) Water

(ix) Utility manholes, vaults and valves

(f) Monuments and benchmarks

(g) Driveways

(h) Signs and poles

(i) Angle of intersecting streets

(j) Building lines

(k) Other pertinent features (e.g., trees, shrubs, street furniture, bus stops, etc.)

d. Plans and Drawings

(1) General.

15.2.14.B.1.d.(1) continued

(a) All plans and drawings should be prepared with black ink.

(b) Standard Title Sheet, General Notes and Responsibilities Sheet, Traffic Signal Plan Sheet(s), Pole Schedule and Cable Schematic Sheet, and Detail Sheets, should be used for all traffic signal projects. An electronic Title Sheet, General Notes and Responsibilities Sheet and blank Pole Schedule are available from the City for use on traffic signal projects. Plan sets should not include copies of the City's standard traffic signal details.

(c) If necessary, additional sheets for plans and profiles, pavement markings or signing shall be provided as needed or as directed.

(d) A legend will be provided showing any non-standard symbols.

(e) On projects where the Engineer of Record finds it necessary to deviate from the standard format presented herein, due to project scope or design requirements, the City's Project Manager should be consulted to determine an acceptable alternate format. Any changes to the format are at the discretion of the City's project manager.

(f) All Drawings shall be prepared in accordance with Chapter 3, Graphic Requirements.

(2) Plan sets should consist of the elements listed below:

(a) Title Sheet (City Standard)

(b) General Notes and Responsibilities Sheet

(c) Traffic Signal Plan Sheet(s)

(d) Pole Schedule and Cable Schematic Sheet(s)

(e) Special (or nonstandard) Detail Sheet(s) (as required)

(f) Plan and Profile Sheets (as required)

(g) Pavement Marking Sheet(s) (as required)

(h) Signing Plan Sheet(s) (as required)

15.2.14.B.1.d.(2) continued

(i) 11-inch by 17-inch plan sheet showing locations of curb lines, sidewalks/ramps, signals and signal cabinets with WB-50 turn movements superimposed over the intersection. This sheet is to be submitted with plan sets for review but is not required as mylar sheet in final plan set.

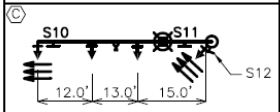
(3) Provide a table showing stations and offsets for vehicle detection systems and stop lines on the plan sheet. A sample table is shown below.

ITEM BY DIRECTION	STREET 1 STATION OF APPROACH EDGE	OFFSET FROM CONST. CL TO CL OF DETECTOR	ITEM BY DIRECTION	STREET 2 STATION OF APPROACH EDGE	OFFSET FROM CONST. CL TO CL OF DETECTOR
EASTBOUND: STOP LINE:	STA. XX+XX		SOUTHBOU: STOP LINE:	STA. XX+XX	
PHASE 2 PULSE LOOP	STA. XX+XX	CENTERED IN LANE	PHASE 4 PULSE LOOP	STA. XX+XX	CENTERED IN LANE
PHASE 5 PRESENCE LOOP	STA. XX+XX	CENTERED IN LANE			
WESTBOUND: STOP LINE: PHASE 6 PULSE LOOP	STA. XX+XX STA. XX+XX	CENTERED IN LANE	NORTHBOUND: STOP LINE: PHASE 8 PULSE LOOP	STA. XX+XX STA. XX+XX	CENTERED IN LANE

Example Stop Line and Detector Locations Schedule

(4) Pole Schedule, Traffic Signal Controller, and Cable Schematic Sheets.

(a) Pole Schedule: A pole schedule shall be provided showing the pole and its identifier, the pole type, information on the mast arm(s), signal heads, luminaire, pedestrian pushbuttons and signs, pole location, communications system, and relative City standards. Each pole will have its own row within the schedule. The pole schedule shall be a table formatted as shown below.

POLE NUMBER	POLE TYPE	MAST ARM		SIGNAL		LUMINAIRE TYPE	PED PB TYPE/SIGN	REMARKS	LOCATION	STANDARDS
		SIGNAL	LUMINAIRE	MOUNTING	FACE					
	TYPE 2	40'	15'	3–ASTROBRAC 1–SIDE OF POLE	1–H3L 2–H3 1–V3L	106–WATT SYSTEM MAX LED COBRA HEAD LUMINAIRE	–	PRE–EMPT SENSOR (DUAL TURRETS) WIMAX ANTENNA SPP RADIO SIGNS: S10 = R10–5L (30"x36") S11 = STREET NAME S12 = R10–5L (30"x36")	AT APPROX: POLE C: STA. 2+89, 51' RT RICHMOND AVE. CONST ℄	02893–02 02893–12 02893–03 02893–04A 02893–04B 02893–05 02893–09

Example Traffic Signal Pole Schedule

(b) Traffic Signal Controller: Meter service and signal controller cabinet assemblies shall be displayed in the Traffic Signal Controller table.

15.2.14.B.1.d.(4)
continued

TRAFFIC SIGNAL CONTROLLER SCHEDULE						
CABINET	TYPE	CONTROLLER	AUX. CONTROL	REMARKS	LOCATION	STANDARDS
Ⓐ 	METERED PEDESTAL SERVICE UL TYPE 3R	METERED PEDESTAL SERVICE WITH ONE 30 AMP AND ONE 60 AMP BREAKER AND PHOTOCELL	–	PROVIDE METER SOCKET WINDOW 4"H X 6"W	AT APPROX: STA. 5+54, 67' RT (CENTER OF CABINET) BELLAIRE BLVD. CONST ℄	02893–14
Ⓑ 	TYPE 340 ITS	2070LX CONTROLLER UINIT W/ 2070–1C CPU MODULE WITH GPS SERIAL COMMUNICATIONS MODULE & UPS BATTARY BACK–UP SYSTEM	–	STANDARD SPECIFICATION 16730 & 16731 UNINTERRUPTIBLE POWER SUPPLY – STANDARD SPECIFICATION 16732 FIELD HARDENED ETHERNET SWITCH (SIX COPPER PORTS ONLY) – STANDARD SPECIFICATION 16733 WIMAX – STANDARD SPECIFICATION 16734 GPS SERIAL COMMUNICATIONS MODULE– STANDARD SPECIFICATION 16785	AT APPROX: STA. 5+56, 78' RT (CENTER OF CABINET) BELLAIRE BLVD. CONST ℄	02893–10C 16735 16740

Example Traffic Signal Controller Schedule

(c) Cable Schematic: Low and high-voltage cable schematics shall be displayed on the pole schedule and cable schematic sheet. The cable schematic shall include:

(i) Conduit Run Identifiers

(ii) Conduit Size

(iii) Type of Conductors in each run

(iv) Legend

(v) Engineer of Record shall conduct interim review of project status and technical issues with city at appropriate project milestones agreed upon by City and Engineer of Record.

e. Field Books

(1) Typically, field books will be prepared by the City upon receipt of signed and sealed plans in PDF format and original CAD files. The Engineer of Record should not submit a field book unless specifically requested by the City.

2. Left Turn Phasing Guidelines

a. Purpose. These guidelines provide a method to uniformly evaluate and install appropriate left turn phasing at traffic signals within the City of Houston. These guidelines attempt to minimize the restrictions placed on motorists' ability to turn safely through gaps in opposing traffic when such turns can be performed safely.

15.2.14.B.2 continued

b. The flowchart shown below (Traffic Signal Timing Manual, 2nd edition) can be used to assist in the determination of whether a left-turn phase is needed for a given movement and whether the operational mode should be protected or protected-permissive.

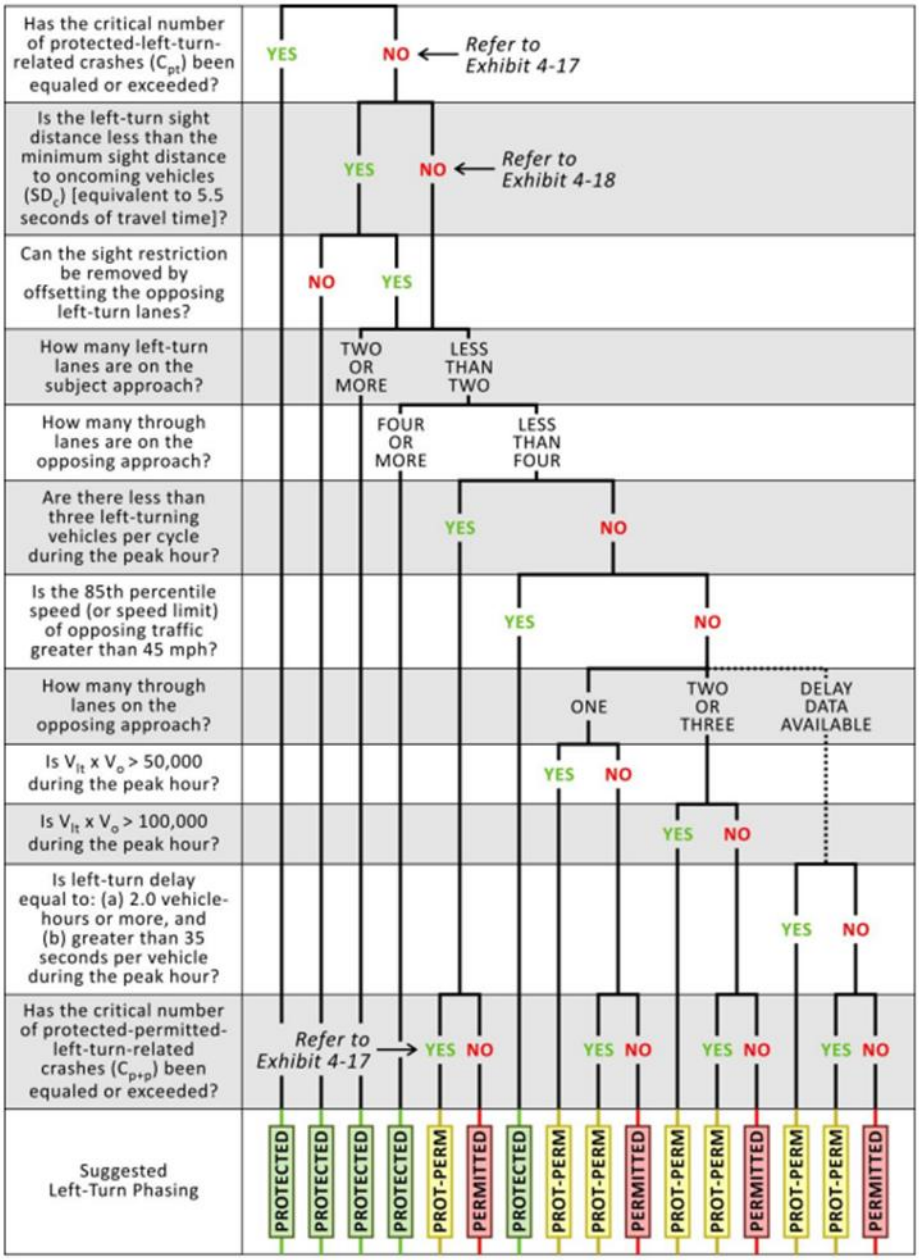


Figure 15.9 – LEFT-TURN PHASING GUIDELINES[18]

[18] Source: National Academies of Sciences, Engineering, and Medicine. 2015. Signal Timing Manual - Second Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/22097.

STM2 Traffic Signal Timing Manual, 2nd Edition

Exhibit 4-17 Critical Left-Turn-Related Crash Count

Number of Left-Turn Movements on Subject Road	Period During Which Crashes are Considered (Years)	Critical Left-Turn-Related Crash Count (Crashes Per Period)	
		When Considering Protected-Only (C_{pt})	*When Considering Protected-Permitted (C_{p+pt})*
One	1	6	4
	2	11	6
	3	14	7
Two	1	11	6
	2	18	9
	3	26	13

Exhibit 4-18 Minimum Sight Distance to Oncoming Vehicles

Oncoming Traffic Speed Limit (Miles Per Hour)	Minimum Sight Distance to Oncoming Vehicles (SD_c) (Feet)
25	200
30	240
35	280
40	320
45	360
50	400
55	440
60	480

In order to account for the inherent variability of crash data, the critical left-turn crash counts identified in Exhibit 4-17 are based on an underlying average critical crash frequency. The underlying averages are 1.3 crashes per year and 3.0 crashes per year for protected-permitted and protected-only left-turn phasing, respectively. If the reported crash count for existing operations exceeds the critical value, then it is likely that the subject intersection has an average left-turn crash frequency that exceeds the aforementioned average (5 percent chance of error), and a more-restrictive operational mode would likely improve the safety of the left-turn maneuver.

Note that the flowchart has two alternative paths following the check of opposing traffic speed. One path requires knowledge of left-turn delay; the other requires knowledge of the left-turn and opposing through volumes. The left-turn delay referred to in the flowchart is the delay incurred when no left-turn phase is provided (i.e. the left-turn movement operates in the permitted mode).

4.3.1.3 Flashing Yellow Arrow Displays

One protected-permitted left-turn display that warrants additional discussion is the recently introduced flashing yellow arrow (FYA) display. (Refer to Chapter 5 for additional guidance on protected-permitted operations.) This indication features a flashing yellow output, which must be accommodated in the signal design with:

- Individual wires to/from the cabinet to each of the four indications in the FYA signal head;
- A signal monitor with the functionality to accommodate the FYA indication; and
- An additional load switch for the flashing yellow indication or an unused load switch channel on a pedestrian load switch (the unused yellow output), as load switches only contain three outputs.

Figure 15.10 – CRITICAL LEFT-TURN RELATED CRASH COUNT AND MINIMUM SIGHT DISTANCE TO ONCOMING VEHICLES[19]

[19] Source: National Academies of Sciences, Engineering, and Medicine. 2015. Signal Timing Manual - Second Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/22097.

15.2.14.B continued

3. Alternative Lane Configurations

   a. An analysis shall be conducted to determine the geometrics of the intersection to satisfy Multimodal Service Standards (MMSS) requirements. Additional lanes may benefit Vehicle Level of Service (VLOS) but should be consistent with MMSS.

   b. Left turn lanes greatly benefit the operation of an intersection which has enough traffic to require signals. As a result, all new traffic signal designs shall require the inclusion of a left turn lane unless otherwise specified by the City. In areas such as the Central Business District, where speeds are low and right-of-way is not available or is very expensive, the benefits of left turn lanes may be outweighed by the cost.

   c. Right turn lanes and double left turn lanes should be reserved for exceptional circumstances where turning volumes are very high. Ensure that additional lanes are consistent with Multimodal Service Standards (MMSS) requirements.

4. Alternative Phasing

   a. Permitted, protected/permitted left turns signal phases should be delayed until the pedestrian WALK phase is terminated and the DON'T WALK phase starts.

   b. Split Phasing. Split phasing shall be defined as separating two opposing directions of traffic such that the compatible through and protected left turn movement receives the right-of-way simultaneously. Split phasing shall require the approval of the City prior to submitting the preliminary design plans. This phasing should only be used if one of the following conditions exists:

      (1) The opposing approaches are offset to the extent that simultaneous left turns in opposing directions would cause a high number of conflicts, resulting in a high collision potential, and the left turn demand is sufficiently high to require as much green time as the adjacent through movement. When left turn volumes are lighter, and physical conflict exists, lead-lag operation should be used.

      (2) Double left turn lanes are used in one or both directions and the turning radii are not sufficient to allow simultaneous left turns without conflicts between opposing left turn traffic, and subject to the same volume requirements in item (a) above.

      (3) The left turn volume is extremely heavy on an approach that does not allow the construction of a separate left turn lane.

15.2.14.B.4.b continued

(4) Left turn volumes are extremely heavy on opposing approaches and both are nearly equal to the adjacent through movement critical lane volume (A check should be made to determine that the design hour level of service will be significantly improved and that there will not be substantial decreases in level of service during other hours of the day).

(5) The critical lane volumes are lowest when drivers are permitted to turn left from more than one lane, and are also permitted to use the right- most left turn lane as a through lane.

(6) If the intersection is in an interconnected system and the coordination plan would be improved by splitting the phases.

c. Right Turn Overlaps. Overlaps are encouraged where needed. Right-turn overlaps should be used only if there is a dedicated right turn lane on the approach and pedestrians are prohibited from crossing parallel and to the right of the concurrent through movement from the same approach. If right turn overlaps are provided, it will be necessary to prohibit u-turns for the opposing left turn approach. Appropriate signing should be detailed in the plans. An example of this operation would be when the left turn arrows on the main street approach are displayed simultaneously with a right turn arrow on one or both side street approaches. This type of operation should only be used where:

(1) there are 250 or more right turns during a peak hour and;

(2) there are 200 or more corresponding left turns during the same hour and;

(3) the per lane through volume for the same approach is approximately equal to, or less than, the right turn volume.

5. Geometric Design Elements: If the construction of geometric changes in the street is required, the work shall be done in accordance with the City of Houston's Uniform Development Code, Chapter 10 of the Infrastructure Design Manual, and in accordance with the following criteria:

a. Design Speed

(1) Motor Vehicles: The anticipated 85th percentile speed plus 5MPH, in accordance with the Major Thoroughfare and Freeway Plan (MTFP), or as directed.

(2) Pedestrian Walk Speed: 3 ft/s across all crosswalks.

b. Design Vehicle: The design vehicle shall be a WB-50 (AASHTO Green Book) or as directed.

15.2.14.B.5 continued

c. Auxiliary Lane Design

(1) Opposing left turn lanes shall be designed for protected/permitted left turn signalization unless protected only left turn phasing is required by section 15.2.14.B.2. Sight Distance for drivers of left turning vehicles to see beyond opposing left turning vehicles shall be calculated in accordance with Case III A - Crossing Maneuver (AASHTO Green Book).

(2) The Storage Length of the left or right turn lanes shall be determined based on the expected queue length as defined in section 15.2.07.C.6 of the Infrastructure Design Manual. The minimum left turn lane Storage Length shall be 100 feet unless restricted by other factors. The maximum left-turn lane length should be 400 feet. If the expected queue Storage Length exceeds 400 feet or the left turning volume during the peak hour exceeds 200 vehicles, dual left turn lanes should be considered.

d. Tapers

(1) A taper, in this context, refers to the transition in pavement width between the centerline and the edge of pavement, e.g., the lateral transition of a Median to accommodate a left turn bay. Wherever possible, the transition taper shall be a symmetrical reverse curve. This taper length shall not be subtracted from the total required Storage Length (Total Turn Lane Length = Storage Length + Transition Taper length).

(2) All approach taper ratios for collectors and thoroughfares shall be based on the posted speed limit plus 5 mph or 85th percentile speed (whichever is greater) and shall be calculated using the formulas described in the Texas Manual on Uniform Traffic Control Devices.

e. Islands

Generally, raised (curbed) islands for the use of channelizing traffic, as in the case of a right turn lane, shall not be used. When islands are needed, sizes and dimensions should meet the recommended AASHTO requirements. Mountable curb and gutter shall be used on all islands.

f. Medians

15.2.14.B.5.f continued

(1) The minimum width of a raised Median shall be four feet from face of curb to face of curb. A six-foot width shall be considered where a left turn lane is opposed by three or more right and through lanes to provide greater pedestrian storage and to reduce pedestrian clearance timings.

(2) Both vehicle and pedestrian characteristics shall be considered for design of the location of the Median nose.

(3) Median nose design shall not impede crosswalks or bicycle facilities.

(4) Bullet nose Medians shall be required adjacent to a left turn bay at an intersection with a street other than a primary arterial. This 3-centered curve shall have radii of 50', 3', and 50'.

(5) The Median opening must be wide enough to provide for adequate turning movements by left turning vehicles. In no case shall the Median opening be narrower than 40 ft.

(6) In the development of a left or right turn lane; the pavement shall be widened via a symmetrical reverse curve as described in the Infrastructure Design Manual, Figure 10.8.

g. Pedestrian Accommodations at Signals

(1) At intersection corners without sidewalks, where traffic signal poles are to be installed, a pedestrian landing shall be constructed according to the City of Houston Specifications and Standard Drawings.

(2) Pedestrian accommodations, including curb ramp design, are specified in Chapter 17, Section 17.3.02.

(3) For purposes of timing the walk phase, a walk speed of 3 ft/s shall be utilized.

(4) Leading Pedestrian Intervals (LPIs)

(a) LPIs are adjustments to signal timing to increase pedestrian safety at signalized intersections. An LPI gives pedestrians a typical 3-to-7 second head start before motorists in the parallel direction are given the green signal indication.

15.2.14.B.5.g.(4) continued

(b) LPIs improve safety for all road users by reducing conflicts between pedestrians and left- or right-turning motorists. The LPI works to position the pedestrian within the crosswalk thereby improving visibility and decreasing the likelihood of a conflict or crash with a left- or right-turning motorist ahead of the turning traffic.

(c) LPIs shall be implemented in Walkable Places Districts, on designated Transit-Oriented Development Streets, and on streets with bicycle signal heads for bicycle facilities.

(d) The LPI length shall be a minimum three (3) seconds in duration. Longer durations may be required when a pedestrian must cross more than one lane of traffic.

(i) Analysis should be performed on corridors with multiple travel lanes to calculate the minimum time required for pedestrians to cross halfway across one direction of travel.

(ii) Longer durations should be considered in the case of a large corner radius, determined by how far pedestrians must travel to establish their position before the turning traffic is released.

(e) LPIs should be included at signalized locations where:

(i) Crash history indicates multiple crashes or severe injury/fatal crashes.

(ii) Pedestrian volumes are heavy for multiple hours of a typical day.

(iii) Vulnerable populations, like school-aged children or older adults, are expected to cross.

(iv) Visibility of pedestrians is limited or restricted by components such as intersection geometry, location of stopped vehicles, vegetation, and streetside features.

h. Bicycle Accommodations at Signals

(1) Bicycle signal heads shall be installed on any approach to a traffic signal that has a high comfort bicycle facility, as defined by Chapter 17.

(2) A Leading Bicycle Interval (LBI) should be installed wherever a conflict exists between bicyclists and turning vehicles.

15.2.14.B.5.h continued

(3) Wherever LBI is utilized, a Leading Pedestrian Interval (LPI) shall be utilized for the adjacent pedestrian crossing.

i. Curb Return Radius

(1) Where two streets intersect, certain radii are required for the curbs per the Infrastructure Design Manual. Refer to Chapter 10 for curb return radius requirements.

6. Traffic Signal Hardware Design

The traffic signal hardware shall be designed in accordance with the following criteria:

a. Traffic Signal Heads and Lane Use Control Signs

(1) Number and Location of Heads:

(a) The minimum number of Traffic Signal Heads for all approaches shall be in conformance with the current edition of the TMUTCD.

(b) Generally, one Traffic Signal Head will be provided for each through lane.

(c) Generally, the Traffic Signal Heads shall be located directly above the center of the travel lane.

(d) Typically, a minimum of two left turn Traffic Signal Heads shall be provided. One left turn Traffic Signal Head will be located centered over the left turn lane. A second left turn head shall be provided on the far-left corner of the intersection adequately aligned with the left turning path. Additional left turn Traffic Signal Heads are required for multiple left turn lanes.

(e) Where there is only one approach lane, two signal heads shall be located at least 8 feet apart between edge of backplates, with the center of the separation between the heads located over the center of the lane.

(f) Bicycle signal heads shall be placed in a location clearly visible to oncoming bicycles. Typically, a single signal head is sufficient; however, consideration of near-sided bicycle signals may be given for improved visibility.

(2) Size and Configuration:

(a) Generally, all Traffic Signal Heads shall be oriented in a horizontal alignment.

15.2.14.B.6.a.(2) continued

(b) All pole mounted Traffic Signal Heads shall be mounted vertically in line with the pole shaft.

(c) All sections of vehicular Traffic Signal Heads shall have 12" LED indications.

(d) For permissive only mode left turns, steady 3-section RYG shall be used (H3 horizontal, V3 vertical). R10-12 "LEFT TURN YIELD ON GREEN BALL" sign shall be installed immediately adjacent to the Traffic Signal Head.

(e) For protected/permissive mode left turns with an exclusive left turn lane, 4-section RYYG flashing yellow arrow signal shall be used (H4LF horizontal, V4LF vertical). R10-17T "LEFT TURN YIELD ON FLASHING YELLOW ARROW" sign shall be installed immediately adjacent to the left turn signal head, and below the second left turn head placed on the far-left corner.

(f) For protected/permissive mode left turns with a left/through share lane, steady 5-section RYYGG signal shall be used (H5L horizontal, V5L vertical). R10-12 "LEFT TURN YIELD ON GREEN BALL" sign shall be installed immediately adjacent to the Traffic Signal Head if horizontal, and below the left turn head if vertical. No supplemental signal head in the far-left corner is required for this case.

(g) For protected only mode left turns, steady 3-section RYG all arrows shall be used (H3L horizontal, V3L vertical). R10-5 "LEFT TURN ON GREEN ARROW ONLY" sign shall be installed immediately adjacent to the left turn signal head, and below the second left turn head placed on the far-left corner.

(h) At split-phase approaches, the left-most head shall be a 4-section RYGG head with a left arrow section (H4TL horizontal, V4TL vertical). No sign is required to accompany this signal head. No supplemental signal head in the far-left corner is required for this case.

(i) Signal heads located in the downtown and uptown district shall be black in color. All other Traffic Signal Heads in the City shall be yellow unless otherwise specified by the City.

(j) Bicycle signal heads shall be mounted vertically.

15.2.14.B.6.a.(2) continued

(k) All sections of bicycle signal heads shall have 12" LED bicycle indications. Steady vertical 3-section RYG bicycle shall be used (B3). "Bicycle symbol SIGNAL" sign plaque (R10-10B) shall be added below the bicycle signal head.

(3) Type of Signal Head:

(a) All signal head housings shall be constructed of polycarbonate in accordance with the Standard Specifications.

(b) Optically programmed signal heads shall be used whenever the indications can be viewed by two or more conflicting movements of traffic at skewed intersections, or where two sets of indications for the same direction are not to be viewed simultaneously, such as the second set of indications on the cross street at an offset intersection.

(c) Bi-modal indication signal sections shall not be used.

(4) Type of Mounting:

(a) All mast arm-mounted Traffic Signal Heads will be mounted on a tenon using a fully adjustable "Astro-Brac Atlas Large Capacity" mount assembly, or an approved equal. In exceptional circumstances when a tenon is not available on the mast arm and after obtaining authorization from the City of Houston, a hole should be drilled and a tenon clamp kit used.

(b) Side-mount signal heads shall be mounted using standard mountings and shown on the plans as being on a side of the pole away from vehicular traffic.

(5) Backplates:

(a) All vehicular Traffic Signal Heads on steel poles shall be equipped with black louvered backplates conforming to Standard Specifications.

(b) All bicycle signal heads (B3) shall be equipped with yellow louvered backplates conforming to Standard Specifications.

(6) Installation Procedures:

15.2.14.B.6.a.(6) continued

(a) Mast arms shall be drilled for wire accesses after installation on the pole base to provide concealed wiring and proper signal head location. All signal head installations shall comply with mounting requirements per Standard Specification 16715 - Vehicle Signal Heads.

b. Pedestrian Traffic Signal Heads

(1) Type and Number:

(a) Pedestrian Traffic Signal Heads shall be installed wherever crosswalks are provided, except crossing free right turn lanes.

(b) Two pedestrian Traffic Signal Heads shall be installed, one at each end of the crosswalk being controlled. Pedestrian signals may be placed on Median islands if the signal heads are not visible for the entire length of the crossing and/or operational considerations indicate benefit of two-stage crossings along with adequate pedestrian refuge area available on the Median. In such case, additional pedestrian signal heads shall be placed in the Median facing each direction.

(2) Legend:

(a) Generally, all pedestrian signal heads shall have international symbol messages consisting of a Portland orange upraised hand (symbolizing DON'T WALK) and a lunar white walking man (symbolizing WALK).

(3) Size and Configuration:

(a) All pedestrian Traffic Signal Heads shall have 16" LED countdown indications.

(b) Pedestrian Traffic Signal Heads located in the downtown and uptown district shall be black in color. All other pedestrian Traffic Signal Heads in the City shall be yellow unless otherwise specified by the City.

(4) Location:

15.2.14.B.6.b.(4) continued

(a) Pedestrian Traffic Signal Heads shall be located as nearly in line with the crosswalk as possible. If the mast arm pole is located such that the pedestrian signal will be blocked by stopped vehicles or if it is more than twenty (20) feet outside of the crosswalk lines extended, then an alternative means of mounting shall be designed. Pedestrian Traffic Signal Heads shall be mounted 8 feet (to the bottom of the head) above the walking surface on the side of pole away from vehicular traffic. Pedestrian traffic signals shall be shown on the plans as being mounted on the side of the pole away from vehicular traffic by use of the respective symbol.

c. Relocating Traffic Signal Heads

(1) Signal heads shall be relocated only when they are in good condition, are in conformance with this section, and no modifications are necessary. The relocation of any Traffic Signal Heads shall require the prior approval of the City.

d. Mast Arm Assemblies and Poles: Typically, the City requires that mast arm poles be used for all new traffic signal installations. In special cases, the City may allow strain pole installations based on a written recommendation by the Engineer of Record explaining the need for a span wire design. Traffic Signal Heads mounted vertically on a pole shaft shall be allowed as supplemental signal indications; they shall not be used as the exclusive method of mounting traffic signals for any approach without prior approval from the City.

(1) Location (Including Setback):

(a) On streets with curbing, poles shall be located such the center of the pole is a minimum of five (5) feet from the face of curb. On streets without curbing, or with speeds greater than 35 MPH, poles shall be located a minimum of ten (10) feet behind the edge of pavement or three (3) feet behind the edge of the paved shoulder, whichever is greater, and should be located fifteen (15) feet from a line extended from the edge of the through traffic lanes.

(b) Mast arm traffic signal poles should not be located in the Median unless no other option exists. Any mast arm poles located in the Median shall require approval by the City prior to the preliminary plan submittal.

(c) Poles should be located in line with the opposing directions stop line (approximately four feet behind the crosswalk line).

15.2.14.B.6.d.(1) continued

(d) Poles should be located as close to the sidewalk or pedestrian landing as possible for pedestrian pushbutton access, yet still be within the guidelines for distance from the curb or traveled way.

(e) No poles shall be located in wheelchair ramps or such that they are an obstruction to pedestrians or wheelchairs.

(f) On the plans, the Engineer of Record shall tie down the location of all poles referenced to the street centerline by station to the nearest foot and offset to the nearest half foot.

(2) Mast Arm Lengths:

(a) Minimum mast arm length that shall be used is 25 feet.

(b) Mast arms longer than 55 feet in length may require an evaluation of the pole and foundation to be used as determined by the City.

(c) Mast arm lengths should allow for probable future modifications to the signal. If a left turn lane exists, the arm should extend to the center of the left turn lane.

(3) Clearances from Utilities:

(a) Poles shall be located such that all portions of the poles and attached equipment have clearances from overhead utilities in accordance with the requirements of the local utility and the National Electrical Safety Code (NESC).

(4) Material and Style:

(a) All poles shall conform to the Standard Specifications and Details. Special poles and features shall be coordinated and approved by the City.

(b) The centerline of the mast arm shall be at 90 degrees to the centerline of the approach it is serving unless otherwise required.

(5) Delivery Time:

(a) Typical delivery time for mast arm poles is 8 - 12 weeks from the approval of submittals. The number of days specified in the contract should account for the long delivery time.

15.2.14.B.6.d continued

(6) Luminaries and Luminary Mast Arms: Luminaries shall be included in all intersection designs unless otherwise indicated by the City, and shall meet the following requirements:

(a) One luminaire shall be utilized for each leg of the intersection.

(b) Luminaries to be positioned to illuminate crosswalks.

(c) All installations shall meet the current National Electrical Code requirements.

(d) The street lighting photo cell shall be mounted in the traffic signal service panel unless otherwise designated by the City of Houston.

(e) Power for the street lighting should come from the traffic signal service panel.

(f) Fixture attributes shall adhere to the latest City specifications for intersection lighting.

(7) Device Mounting:

(a) No non-traffic related devices may be mounted on the mast arm. Non-traffic related devices may be mounted on the pole shaft with approval. All devices to be installed on the signal pole and mast arm assembly shall be in accordance with the maximum loading information provided by the manufacturer. Reference to City of Houston Standard Detail for Traffic Signal Structures 02582-03. The installation of any device in deviation of the traffic signal items defined on Standard Detail 02582-03 shall be submitted for review to the City with the respective supporting structural analysis. See Chapter 16, Section 2 “Communication Facility Design Requirements” for additional device mounting requirements.

e. Pedestrian Pushbuttons: Pedestrian pushbuttons shall be required at all new or modified traffic signal locations within the City of Houston. The omission of pedestrian pushbuttons at any location shall require the approval of the City.

(1) All pedestrian pushbuttons shall be Polara Navigator or approved equal Accessible Pedestrian Systems (APS).

(2) No more than one pedestrian pushbutton shall be located on a single traffic signal pole.

15.2.14.B.6.e continued

(3) Pedestrian pushbuttons should be located no more than ten (10) feet from the face of curb or more than five (5) feet from the crosswalk extension.

(4) Pedestrian pushbuttons shall be separated by a minimum distance of ten (10) feet.

(5) All pedestrian pushbutton stations shall be accompanied by a pedestrian pushbutton sign (R10-3e) with instructions.

7. Controller and Cabinet Design

a. Controllers

(1) All new controllers shall be the Type 2070 Advanced Traffic Controllers (ATC) in compliance with the latest Model 2070 Controller Unit Specification unless otherwise directed by the City.

b. Phasing

(1) The sequence of operations shall be shown by the phasing sequence diagram for each intersection on the plan sheet. Permitted movements shall not be indicated unless part of a protected/permitted sequence. All pedestrian movements shall be shown.

(2) Phases shall be designated on the traffic signal plan sheet in accordance with the standard NEMA phase designations. In addition, the phases shall be assigned as follows (unless limited by the controller cabinet). As shown, phases 3 and 8 are to be oriented north on standard 8-phase intersections, and phase 8 is to be assigned to the feeder road approach oriented north or west as shown.

15.2.14.B.7
continued

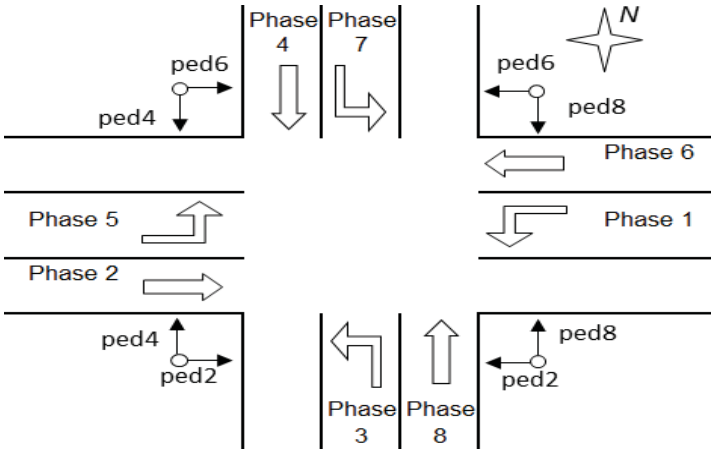


Figure 15.11 - STANDARD 8-PHASE INTERSECTION

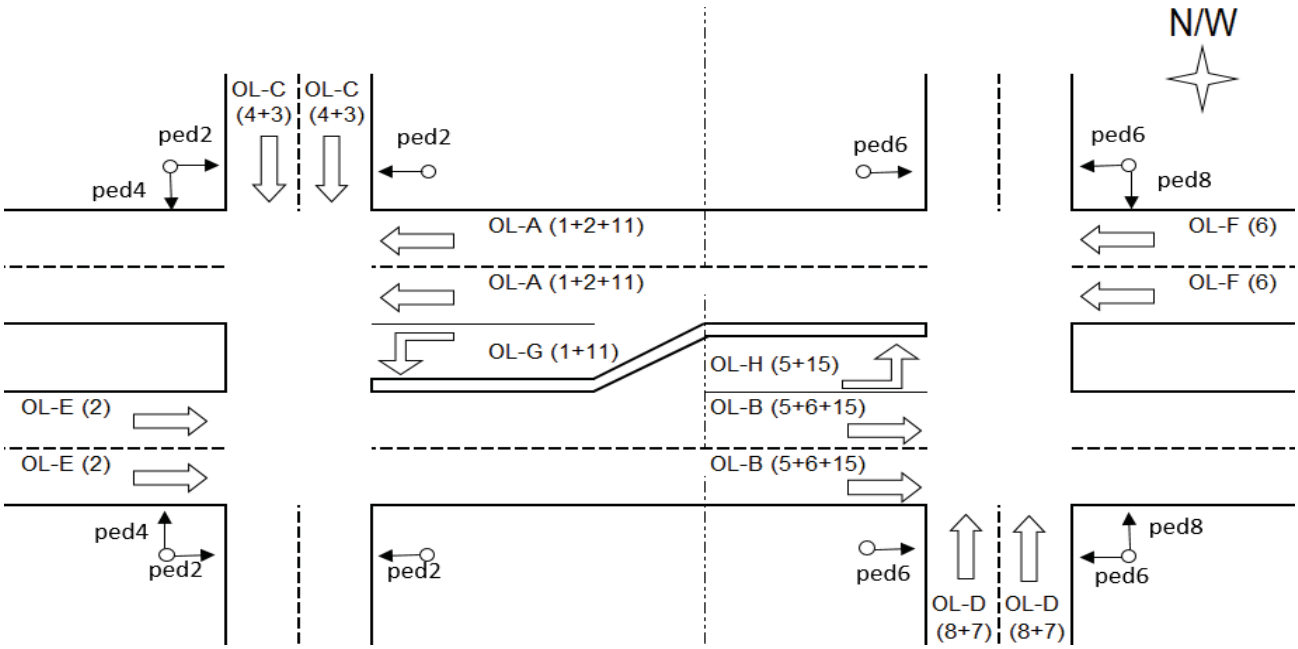


Figure 15.12 - STANDARD DIAMOND INTERCHANGE INTERSECTION (4-PHASE OPERATION)

c. Controller Cabinet Type

(1) New type 2070 ATC controllers shall be housed in one of a selection of four cabinets from the Standard Specifications:

15.2.14.B.7.c.(1) continued

(a) Type 340 ITS Cabinet (housing package type 3): This is the standard cabinet for installation at City of Houston intersections. This cabinet shall be used at locations where 8 or more phase operation would be employed in the new or future system. This cabinet will fit on a standard NEMA "P" cabinet foundation.

(b) Type 342 ITS Cabinet (housing package type 1): The type 342 ITS cabinet is a smaller cabinet that uses the type 332 cabinet profile and will fit a type 332 cabinet foundation. This cabinet should only be used on intersection retrofit projects where the existing foundations and conduit system are to remain. It should not be specified without prior approval by the City.

(c) Type 346 ITS Cabinet (housing package type 2): The type 346 ITS cabinet generally has the same capabilities as the type 342 cabinet in a smaller unit. These cabinets are to be used in the downtown area, pedestrian hybrid beacon locations, and fire stations.

(2) Selection of which cabinet to use shall be based on the cabinet use descriptions above and approved by the City.

d. Controller Cabinet Location

(1) The controller cabinet should be located to minimize the probability of being hit by a vehicle. Locations particularly susceptible to accident damage are:

(a) The far corner (apex) for a dual left turn or right turn movement where the crossing street doesn’t have a raised Median.

(b) The far corner (apex) for a heavy left turn movement.

(c) The far-right corner of a high-speed approach where a right-angle collision can knock a car into the controller.

(d) Generally, the controller should be located upstream on the heaviest approach and/or back from the corner on the minor approach if there is a significant difference in approach volumes or speeds. Consideration should be given to locating the controller where it is protected by an existing non-breakaway pole or a mast arm pole.

(2) Where possible, the controller should be located on the same corner as the power supply. Special care should be taken that the load center is not separated from the controller by a wide, high speed or high-volume street.

15.2.14.B.7.d continued

(3) Areas subject to flooding shall be avoided. Where not possible, the foundation should be raised 2' above the 100-year flood plain.

(4) Cabinet placement should not obstruct the minimum Sight Distance of any approach of the intersection. The cabinet should not obstruct the sidewalk or the ramp, even when the doors are open. Care shall be taken such that the cabinet doors do not open off the right-of-way.

(5) Cabinets shall be positioned such that when the door opens, the maintenance personnel will have a clear view of the intersection and the inside of the cabinet. If the cabinet is too high to see over, the cabinet shall be positioned and oriented so that the technician has a clear view of the intersection without looking around the open door.

(6) No device serving purposes different that traffic signal operations shall be placed on top or attached in any way to the traffic signal cabinet without the prior review and approval of the City. No device compromising the physical integrity of the signal cabinet will be authorized.

8. Detector Design

a. General

(1) The City's practice is to install inductive loop detectors as primary detection method at all new or upgraded traffic signal installations. The use of video detection as an alternative detection method shall be considered if the installation of inductive loops is unfeasible (e.g. bridge deck, paver surface) or impractical (e.g. poor pavement conditions). Any other detection technologies shall require prior approval of the City.

b. Emergency Vehicle Pre-Emption Equipment

(1) All new City traffic signal installations shall require the installation of GTT Opticom emergency pre-emption equipment. Sensors shall be installed for all intersection approaches. The City of Houston uses a coded system which requires proprietary software. For this reason, only GTT (Global Technologies, LLC) Opticom equipment can be used for City installations.

c. Inductive Loop Detectors: Inductive loop detectors are the standard means of vehicle detection to be used in the City of Houston.

(1) Types of loop installations shall be broken into two categories depending on the proposed pavement work:

15.2.14.B.8.c.(1) continued

(a) Pre-formed Loops - Use pre-formed loops any place where the entire loop falls in an area of new, overlaid, milled and replaced, or seal- coated pavement. The excavation and patching required are easily covered up by the pavement work, and the pre-formed loops can last virtually forever, if properly installed.

(b) Saw cut Loops - Use saw cut loops if the loop or any part of the loop would end up in an existing pavement that will not be modified by any of the methods noted above. This is a less desirable method of loop installation but can give acceptable loop life if properly installed.

(2) The detector lead-in cable is a shielded twisted pair cable extending from the loop pull box to the controller cabinet. The detector lead-in cable shall be a continuous run without splices.

(3) Except where noted otherwise, dimensions for detector loop setbacks shall be referenced from stop line. The detector reference line should be curved if needed to follow the alignment of the street.

(4) Each loop shall be connected to its own detector lead-in cable. Multiple detector lead-in cables may run in the same conduit.

d. Identification Scheme

(1) Detectors shall be identified on the plan sheets by their phase, lane and purpose. Each lane will be numbered from left to right starting with the lane closest to the centerline. Advance detection loops shall be identified as pulse loops. Detectors in through lanes at the stop line will be designated as call detectors. Finally, detectors in the turn lanes or on low-speed minor approaches shall be presence detectors. For example, when speaking about the advance loop for eastbound in the lane closest to the Median would be referred to as the Phase 2 pulse loop 1.

e. Detectors on Higher Speed Approaches (posted speed ≥ 30 MPH)

(1) Location

(a) For higher speed approaches, advance inductance loop detectors for the through lanes of traffic are required and shall be located five (5) seconds from the stop line using the following table:

15.2.14.B.8.e.(1)(a) continued

Table 15.9 - ADVANCE DETECTOR LOCATION TABLE

Posted Speed/ Design Speed (mph)	Advance Detector Distance (ft.)*
30	220
35	260
40	300
45	330
50	370
55	410
*As measured from the leading detector edge to the stop line.	

(b) In addition to the advance detectors, call detectors in each lane shall be placed near the crosswalk. The front edge of a 6’ x 6’ detection zone (either pre-formed or saw cut loops, or video) shall be located four (4) feet back from the stop line. At locations involving skewed intersections, or other extenuating circumstances, the detector positions and sizes may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. In all cases, detection must be provided ten (10) feet upstream from the back of the crosswalk. The intent of the detector’s placement is to prevent the smallest passenger cars, motorcycles and bicycles from being caught in an undetected area. If adjusted, the size and spacing of the detectors shall remain constant.

(2) Detector Lead-in Cable

(a) The upstream pulse loops for the dilemma zone protection shall be on separate detector amplifier channels.

(b) If there is more than one through lane, adjacent upstream loops shall be placed on separate channels without connection to any other loop.

(c) The two stop line loops shall be spliced in series at the cabinet and connected to the same detector amplifier. This amplifier shall be the "call" input amplifier, with the loops of each lane split between the two channels.

15.2.14.B.8.e.(2) continued

(d) The upstream loop detector lead-in cables shall be routed to the nearest junction box along a patch perpendicular to the direction of travel. Homeruns for adjacent loops, less than sixteen (16) feet apart, should be routed to the nearest junction box in the same cut to the extent possible to minimize excavation of the pavement. When loops are adjacent to Medians, the homerun can be routed directly to the Median and then to the nearest junction box.

(e) The stop line loop lead-in cable will generally be routed to the same junction box. All the detector lead-in cables for conduit-encased loops should be routed parallel and adjacent to each other along a path perpendicular to the direction of travel. A path parallel to the direction of travel may be needed from the individual loop to the common perpendicular routing.

f. Detectors on Low-Speed Approaches

(1) Location

(a) Large area presence detection shall be used on approaches with less than 35 MPH posted or anticipated 85th percentile speed. It shall also be used on side street approaches, with a posted or anticipated 85th percentile speed of 35 MPH, if the higher through phase critical lane volume is less than one-half the critical lane volume of the highest volume main street through phase.

(i) Pre-formed loops. A 6' x 21' presence detection zone shall consist of one (1) 6' x 6' detector loop placed in each lane beginning at the stop line, and a second 6' x 6' detector loop placed an additional nine (9) feet upstream of the trailing edge of the first detector. An additional 6' x 6' detector loop shall be placed in front of the stop line if the curb return allows for a full vehicle length to the stop line.

(ii) Saw cut loops. A 6' x 20' presence detection zone shall consist of one (1) 6' x 6' detector loop placed in each lane beginning at the stop line, and one (1) 6' x 10' detector loop placed four (4) feet upstream of the trailing edge of the first detector. An additional 6' x 6' detector loop shall be placed in front of the stop line if the extension of the curb line allows for a full vehicle length to the stop line.

15.2.14.B.8.f.(1) continued

(b) At locations involving skewed intersections, or other extenuating circumstances, the detector positions, number or sizes may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. Care should be taken to not leave too much undetected space immediately upstream of the crosswalk. The intent of the detector placement is to prevent the smallest passenger cars, motorcycles and bicycles from being caught in an undetected area. If adjusted, the distances between the detectors shall remain constant.

(2) Detector Lead-in Cable

(a) In the case of the pre-formed detector loops, the loops in a lane may be combined on one channel. In all cases, each loop shall be spliced to its own detector lead-in cable running back to the cabinet.

(b) Detector lead-in cables for the loops closest to the intersection should be routed to the same junction box. Detector lead-in cables for adjacent loops should be routed to the nearest junction box in the same cut to the extent possible to minimize excavation of the pavement. A path parallel to the direction of travel may be needed from the individual loop to the common perpendicular routing.

g. Downstream Detection

(1) Downstream detector loops shall be placed on the receiving lanes of all through approaches, low and high speed, one hundred (100) feet measured from the crosswalk line furthest from the intersection. In case of no crosswalk line present or not clearly marked, downstream detector loops to be placed one hundred (100) feet measured from the curb return furthest from the intersection.

h. Left Turn Lane Detection

(1) Location

(a) Large area presence detection shall be used for left turn lane detections.

15.2.14.B.8.h.(1) continued

(b) Pre-formed Loops. A 6'x 51' presence detection zone shall consist of one (1) 6'x 6' detector loop with trailing edge four (4) feet in front of the stop line extending into the crosswalk, and additional three (3) 6'x 6' detector loops placed at nine (9) feet intervals upstream starting at the trailing edge of each loop.

(c) Saw cut Loops. A 6'x 50' presence detection zone shall generally consist of one (1) 6'x 6' detector loop with trailing edge four (4) feet in front of the stop line extending into the crosswalk, one (1) 6'x 6' detector loop placed with leading edge at the stop line, and one (1) 6'x 30' detector loop placed four (4) feet behind the trailing edge of the stop line detector loop.

(d) At locations involving skewed intersections, or other extenuating circumstances, the detector positions, number or sizes may need to be adjusted to account for vehicles stopping in front of or in the crosswalk. Care should be taken to not leave too much undetected space immediately upstream of the crosswalk. The intent of the detector placement is to prevent the smallest passenger cars, motorcycles and bicycles from being caught in an undetected area. If adjusted, the distances between the detectors shall remain constant.

(2) Detector Lead-in Cable

(a) Where Medians are constructed adjacent to left turn lanes, the detector lead-in cable(s) should be routed to a junction box in the Median.

(b) In the case of the pre-formed loops, the upstream loop shall be connected to its own channel on an amplifier. The other loops may be combined on one channel. For multiple saw cut loops, the rear loop and front loops shall be on separate channels. In all cases, each loop shall be spliced to its own lead-in cable running back to the cabinet.

(c) If there are two or more left turn lanes, all the loops in one lane shall be connected in a like manner as described in article 15.2.14.B.8.h.(2) above.

i. Right Turn Lane Detection

(1) Location: Detection for a right turn lane shall be installed in the same manner as a presence detection zone for a through lane on a low-speed approach.

15.2.14.B.8.i continued

(2) Detector Lead-in Cable: The right turn presence detection loop shall be connected into its own detector lead-in cable, and separate channel on an extension amplifier for the through phase.

j. Installation of Vehicle Detection Systems: See the Standard Specifications and Details for construction requirements for primary (inductance loops) and secondary (video) vehicle detection methods.

k. Video Detection Systems

(1) The City's practice is to install inductive loop detectors as a standard means of detection. The use of video detection system as an alternative detection method shall be considered if the installation of inductive loops is unfeasible (e.g. bridge deck, paver surface) or impractical (e.g. poor pavement conditions).

(2) When using video detection systems, at least one camera shall be installed for each intersection approach.

l. Bicycle Detection

(1) Bicycle detection systems shall be consistent with the method used for vehicle detection at the intersection.

(2) Applications for bicycle detection:

(a) On any approach that warrants installation of a bicycle signal head.

(b) On new and modified signalized intersections when the existing or proposed bicycle facility is on an approach that typically operates in actuated mode. In these situations, specific bicycle detection is required to recognize the presence of a bicyclist and provide a green indication for the bicyclist to proceed.

(c) Bicycle detection shall not be installed at signalized intersections when none of the applications to warrant bicycle signals are met, or the bicycle lane is located on a major approach typically operated in fixed-time mode, and that therefore, does not require a method to recognize the presence of a bicycle to receive a green indication and proceed parallel to the adjacent vehicular movement served every signal cycle.

(3) Design requirements for bicycle detection:

15.2.14.B.8.l.(3) continued

(a) If loop detectors are used, diagonal slashed and quadrupole loop detectors are recommended for bicycle lanes. Refer to loop detector standard details.

(b) If camera detection is used, a detection zone shall be defined that captures any place where a bicyclist may be expected to legally stop and wait.

(c) A bicycle detection symbol shall be adequately placed in reference to the bicycle detector to assist bicyclists in knowing where to stop. Refer to standard pavement marking drawings.

m. Other Detection Devices: The Engineer of Record may recommend other detection technologies and submit a written recommendation outlining the benefits of the technology. However, the City reserves the final authority to approve or disapprove the use of these technologies.

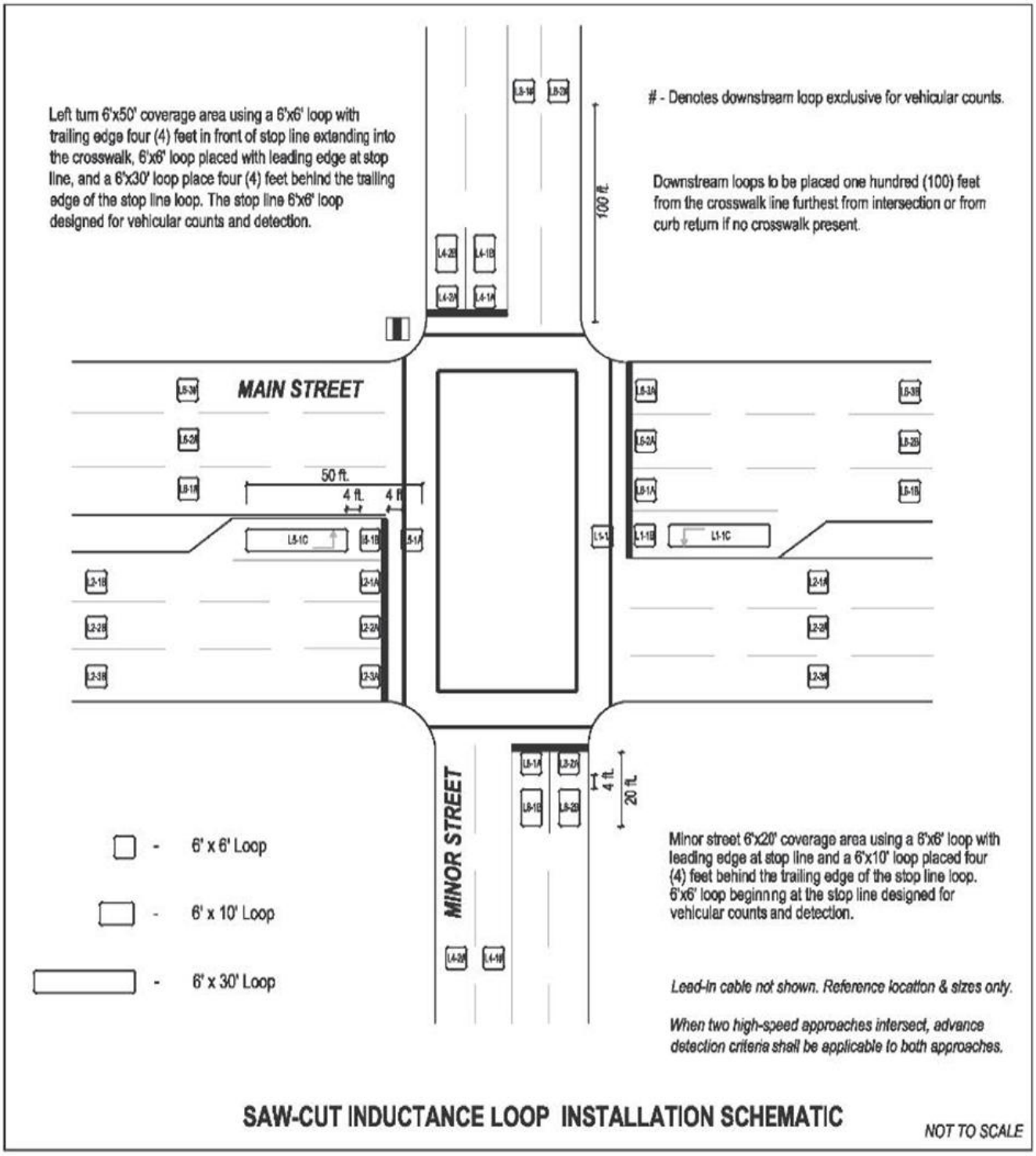


Figure 15.13 - SAW-CUT INDUCTANCE LOOP INSTALLATION SCHEMATIC

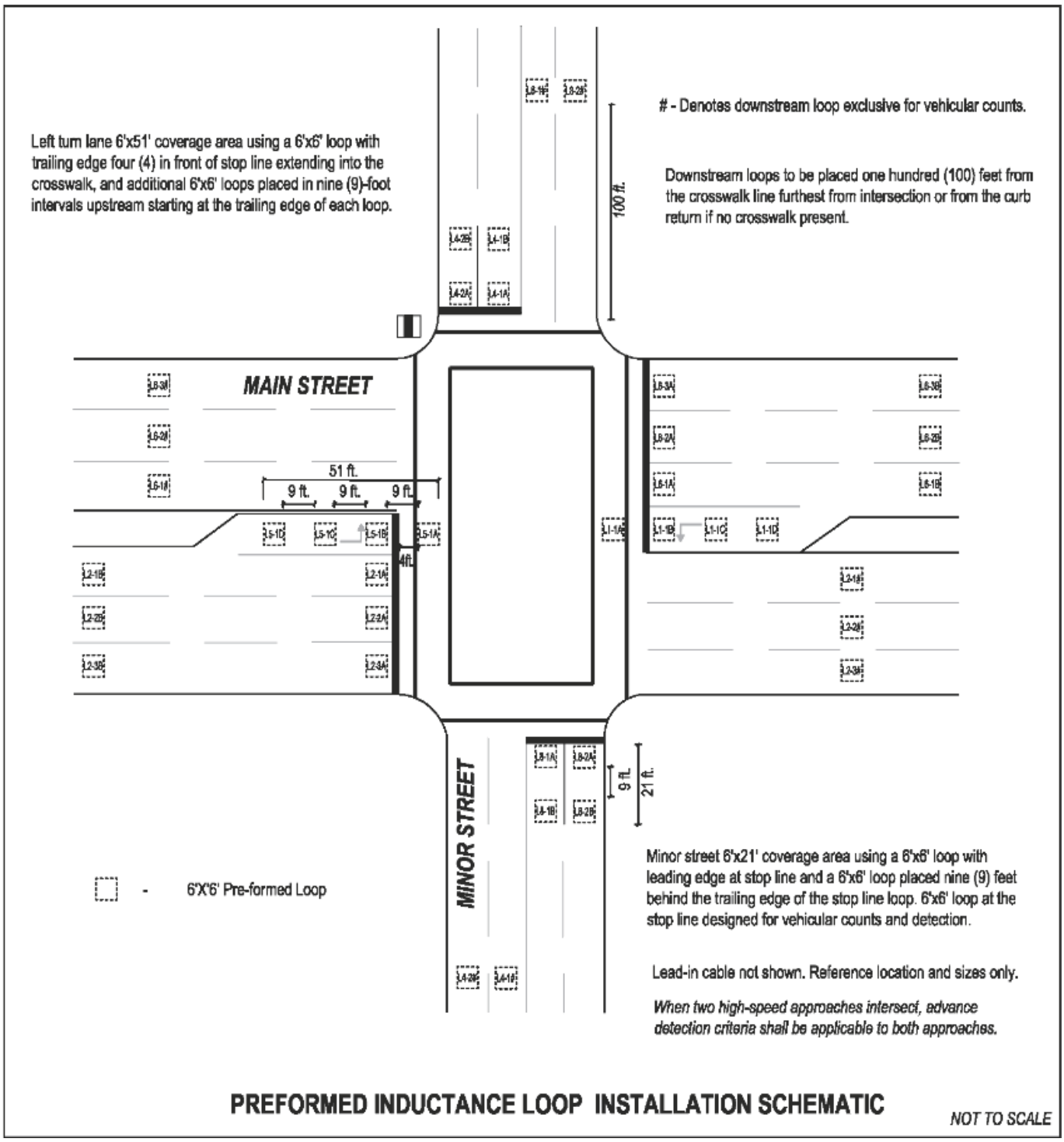


Figure 15.14 - PRE-FORMED INDUCTANCE LOOP INSTALLATION SCHEMATIC

15.2.14.B continued

9. Underground Systems

a. Conduit

(1) Type of Conduit

(a) All conduits shall be as specified in the standard specifications. The Engineer of Record must pay careful attention to where the standard specifications call for certain types of conduits for certain uses as well as when boring and encasing is to be used so the estimates can accurately reflect the field quantities.

(2) Installation

(a) Conduit shall be installed according to the standard specifications. Requirements for depth below finish grade shall be strictly adhered to.

(b) The Engineer of Record, in conjunction with the City, shall determine if conduit crossing certain paved streets should be shown as open cut or bored due to extensive utility problems. The specifications should require an alternate bid option of both methods to allow for unforeseen factors.

(c) In general, conduit runs crossing paved alleys, drives, and streets shall be bored.

(3) Conduit Sizing

(a) Conduits shall be sized according to minimum allowed sizes and allowed conduit fill.

(b) Conduit placed under roadway shall not be less than 3-inches in diameter.

(c) Conduit shall be in ½" incremental sizes, with the exception of the rigid galvanized conduits on span-wire installations as shown in the standard details.

(d) Conduit fill shall not exceed 40% on any one conduit or 26% average for all conduits on any one run.

(e) When crossing the street with interconnects cable, the spare conduit required for a street crossing may be used if adequate capacity is available.

(f) One (1) inch conduit shall only be used to protect the street loop wire from the loop to the adjacent pull box.

15.2.14.B.9.a
continued

Table 15.10 - DIMENSIONS AND MAXIMUM PERCENTAGE OF FILLED AREA OF CONDUIT

Trade Size	Internal Diameter (In)	Cross Sectional Area (Sq In)	26% Fill (Sq In)	40% Fill (Sq In)
1"	1.029	0.83	0.22	0.33
2"	2.047	3.29	0.86	1.32
2-1/2"	2.445	4.70	1.22	1.88
3"	3.042	7.27	1.89	2.91
4"	3.998	12.55	3.26	5.02

Source: National Electrical Code; Chapter 9, Table 4.

(4) Length of Conduit Run

(a) Conduit runs should be limited to 190 feet between pull boxes or structures where the cable is reasonably accessible for pulling. If the conduit run is very straight, with no more than 180 degrees of bend, and contains only a single cable, the run may be extended to 350 feet.

(5) Spare Conduits

(a) Spare conduits shall be installed as shown in the standard details.

(6) Location of Conduit Runs

(a) If new sidewalk is part of the construction, conduit runs may be located under the new sidewalk with the junction boxes being constructed flush with the sidewalk.

(b) If the sidewalk is existing, and a planting strip exists between the curb and the sidewalk, the conduit and junction boxes should be located either in the planting strip or on the other side of the sidewalk (right- of-way permitting), whichever has fewer utility conflicts.

(c) If there is no curb and gutter, the conduit and junction boxes should be located as far as possible back near the right-of-way, but not in drainage areas.

(d) Conduit runs shall be located away from drainage collection points whenever possible.

15.2.14.B.9 continued

b. Pull Boxes

(1) Size: Three sizes are available for use from the standard specifications and details. The Engineer of Record shall select the applicable box based on number and size of conduits to be contained in the box. If the Engineer of Record is concerned that the standard pull box will be too small, they should select the next larger size pull box. The three sizes of standard pull boxes used by the City and their applications are:

(a) Type A - To be used for detector loop pull boxes and hardwire interconnect boxes.

(b) Type B - This is the standard traffic signal pull box but may also be used as a detector loop pull box where multiple loops enter a single pull box.

(c) Type C - This is the standard pull box to be used for most communications applications. It can also be used for traffic signals where a large pull box is required due to multiple large conduits entering the pull box. The most frequent use of this pull box in traffic signal construction is for the pull box adjacent to the controller cabinet.

(2) Location

(a) A pull box is generally required adjacent to each loop, set behind the curb or located on the shoulder to minimize being run over by vehicles.

(b) For low-speed approach and turn lane detectors, a junction box should be located to minimize the length of the detector lead-in cable.

(c) Each quadrant of the intersection shall have a pull box that is within 30 feet of the traffic signal pole. This pull box should service the traffic signal pole, detector lead-in conduit, and the conduit crossing the street. If the intersection is actuated, this pull box can usually be the same box servicing the detectors at the crosswalk, and possibly the left turn detectors if no Median island exists. It should be located to allow the most direct path for the detector lead-in cables as well as the conduit crossing the street.

(d) Pull boxes located on corners should be positioned so that turning vehicles do not track across the pull box.

15.2.14.B.9.b.(2) continued

(e) At span-wire signal installations, item (c) holds true for the pull box location with the exception that you do not have a street-crossing conduit running to this pull box in most cases.

(f) On the quadrant where the controller cabinet is located, there should generally be only the one pull box which services the conduit crossing the street, some detector loops, traffic signal pole, and the controller cabinet. An additional pull box is required in the Type 332 foundation, per the standard detail, and is also required in many cases where the controller cabinet is post-mounted.

(g) For interconnect runs between intersections, pull boxes shall be provided at appropriate intervals.

c. Traffic Signal Communications

(1) See requirements in Section 15.2.15.C.

10. Electrical Cable

a. Detector Lead-In Cable

(1) Detector lead-in cable shall be 14 AWG IMSA 50-2-1984 shielded cable meeting the requirements of the Standard Specifications.

(2) All detector lead-ins cables shall be continuous runs from the splice with the loop to the controller cabinet terminal strip.

(3) Each loop shall be individually brought back to the cabinet on a separate shielded cable.

b. Street Loop Wire

(1) Street loop wire shall be 14 AWG IMSA 51-5-1985 cable.

c. Power Cable

(1) Power shall be 120 volt, single-cycle, 60 Hz AC.

15.2.14.B.10.c continued

(2) All services shall comply with electric company requirements and consist of six (6) #4 AWG XHHW stranded wires and an 8 AWG Solid Bare Ground. The six (6) #4 AWG XHHW wires shall consist of two (2) white, one (1) black, one (1) red and two (2) green wires. A black #4 AWG XHHW stranded wire will be used for the "hot" signal leg and a white #4 AWG XHHW stranded wire will be used for the "common" signal leg. The two green, one red and one spare white #4 AWG XHHW stranded wires shall be reserved as spares or for future luminaire usage.

d. Signal Cable

(1) Traffic Signal Heads

(a) All Traffic Signal Heads shall be serviced with a 7 conductor, 14 AWG IMSA 19-1-1984 cable meeting the requirements of the standard specifications.

(b) IMSA cables are to run un-spliced from the controller cabinet to the terminal strip in the pole or to the signal heads where termination in the pole is unavailable.

(c) Each approach will require that at least two heads be on separate IMSA cables. For additional heads, cables may be run from the first through head with a second cable from the first head to the additional heads.

(d) Each protected/permissive and protected only left turn signal heads shall be serviced by its own cable with no splices to other heads.

(2) Pedestrian Signal Heads and Pushbuttons

(a) Each pedestrian signal head shall be serviced by its own five (5) conductors, 14 AWG IMSA 19-1-1984 cables with no splices to other heads.

(b) Each pedestrian pushbutton shall be serviced by a three (3) conductor, 14 AWG IMSA 19-1-1984 cables.

(3) Installation, Continuity of Cables, and Splices

(a) All cable shall meet the requirements of the standard specifications for installation, continuity, and splices.

(b) No conduit or isolated cable for purposes different than traffic signal service should be attached or placed inside any signal pole.

15.2.14.B.10 continued

e. Spare Cables

(1) Where future pedestrian movements or left turn signal heads are anticipated, spare electric cables shall be routed from the controller cabinet to the pole on which they would be installed. In all cases, sufficient spare cable should be provided to connect to the future location of the equipment.

f. Voltage Drop Calculations

(1) The Engineer of Record shall take into account voltage drop calculations where applicable due to loss over long distances and consider special exceptions to the wire sizes normally used to accommodate losses.

11. Electrical Services

a. Type

(1) The City's standard installation for electrical service will be a service pedestal. All service pedestals and poles shall be as shown in the standard specifications and details and in compliance with the electric company standards.

b. Procedures for Hook-Up to Utility Company

(1) The utility company shall be contacted for the location of the power source and to verify their procedures for hook-up of power during the design process.

(2) Appropriate notes shall be placed on the plan sheet detailing the contractor's responsibilities for hook-up, including sufficient advance notice to allow hook-up when the signal system is ready for testing.

(3) The service center shall be a ground-mounted service pedestal when there is to be a steel pole installation. On wood pole span-wire type installations, a wood pole-mounted service assembly is appropriate. Under no circumstances will the electric company or the City allow a meter assembly to be attached to an electric company pole. The assembly has to be located either on a corner signal support pole or a separately installed service pole, put in by the contractor.

12. Signs

a. General

15.2.14.B.12.a continued

(1) All traffic sign codes in this section are from the current editions of the Standard Highway Sign Designs for Texas and the TMUTCD.

b. Overhead Mounted Street Name Signs

(1) A street name sign (D3, Texas Manual on Uniform Traffic Control Devices) for each approach shall be installed on the mast arm between the pole and the first signal head as shown on the standard detail.

(2) If the two legs of the cross street have different names, two signs with arrows shall be installed in lieu of a single street name sign. The sign on the left shall have an arrow pointing left followed by the street name. To the right of this sign is a sign with the name of the street to the right followed by an arrow pointing right.

(3) Street name signs shall include block numbers per the standard details.

(4) Customized street name signs require separate approval from the City Traffic Engineer. Interested parties should contact the Traffic Hotline at 832-395- 3000 to apply.

c. Overhead Lane Use Control Signs

(1) Refer to Traffic Signal Heads and Lane Use Control Signs in Section 15.2.14.B.6.

d. Median and Island Approaches

(1) Median approaches should have an R4-7 Keep Right sign (symbol only) mounted at the nose of the Median.

(2) Island approaches, with same directional traffic on both sides shall have a W12-1 Double Arrow sign mounted at the nose of the island.

e. Pedestrian Pushbutton Signs: Pedestrian pushbutton signs shall be as shown in the standard details.

(1) An R10-3e shall be used at most locations.

(2) An R10-3b may be used at installations where standard pedestrian indications without the countdown feature are used.

f. No Pedestrian Crossing Signs

15.2.14.B.12.f continued

(1) An R9-3A sign with plaque shall be installed on the mast arm pole at each side of an approach where no pedestrian signals or crosswalks are used.

g. Sheeting on Intersection Control Signs

(1) All traffic control signs that are mounted overhead shall have diamond grade reflective sheeting. This applies to street name signs, one-way signs, turn restriction signs, etc. Any other supplemental intersection control signs that are ground mounted shall use at a minimum high intensity prismatic reflective sheeting.

h. Other Traffic Signs

(1) Other traffic control signs, e.g., one-way, left lane must turn left, no right turn on red, no parking, etc., shall be installed as needed. These signs shall meet the requirements of the TMUTCD.

i. Battery Backup/ Uninterrupted Power Supply (UPS) Systems

(1) General: The City of Houston shall require the installation of Battery Back Up/Uninterrupted Power Supply (UPS) systems on all new or reconstructed traffic signals. The Battery Backup/UPS System will meet the requirements of the Standard Specifications.

15.2.15 INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

15.2.15.A ITS Devices: All existing ITS infrastructure must be shown on design plans and kept operational during construction. All new and redesigned traffic signals shall have new ITS infrastructure included in the design. All ITS devices shall be designed with the following criteria:

1. Ethernet Switch - A new field hardened managed ethernet switch shall be installed at all traffic signals. If fiber cable is the communication method then the switch shall have City of Houston standard fiber cable ports.

2. Bluetooth - A new Bluetooth card and antenna shall be installed at all traffic signals with existing Bluetooth infrastructure. All new Bluetooth equipment shall be compatible with existing Bluetooth travel time monitoring system.

3. Gateway - A new gateway shall be installed at all traffic signals. The gateway shall be the City of Houston current approved equipment.

4. Dynamic Message Sign (DMS) - A new DMS shall be installed on all projects that require the removal or relocation of existing DMS.

15.2.15.A continued

5. Closed Circuit TV (CCTV) - A new CCTV camera shall be installed at all traffic signals with existing cameras.

6. Midblock Count Station - A new midblock count station shall be installed on all projects that require the removal or relocation of existing midblock count stations.

15.2.15.B General Requirements

1. It is the responsibility of the Engineer of Record to field verify all ITS devices and communications infrastructure within the project limits. Also, it is the responsibility of the Engineer of Record to perform all necessary research, coordination and analysis for ITS device and communications deployment.

2. All ITS devices and communications infrastructure shall be:

   a. Compatible with existing infrastructure;

   b. Securely installed and mounted on din rail/shelf if applicable;

   c. Integrated into the relevant central system for control and monitoring;

   d. Kept operational during construction;

   e. Properly configured to current City of Houston Specifications and Standards.

3. Refer to the City of Houston's website for ITS device specifications and standard drawings. Contact Transportation & Drainage Operations / ITS section for compatibility questions with City of Houston ITS and/or communications infrastructure. Contact the Transportation & Drainage Operations / ITS section for questions and/or request at 713.881.3172.

15.2.15.C Traffic Signal Communications

1. Fiber optic cable (FOC) shall be the standard form of traffic signal communications. All City of Houston projects shall include provisions for new FOC. Also, provisions for tying the new FOC into Houston TranStar via existing FOC (or Wireless Broadband (WB) if no FOC path exists to Houston TranStar) shall be included.

2. Fiber Optic Cable (FOC)

   a. All drop cable shall be terminated in a secondary fiber distribution unit (SFDU);

   b. Pre-connectorized pigtails shall be used - all cables to be spliced;

15.2.15.C.2 continued

c. For traffic signals being reconstructed:

(1) Ensure new conduit is deployed between traffic signal cabinet and splice enclosure;

(2) Deploy new drop cable at all locations;

(3) Deploy new communications service box next to cabinet;

(4) Deploy new splice enclosure at all locations.

d. All FOC deployed shall be tied into existing FOC for backhaul to Houston TranStar (if the existing FOC is within close proximity**);

e. All design plans need to have splice details.

3. Cellular - USB air cards are in use at many traffic signals. These shall be maintained during construction. Also, the air card shall be reinstalled with newly deployed ITS infrastructure. In special cases where there is no FOC backhaul to Houston TranStar, air cards shall be deployed as the communications backhaul method.

**Close proximity is if the FOC is within one intersection from any approach of the project intersection (new or rebuild) regardless of distances. Fiber optic cable shall be extended to the newly built or reconstructed intersection.

15.2.15.D ITS Notes to be added to all plans:

1. Any interruption of ITS operations requires City of Houston Transportation & Drainage Operations / ITS section approval at a minimum of one (1) week in advance at 713-881-3172 or 713-881-3000 (Houston TranStar).

2. All existing ITS infrastructure and traffic signal communications shall be kept operational during construction.

3. Any questions or concerns related to deployment of any ITS device call City of Houston Transportation & Drainage Operations / ITS section at 713-881-3172 or 713-881-3000 (Houston TranStar).

4. All ITS devices that are being removed due to construction shall be delivered to Transportation & Drainage Operations. Notify ITS section staff immediately upon removal at 713-859-3362.

5. If a fiber optic cable (FOC) exists within 1500 feet of the intersection being upgraded, the existing FOC should be extended to serve the new or upgraded traffic signal.

END OF CHAPTER

APPENDIX A - TYPICAL SIGNALIZED INTERSECTION DESIGNS

Appendix A presents a typical City of Houston signalized intersection design illustrating the requirements for proposed new traffic signal installation or reconstruction of existing ones. Existing field conditions vary from one location to another; therefore, the Engineer of Record with consultation with the City of Houston's project manager shall determine the appropriate type, size, and location of any applicable traffic component.

Typical positions and arrangements of Traffic Signal Heads and signs related to various configurations are also shown in Appendix A.

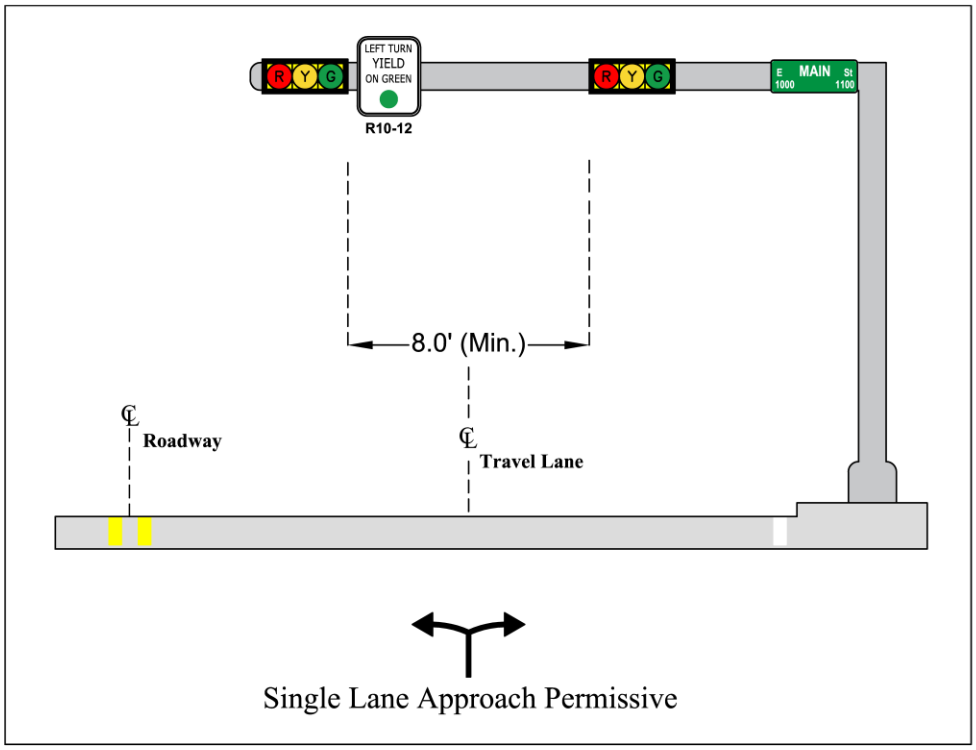


Figure 1

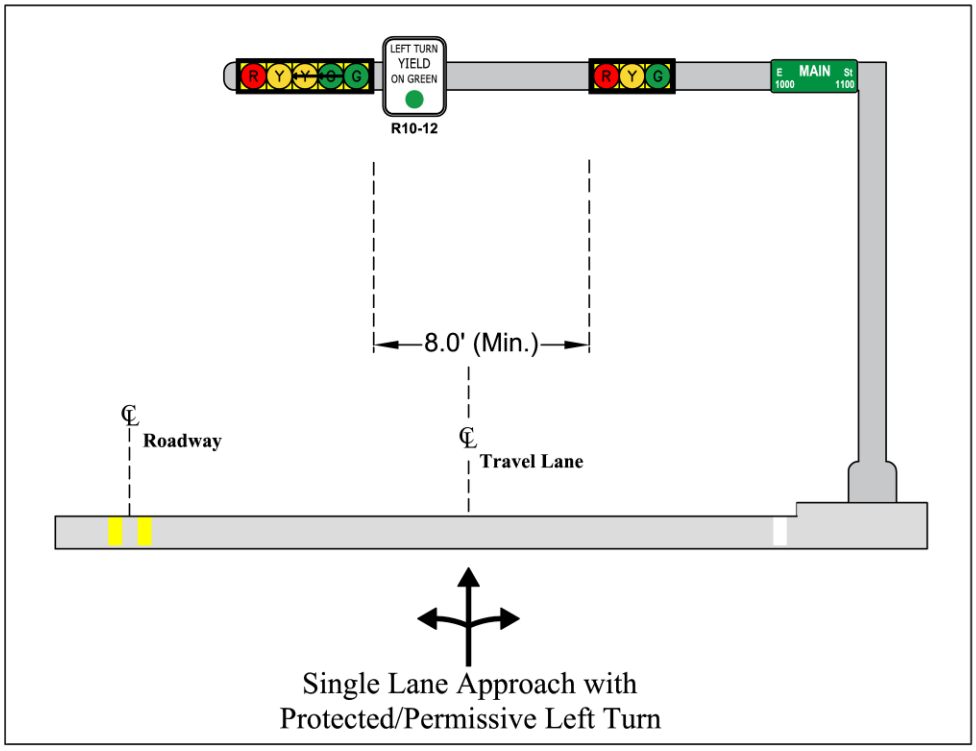


Figure 2

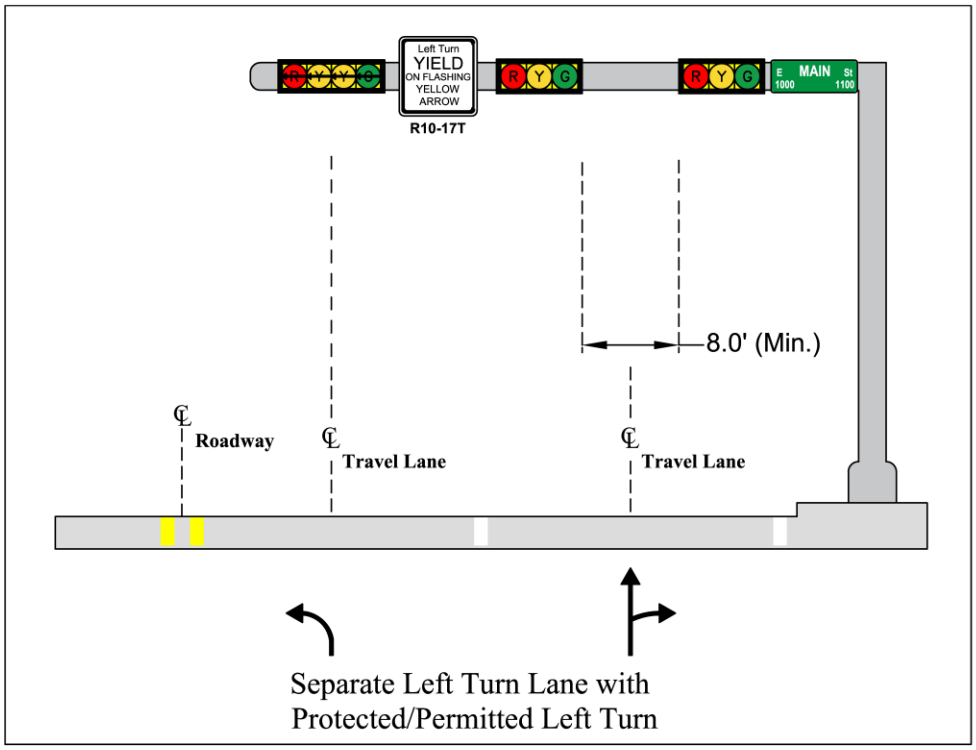


Figure 3

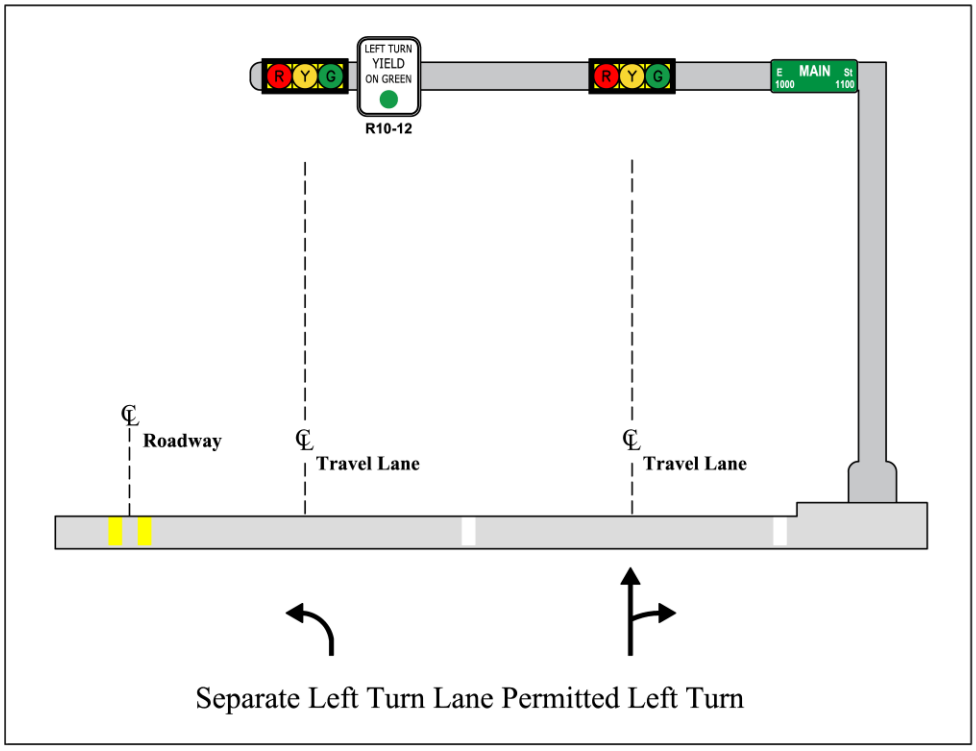


Figure 4

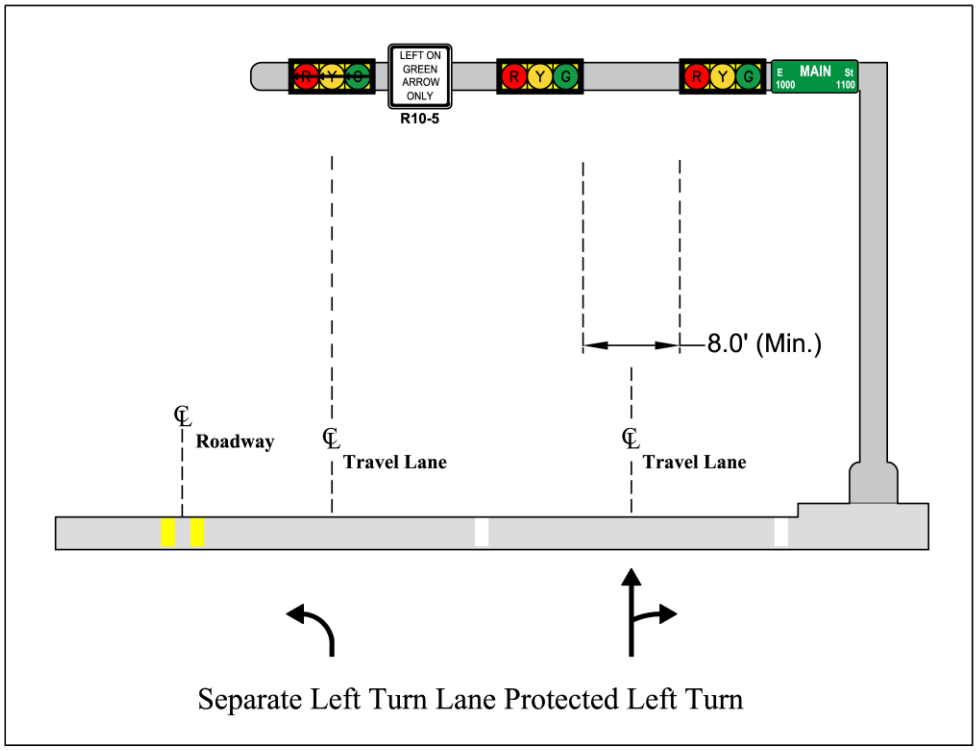


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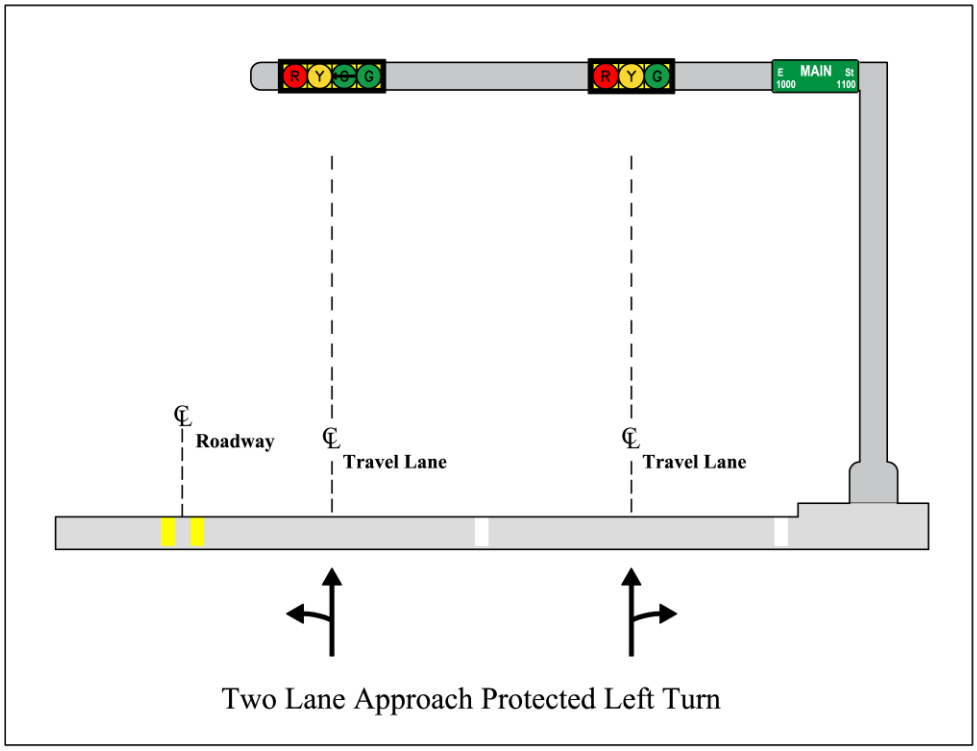
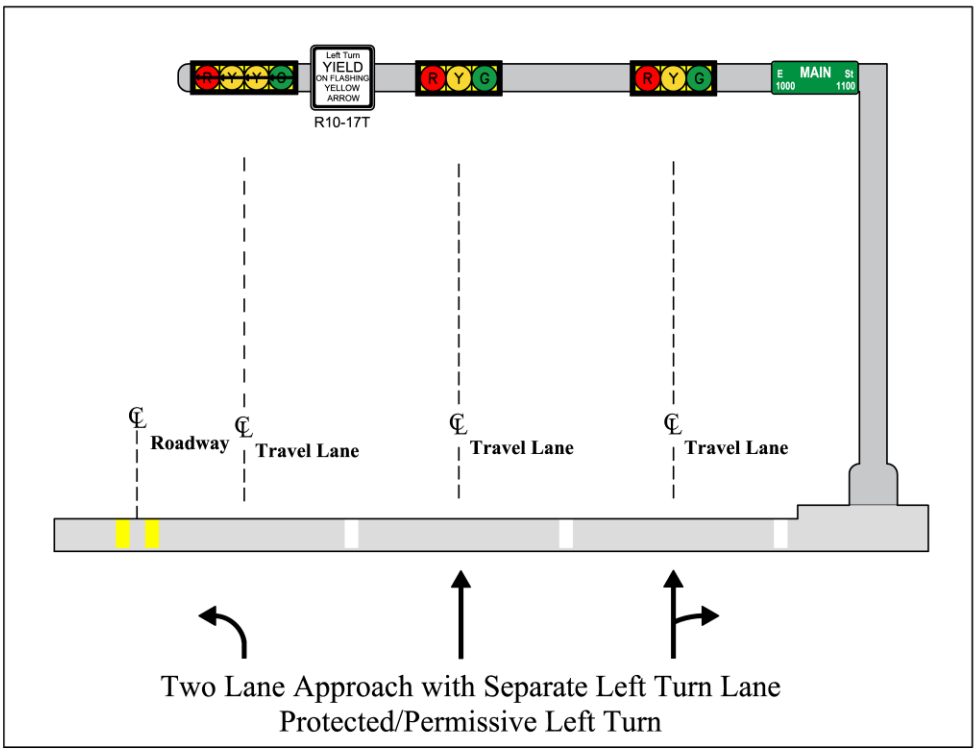
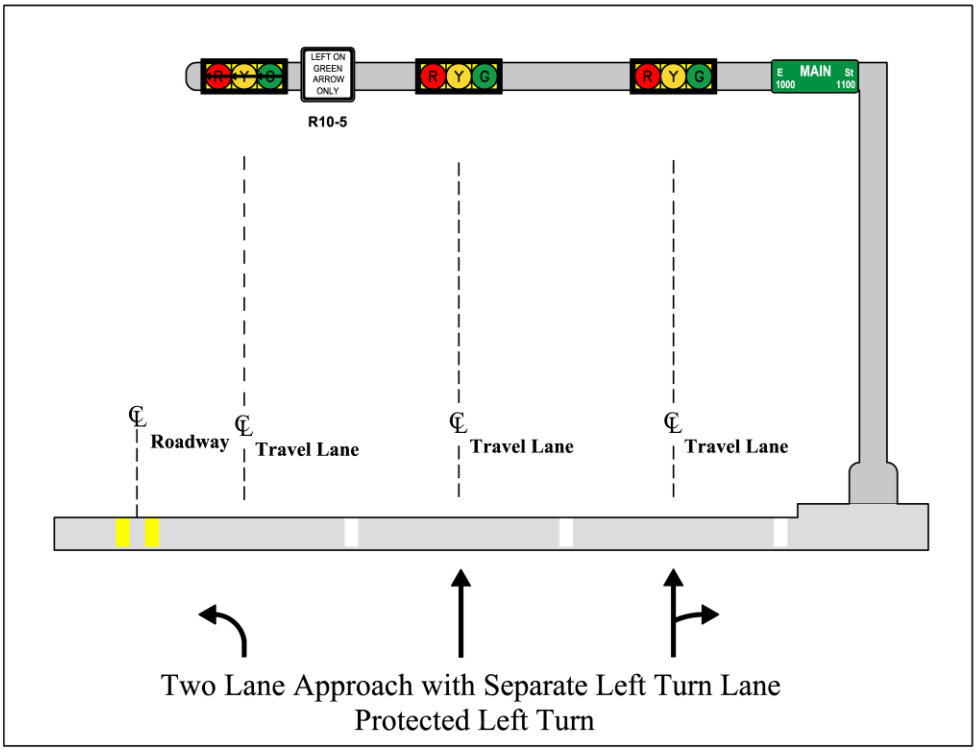


Figure 6



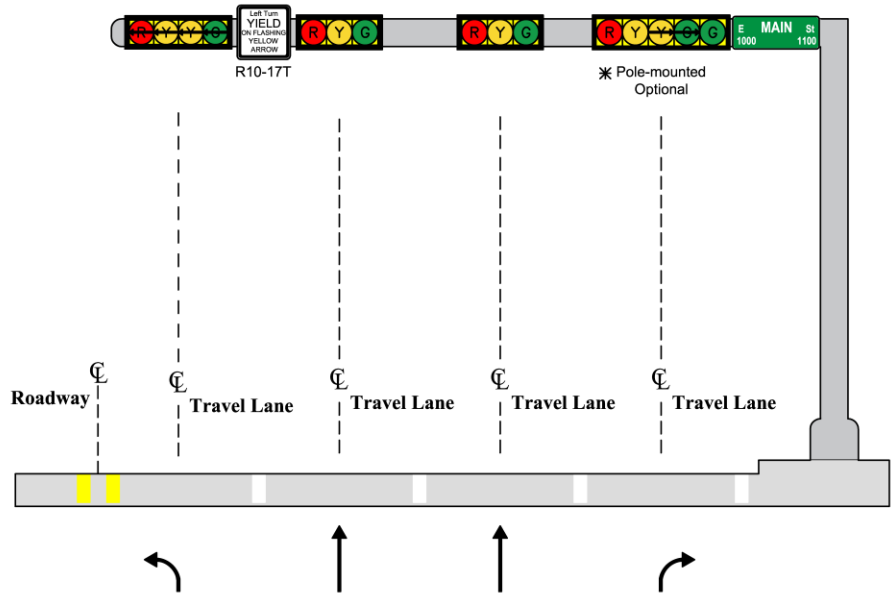
Two Lane Approach with Separate Left Turn Lane
Protected/Permissive Left Turn

Figure 7



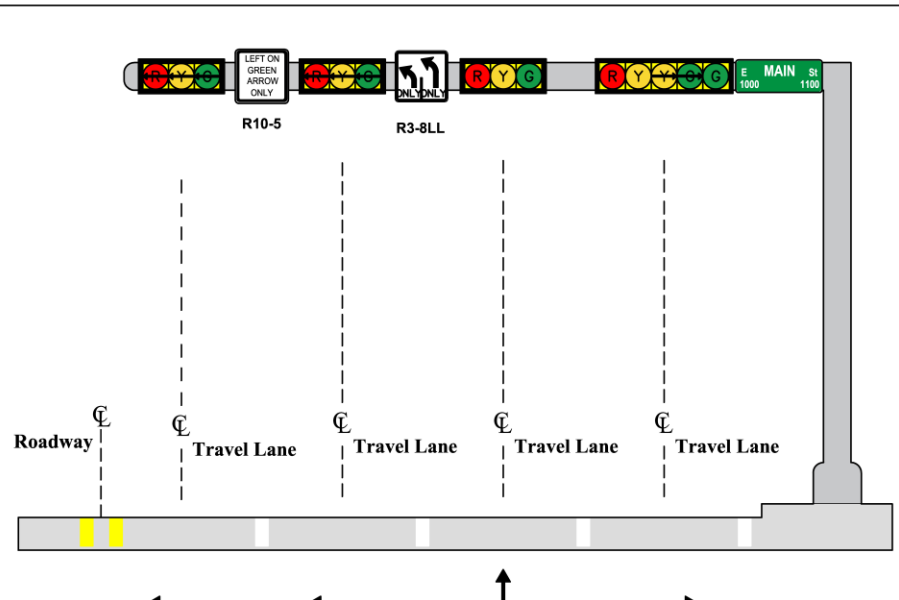
Two Lane Approach with Separate Left Turn Lane
Protected Left Turn

Figure 8



Two Lane Approach with Separate Left and Right Turn Lane
Protected/Permitted Left Turn (Right Turn Overlap)

Figure 9



Two Lane Approach with Separate Dual Left Turn Lanes
Protected Dual Left Turn

Figure 10

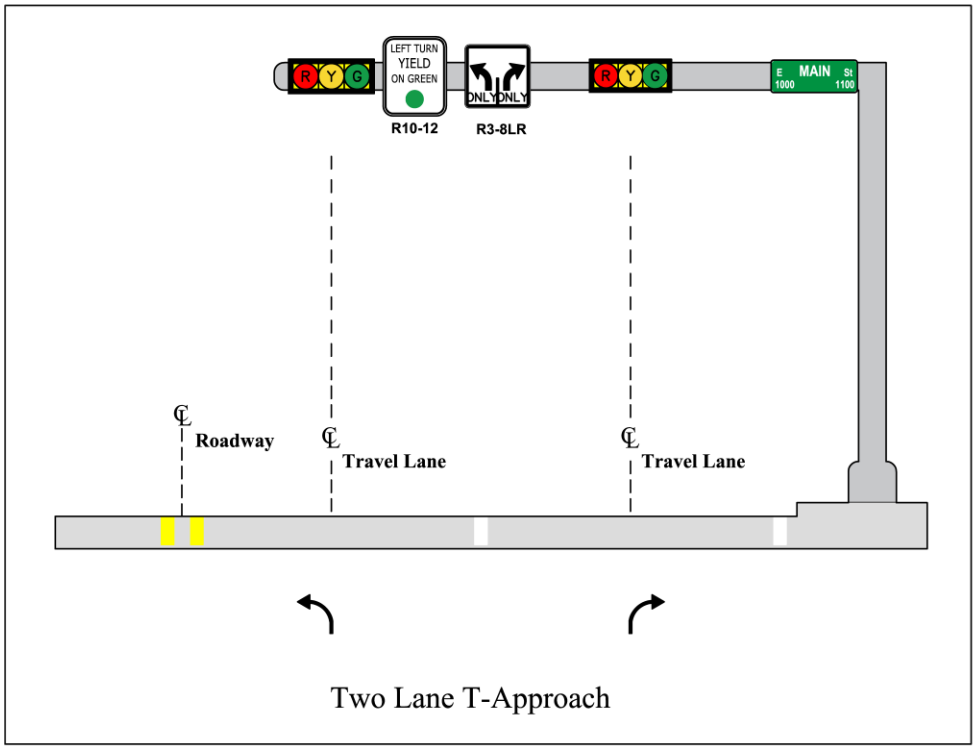
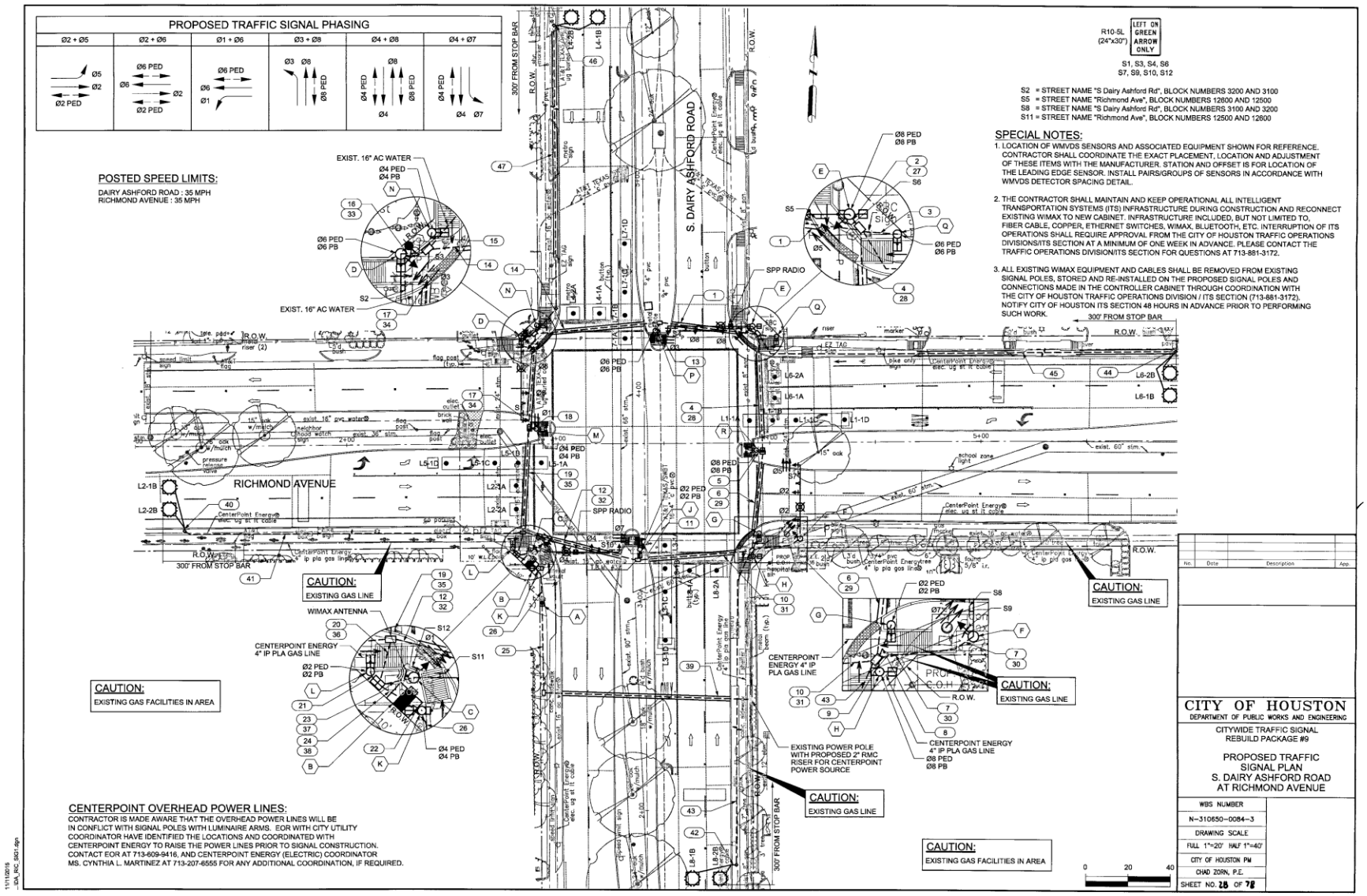
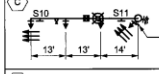
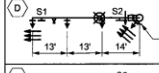
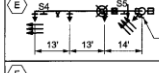
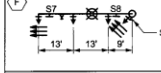
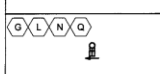
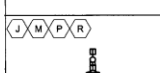
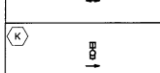

LEFT TURN
YIELD
ON GREEN
R
Y
G
R10-12
ONLY
ONLY
R3-8LR
MAIN St
1000
1100
Roadway
Travel Lane
Travel Lane
Two Lane T-Approach

Figure 11

APPENDIX B - TRAFFIC SIGNAL DESIGN EXHIBITS


PROPOSED TRAFFIC SIGNAL PHASING
Ø2 + Ø5
Ø2 + Ø6
Ø1 + Ø6
Ø3 + Ø8
Ø4 + Ø8
Ø4 + Ø7
POSTED SPEED LIMITS:
DAIRY ASHFORD ROAD : 35 MPH
RICHMOND AVENUE : 35 MPH
S. DAIRY ASHFORD ROAD
RICHMOND AVENUE
SPECIAL NOTES:
1. LOCATION OF WMVDS SENSORS AND ASSOCIATED EQUIPMENT SHOWN FOR REFERENCE. CONTRACTOR SHALL COORDINATE THE EXACT PLACEMENT, LOCATION AND ADJUSTMENT OF THESE ITEMS WITH THE MANUFACTURER. STATION AND OFFSET IS FOR LOCATION OF THE LEADING EDGE SENSOR. INSTALL PAIRS/GROUPS OF SENSORS IN ACCORDANCE WITH WMVDS DETECTOR SPACING DETAIL.
2. THE CONTRACTOR SHALL MAINTAIN AND KEEP OPERATIONAL ALL INTELLIGENT TRANSPORTATION SYSTEMS (ITS) INFRASTRUCTURE DURING CONSTRUCTION AND RECONNECT EXISTING WIMAX TO NEW CABINET. INFRASTRUCTURE INCLUDED, BUT NOT LIMITED TO, FIBER CABLE, COPPER, ETHERNET SWITCHES, WIMAX, BLUETOOTH, ETC. INTERRUPTION OF ITS OPERATIONS SHALL REQUIRE APPROVAL FROM THE CITY OF HOUSTON TRAFFIC OPERATIONS DIVISIONS/ITS SECTION AT A MINIMUM OF ONE WEEK IN ADVANCE. PLEASE CONTACT THE TRAFFIC OPERATIONS DIVISION/ITS SECTION FOR QUESTIONS AT 713-881-3172.
3. ALL EXISTING WIMAX EQUIPMENT AND CABLES SHALL BE REMOVED FROM EXISTING SIGNAL POLES, STORED AND RE-INSTALLED ON THE PROPOSED SIGNAL POLES AND CONNECTIONS MADE IN THE CONTROLLER CABINET THROUGH COORDINATION WITH THE CITY OF HOUSTON TRAFFIC OPERATIONS DIVISION / ITS SECTION (713-881-3172). NOTIFY CITY OF HOUSTON ITS SECTION 48 HOURS IN ADVANCE PRIOR TO PERFORMING SUCH WORK.
S1, S3, S4, S6
S7, S9, S10, S12
S2 = STREET NAME "S Dairy Ashford Rd", BLOCK NUMBERS 3200 AND 3100
S5 = STREET NAME "Richmond Ave", BLOCK NUMBERS 12600 AND 12500
S8 = STREET NAME "S Dairy Ashford Rd", BLOCK NUMBERS 3100 AND 3200
S11 = STREET NAME "Richmond Ave", BLOCK NUMBERS 12500 AND 12600
CAUTION: EXISTING GAS LINE
CAUTION: EXISTING GAS FACILITIES IN AREA
CENTERPOINT OVERHEAD POWER LINES:
CONTRACTOR IS MADE AWARE THAT THE OVERHEAD POWER LINES WILL BE IN CONFLICT WITH SIGNAL POLES WITH LUMINAIRE ARMS. EOR WITH CITY UTILITY COORDINATOR HAVE IDENTIFIED THE LOCATIONS AND COORDINATED WITH CENTERPOINT ENERGY TO RAISE THE POWER LINES PRIOR TO SIGNAL CONSTRUCTION. CONTACT EOR AT 713-609-9416, AND CENTERPOINT ENERGY (ELECTRIC) COORDINATOR MS. CYNTHIA L. MARTINEZ AT 713-207-6555 FOR ANY ADDITIONAL COORDINATION, IF REQUIRED.
CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
CITYWIDE TRAFFIC SIGNAL REBUILD PACKAGE #9
PROPOSED TRAFFIC SIGNAL PLAN
S. DAIRY ASHFORD ROAD AT RICHMOND AVENUE
WBS NUMBER
N-310650-0084-3
DRAWING SCALE
FULL 1"=20' HALF 1"=40'
CITY OF HOUSTON PM
CHAD ZORN, P.E.
SHEET NO. 28 OF 78

PROPOSED TRAFFIC SIGNAL POLE SCHEDULE

POLE NUMBER	POLE TYPE	MAST ARM		SIGNALS		LUMINAIRE TYPE	PED PB TYPE/SIGN	REMARKS	LOCATION	STANDARDS
		SIGNAL	LUMINAIRE	MOUNTING	FACE					
C 	TYPE 2	40'	15'	3 - ASTROBRAC 1 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L	115 WATT LED COBRA HEAD LUMINAIRE W/PHOTOCELL	-	PRE-EMPT SENSOR (DUAL TURRETS) WIMAX ANTENNA SPP RADIO SIGNS: S10 = R10-5L (24"x30") S11 = STREET NAME S12 = R10-5L (24"x30")	BY ENGINEER IN FIELD AT APPROX: POLE C: STA. 2+89, 51' RT RICHMOND AVE. CONST ℄	02893-02 02893-12 02893-03 02893-04A 02893-04B 02893-05 02893-09
D 	TYPE 2	40'	15'	3 - ASTROBRAC 2 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L 1 - CDP	115 WATT LED COBRA HEAD LUMINAIRE	POLARA NAVIGATOR R10-3E (R)	PRE-EMPT SENSOR (DUAL TURRETS) SIGNS: S1 = R10-5L (24"x30") S2 = STREET NAME S3 = R10-5L (24"x30")	BY ENGINEER IN FIELD AT APPROX: POLE D: STA. 2+83, 52' LT RICHMOND AVE. CONST ℄	02893-02 02893-12 02893-03 02893-04A 02893-04B 02893-05 02893-09
E 	TYPE 2	40'	15'	3 - ASTROBRAC 2 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L 1 - CDP	115 WATT LED COBRA HEAD LUMINAIRE	POLARA NAVIGATOR R10-3E (R)	PRE-EMPT SENSOR SPP RADIO (DUAL TURRETS) SIGNS: S4 = R10-5L (24"x30") S5 = STREET NAME S6 = R10-5L (24"x30")	BY ENGINEER IN FIELD AT APPROX: POLE E: STA. 3+92, 56' LT RICHMOND AVE. CONST ℄	02893-02 02893-12 02893-03 02893-04A 02893-04B 02893-05 02893-09
F 	TYPE 1	35'	15'	3 - ASTROBRAC 1 - SIDE OF POLE	1 - H3L 2 - H3 1 - V3L	115 WATT LED COBRA HEAD LUMINAIRE	-	PRE-EMPT SENSOR (DUAL TURRETS) SIGNS: S7 = R10-5L (24"x30") S8 = STREET NAME S9 = R10-5L (24"x30")	BY ENGINEER IN FIELD AT APPROX: POLE F: STA. 4+14, 46' RT RICHMOND AVE. CONST ℄	02893-02 02893-12 02893-03 02893-04A 02893-04B 02893-05 02893-09
H 	PED POLE 15'	-	-	1 - SIDE OF POLE	1 - CDP	-	POLARA NAVIGATOR R10-3E (L)	-	BY ENGINEER IN FIELD AT APPROX: POLE H: STA. 3+92, 54' RT RICHMOND AVE. CONST ℄	02893-02 02893-03 02893-06 02893-07
G L N Q 	PED POLE 15'	-	-	1 - SIDE OF POLE	1 - CDP	-	POLARA NAVIGATOR R10-3E (L)	-	BY ENGINEER IN FIELD AT APPROX: POLE G: STA. 3+95, 43' RT POLE L: STA. 2+78, 49' RT POLE N: STA. 2+90, 57' LT POLE Q: STA. 4+03, 51' LT RICHMOND AVE. CONST ℄	02893-02 02893-03 02893-06 02893-07
J M P R 	PED POLE 15'	-	-	2 - SIDE OF POLE	2 - CDP	-	POLARA NAVIGATOR R10-3E L (R)	-	BY ENGINEER IN FIELD AT APPROX: POLE J: STA. 3+38, 50' RT POLE M: STA. 2+89, 07' LT POLE P: STA. 3+46, 54' LT POLE R: STA. 4+94, 03' RT RICHMOND AVE. CONST ℄	02893-02 02893-03 02893-06 02893-07
K 	PED POLE 15'	-	-	1 - SIDE OF POLE	1 - CDP	-	POLARA NAVIGATOR R10-3E (R)	-	BY ENGINEER IN FIELD AT APPROX: POLE K: STA. 2+90, 59' RT RICHMOND AVE. CONST ℄	02893-02 02893-03 02893-06 02893-07

TRAFFIC SIGNAL CONTROLLER

CABINET	TYPE	CONTROLLER	AUX. CONTROL	REMARKS	LOCATION	STANDARDS
A 	METERED PEDESTAL SERVICE UL TYPE 3R	METERED PEDESTAL SERVICE WITH ONE 30 AMP AND ONE 60 AMP BREAKER	-	PROVIDE METER SOCKET WINDOW 4" H X 6" W	BY ENGINEER IN FIELD AT APPROX: STA. 2+92, 75' LT (CENTER OF CABINET) RICHMOND AVE. CONST ℄	02893-14
B 	TYPE 340 ITS	2070L WITH GPS SERIAL COMMUNICATIONS MODULE	-	STANDARD SPECIFICATION 16730 & 16731 UNINTERRUPTIBLE POWER SUPPLY - STANDARD SPECIFICATION 16732 FIELD HARDENED ETHERNET SWITCH (SIX COPPER PORTS ONLY) - STANDARD SPECIFICATION 16733 WIMAX - STANDARD SPECIFICATION 16734 WIRELESS MAGNETOMETER VEHICLE DETECTION SYSTEM - STANDARD SPECIFICATION 16751 GPS SERIAL COMMUNICATIONS MODULE- STANDARD SPECIFICATION 16785	BY ENGINEER IN FIELD AT APPROX: STA. 2+86, 57' RT (CENTER OF CABINET) RICHMOND AVE. CONST ℄	02893-10C

NOTES:
1. ALL SIGNAL HEADS WILL BE 12" WITH LOUVERED BACK PLATES AND YELLOW HOUSING
2. POLES G, K, L, M AND Q WILL HAVE CONCRETE FOUNDATION
3. POLES H, J, N, P AND R WILL HAVE SCREW-IN ANCHOR FOUNDATION

11/01/2015
...IDA_RC_3002.dgn

STOP LINE AND WMVDS SENSOR LOCATIONS

ITEM BY DIRECTION	STATION S. DAIRY ASHFORD RD.	OFFSET
SOUTHBOUND		
STOP LINE @ GUTTER	4+32	39' LT
STOP LINE @ CENTERLINE	4+32	01' LT
SOUTHBOUND (THRU LANES)		
PHASE 4 CALL SENSOR		
L4-1A SENSOR	4+36	CENTERED IN LANE
L4-2A SENSOR	4+36	CENTERED IN LANE
PHASE 4 PULSE LOOPS		
L4-1B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
L4-2B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
SOUTHBOUND (LEFT TURN LANE)		
PHASE 7 PRESENCE SENSOR		
L7-1A SENSOR	4+24	CENTERED IN LANE
L7-1B SENSOR	4+35	CENTERED IN LANE
L7-1C SENSOR	4+46	CENTERED IN LANE
L7-1D SENSOR	4+69	CENTERED IN LANE
NORTHBOUND		
STOP LINE @ GUTTER	3+18	39' RT
STOP LINE @ CENTERLINE	3+18	03' RT
NORTHBOUND (THRU LANES)		
PHASE 8 CALL SENSOR		
L8-1A SENSOR	3+14	CENTERED IN LANE
L8-2A SENSOR	3+14	CENTERED IN LANE
PHASE 8 PULSE LOOPS		
L8-1B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
L8-2B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
NORTHBOUND (LEFT TURN LANE)		
PHASE 3 PRESENCE SENSOR		
L3-1A SENSOR	3+26	CENTERED IN LANE
L3-1B SENSOR	3+15	CENTERED IN LANE
L3-1C SENSOR	3+08	CENTERED IN LANE
L3-1D SENSOR	2+81	CENTERED IN LANE

ITEM BY DIRECTION	STATION RICHMOND AVE.	OFFSET
EASTBOUND		
STOP LINE @ GUTTER	2+84	39' RT
STOP LINE @ CENTERLINE	2+84	01' RT
EASTBOUND (THRU LANES)		
PHASE 2 CALL SENSOR		
L2-1A SENSOR	2+80	CENTERED IN LANE
L2-2A SENSOR	2+80	CENTERED IN LANE
PHASE 2 PULSE LOOPS		
L2-1B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
L2-2B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
EASTBOUND (LEFT TURN LANE)		
PHASE 5 PRESENCE SENSOR		
L5-1A SENSOR	2+92	CENTERED IN LANE
L5-1B SENSOR	2+81	CENTERED IN LANE
L5-1C SENSOR	2+76	CENTERED IN LANE
L5-1D SENSOR	2+47	CENTERED IN LANE
WESTBOUND		
STOP LINE @ GUTTER	3+98	40' LT
STOP LINE @ CENTERLINE	3+98	05' LT
WESTBOUND (THRU LANES)		
PHASE 6 CALL SENSOR		
L6-1A SENSOR	4+02	CENTERED IN LANE
L6-2A SENSOR	4+02	CENTERED IN LANE
PHASE 6 PULSE LOOPS		
L6-1B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
L6-2B LEADING EDGE (6'X6')	300' FROM STOP BAR	CENTERED IN LANE
WESTBOUND (LEFT TURN LANE)		
PHASE 1 PRESENCE SENSOR		
L1-1A SENSOR	3+90	CENTERED IN LANE
L1-1B SENSOR	4+02	CENTERED IN LANE
L1-1C SENSOR	4+12	CENTERED IN LANE
L1-1D SENSOR	4+35	CENTERED IN LANE

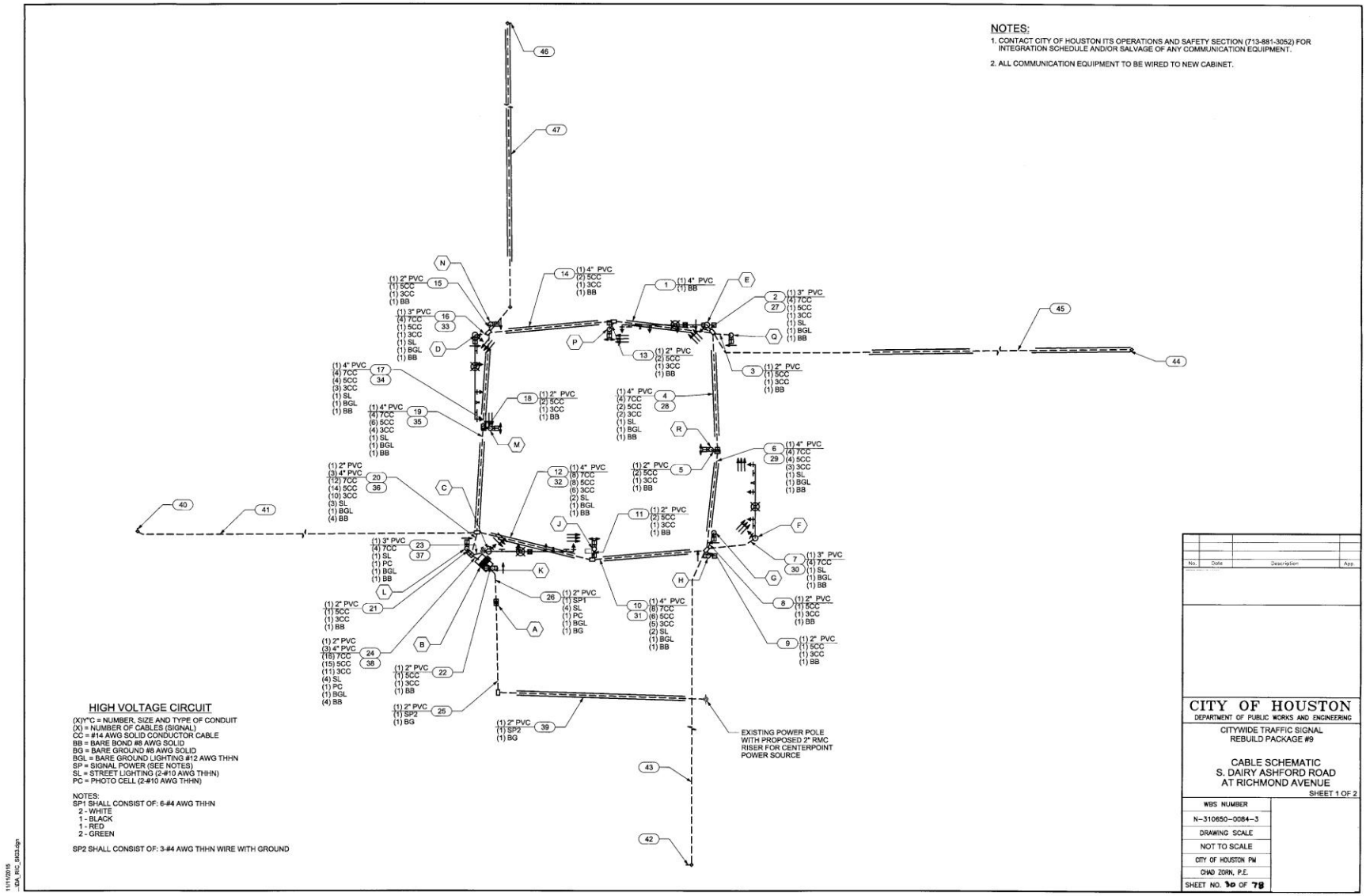
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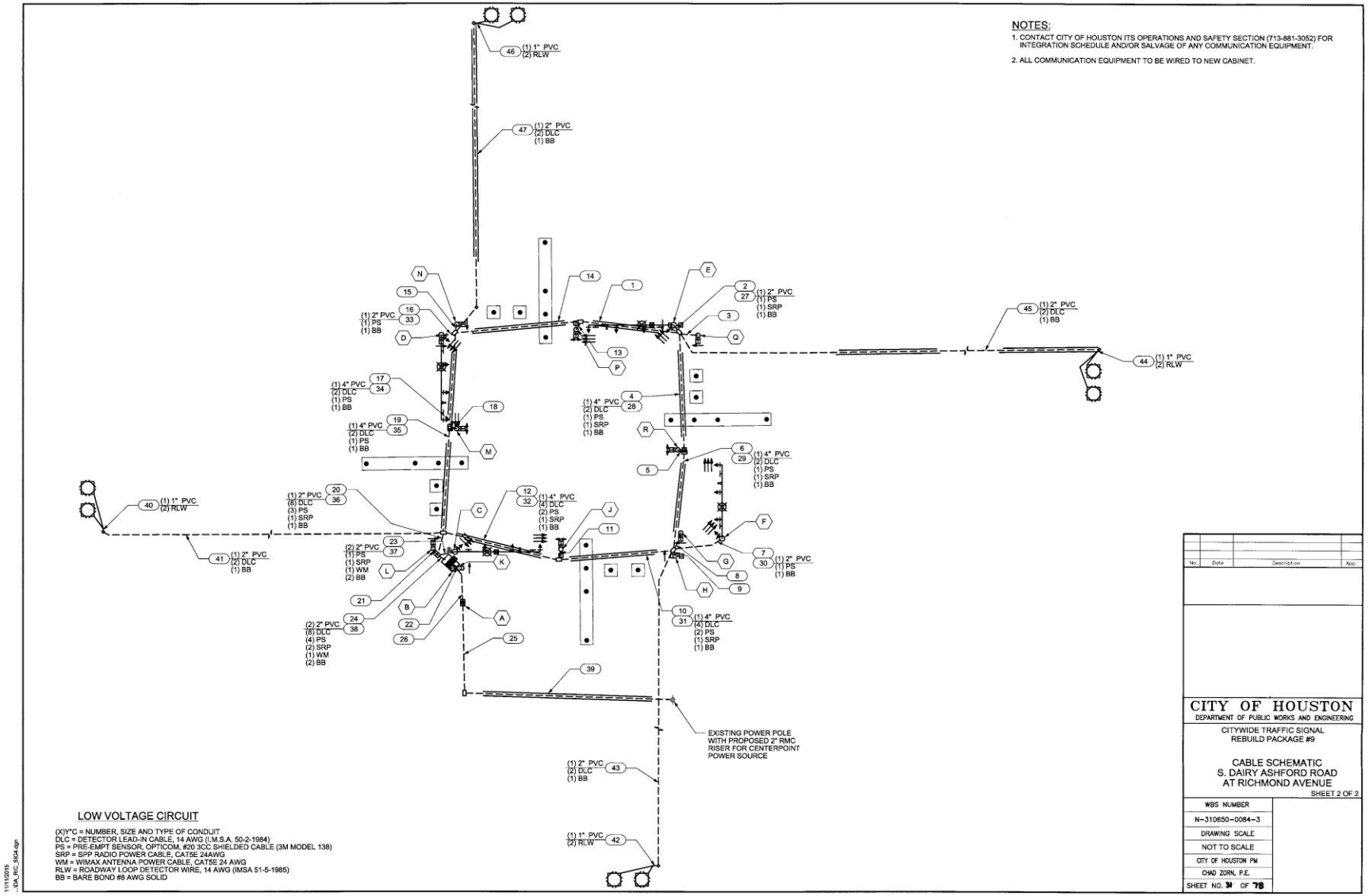
CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING

CITYWIDE TRAFFIC SIGNAL REBUILD PACKAGE #9

TRAFFIC SIGNAL POLE SCHEDULE
S. DAIRY ASHFORD ROAD AT RICHMOND AVENUE

WBS NUMBER	
N-310650-0084-3	
DRAWING SCALE	
NOT TO SCALE	
CITY OF HOUSTON PM	
CHAD ZORN, P.E.	
SHEET NO. 24 OF 78	


NOTES:
1. CONTACT CITY OF HOUSTON ITS OPERATIONS AND SAFETY SECTION (713-881-3052) FOR INTEGRATION SCHEDULE AND/OR SALVAGE OF ANY COMMUNICATION EQUIPMENT.
2. ALL COMMUNICATION EQUIPMENT TO BE WIRED TO NEW CABINET.
HIGH VOLTAGE CIRCUIT
(X)Y"C = NUMBER, SIZE AND TYPE OF CONDUIT
(X) = NUMBER OF CABLES (SIGNAL)
CC = #14 AWG SOLID CONDUCTOR CABLE
BB = BARE BOND #8 AWG SOLID
BG = BARE GROUND #8 AWG SOLID
BGL = BARE GROUND LIGHTING #12 AWG THHN
SP = SIGNAL POWER (SEE NOTES)
SL = STREET LIGHTING (2-#10 AWG THHN)
PC = PHOTO CELL (2-#10 AWG THHN)
NOTES:
SP1 SHALL CONSIST OF: 6-#4 AWG THHN
2 - WHITE
1 - BLACK
1 - RED
2 - GREEN
SP2 SHALL CONSIST OF: 3-#4 AWG THHN WIRE WITH GROUND
EXISTING POWER POLE WITH PROPOSED 2" RMC RISER FOR CENTERPOINT POWER SOURCE
CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
CITYWIDE TRAFFIC SIGNAL REBUILD PACKAGE #9
CABLE SCHEMATIC
S. DAIRY ASHFORD ROAD AT RICHMOND AVENUE
SHEET 1 OF 2
WBS NUMBER
N-310650-0084-3
DRAWING SCALE
NOT TO SCALE
CITY OF HOUSTON PM
CHAD ZORN, P.E.
SHEET NO. 30 OF 78


NOTES:
1. CONTACT CITY OF HOUSTON ITS OPERATIONS AND SAFETY SECTION (713-881-3052) FOR INTEGRATION SCHEDULE AND/OR SALVAGE OF ANY COMMUNICATION EQUIPMENT.
2. ALL COMMUNICATION EQUIPMENT TO BE WIRED TO NEW CABINET.
LOW VOLTAGE CIRCUIT
(X)Y*C = NUMBER, SIZE AND TYPE OF CONDUIT
DLC = DETECTOR LEAD-IN CABLE, 14 AWG (I.M.S.A. 50-2-1984)
PS = PRE-EMPT SENSOR, OPTICOM, #20 3CC SHIELDED CABLE (3M MODEL 138)
SRP = SPP RADIO POWER CABLE, CAT5E 24AWG
WM = WIMAX ANTENNA POWER CABLE, CAT5E 24 AWG
RLW = ROADWAY LOOP DETECTOR WIRE, 14 AWG (IMSA 51-5-1985)
BB = BARE BOND #8 AWG SOLID
EXISTING POWER POLE WITH PROPOSED 2" RMC RISER FOR CENTERPOINT POWER SOURCE
CITY OF HOUSTON
DEPARTMENT OF PUBLIC WORKS AND ENGINEERING
CITYWIDE TRAFFIC SIGNAL REBUILD PACKAGE #9
CABLE SCHEMATIC
S. DAIRY ASHFORD ROAD AT RICHMOND AVENUE
SHEET 2 OF 2
WBS NUMBER
N-310650-0084-3
DRAWING SCALE
NOT TO SCALE
CITY OF HOUSTON PM
CHAD ZORN, P.E.
SHEET NO. 31 OF 78

City of Houston

Design Manual

Chapter 16

COMMUNICATION FACILITY REQUIREMENTS

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Communication Facility Requirements

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Chapter 16

COMMUNICATION FACILITY REQUIREMENTS

SECTION 1 - COMMUNICATION FACILITY REQUIREMENTS OVERVIEW

16.1.01 CHAPTER INCLUDES

16.1.01.A Criteria for Communication Facilities within the Public Right-of-Way including:

1. Wireless or radio, cable and wireline facilities, ground equipment, and pole.

16.1.02 REFERENCES

16.1.02.A AASHTO, Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, latest edition.

1. LRFD Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals
2. Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals

16.1.02.B AASHTO, A Policy on Geometric Design of Highways and Streets ("The Green Book"), latest edition.

16.1.02.C AASHTO, Roadside Design Guide, latest edition.

16.1.02.D City of Houston Code of Ordinances, Chapter 40, Article XXI - Facilities in the Public Right-of-Way.

16.1.02.E City of Houston Construction Code Amendments, latest adopted amendments.

16.1.02.F International Building Code (IBC), edition adopted by the City of Houston.

16.1.02.G Structural Standard for Antenna Supporting Structures, Antennas and Small Wind Turbine Support Structures (TIA-222), editions identified in the International Building Code (IBC).

16.1.02.H Texas Local Government Code 283 – Management of Public Right-of-Way Used by Telecommunications Provider in Municipality.

16.1.02.I Texas Local Government Code 284 – Deployment of Network Nodes in Public Right-of-Way.

16.1.02.J Texas Utilities Code, Chapter 251 - Underground Facility Damage Prevention and Safety.

16.1.02.K Refer to list of references in Chapter 1, General Requirements.

16.1.03 DEFINITIONS

16.1.03.A The following terms are as defined in Chapter 284 of the Texas Local Government Code:

1. Antenna
2. Collocate and Collocation Design District
3. Historic District
4. Micro Network Node
5. Municipal Park
6. Network Node
7. Network Provider
8. Node Support Pole
9. Permit
10. Public Right-of-Way
11. Service Pole
12. Utility Pole

16.1.03.B Communication Facility – Devices and equipment for wired and radio communications, including transport fiber or other transmission lines, above ground cabinets, radios, Antennas, Network Nodes, backup batteries, transmitters, wires, and support ports.

16.1.03.C Drawings – Plans, profiles, details, and other graphic sheets to be used in a construction contract which define character and scope of the project.

16.1.03.D Professional Engineer - An engineer currently licensed and in good standing with the Texas Board of Professional Engineers and Land Surveyors (TBPELS).

16.1.03.E Repeater Device – An efficient Antenna system, that receives weak signals and widens transmission coverage.

16.1.03.F Repeater Poles – Poles on which Repeater Devices are installed.

16.1.03.G Residential Areas – Single-family, multifamily, town home, duplex, apartment, any other residential configurations, and undeveloped land that is platted for residential use.

16.1.03.H Street Right-of-Way – The entire width between the boundary lines of every way which is held by the City, county, state or otherwise by the public in fee or dedication when any part thereof is open to the use of the public for purposes of vehicular travel.

SECTION 2 - COMMUNICATION FACILITY DESIGN REQUIREMENTS

16.2.01 DESIGN REQUIREMENTS

16.2.01.A General Requirements

1. Communication Facilities shall comply with Texas Local Government Code 283 – Management of Public Right-of-Way Used by Telecommunications Provider in Municipality, Texas Local Government Code 284 – Deployment of Network Nodes in Public Right-of-Way, Article XXI, Chapter 40, – Facilities in the Public Right-of-Way of the City of Houston Code of Ordinances and this Infrastructure Design Manual. The most stringent requirements shall govern.

2. Facilities must comply with all applicable state and federal requirements, including the Americans with Disabilities Act and must not create a visibility or accessibility issue as finally configured.

3. Communication Facility Markings:

   a. All Communication Facilities must have a permanent identification marking that provides the following owner information:

      (1) Name (Pole owner or ground facility owner)

      (2) Address

      (3) Phone Number

   b. Permanent identification marking text must be legible at eye level for all poles.

4. Prior to submitting Drawings to the City of Houston, the Network Provider shall coordinate with the Historic or Design District and submit the evidence of coordination with the Drawings to the Houston Permitting Center located on the 2nd floor of 1002 Washington Ave, Houston TX 77002.

5. The maximum dimensions measured for the Antenna components of the installation shall meet the Texas Local Government Code, Chapter 284.

6. Proposed equipment (i.e., power supply and cabinets) associated with the Communication Facilities can be placed in line with existing poles if the proposed node is Collocated on the existing pole. The edge of the equipment shall not be any closer to the curb than the associated pole.

7. If the proposed pole(s) or equipment installation cannot meet required clearances from sidewalk, public utilities, and other public infrastructure, then the proposed pole or equipment must be relocated to a location where the clearances are met. Special circumstances need to be reviewed and approved by the Office of the City Engineer.

16.2.01.A continued

8. The use of City infrastructure is prohibited without the approval of the City Engineer and the City Bridge Engineer/Traffic Engineer or the Director of the operations unit responsible for its maintenance. The standard approval is dependent on the type of City infrastructure.

    a. Upon request from the City, approved non-traffic related devices mounted to City infrastructure that interfere with any existing traffic signal communications or ITS equipment shall be immediately removed at the cost of the provider.

9. At or above ground Communication Facilities and related equipment shall be placed in accordance with the following requirements:

    a. Within two (2) feet inside of the Street Right-of-Way line.

        (1) Curb and Gutter Roadway Section

            (a) Provide a minimum clearance of two (2) feet between the back of curb and outer surface of Communication Facilities and poles.

        (2) Roadways with Ditch

            (a) No at or above ground Communication Facilities and poles are allowed within the ditch or between the ditch and the edge of pavement.

    b. Poles and cabinets shall not be within ten (10) feet of a driveway.

    c. Poles and cabinets shall not be within fifty (50) feet (measured from the Street Right-of-Way line) of a local street intersection and one hundred (100) feet (measured from the Street Right-of-Way line) of a major street intersection.

    d. Network Provider shall not install Network Nodes or Repeater Devices within two hundred and fifty (250) foot radius from a traffic signal pole or ITS equipment. Any Network Node or Repeater Device within two hundred and fifty (250) feet will require a zero (0) interference study and must be approved by the City Engineer through a variance request.

    e. A clearance of one (1) foot from the edge of the sidewalk is required for Communication Facilities above ground.

    f. Installing above ground Communication Facilities on Main Street in the downtown urban Design Districts is prohibited.

    g. Preferred locations for poles are industrial areas, highway areas and retail/commercial areas that are not adjacent to Municipal Parks, Residential Areas, and Historic or Design Districts.

16.201.A.9 continued

h. In Residential Areas, poles and cabinets shall be located where the shared property line between two residential parcels intersects the Public Right-of-Way.

i. In non-Residential Areas, poles and cabinets shall be located between tenant spaces, storefront bays, or adjoining properties where their shared property lines intersect the Public Right-of-Way.

j. In no instance shall any pole or cabinet be located in front of a building entrance or exit.

k. No components may obstruct any existing signage, signals or ITS devices.

l. All components must be positioned as to assure that all intersection and driveway visibility requirements are maintained.

10. Requirements for Communication Device Installation on Poles:

a. No penetration of the pole is allowed.

16.2.01.B Network Nodes:

1. Network Node attachments to all poles shall be installed at least twelve (12) feet above the ground. If a Network Node attachment is projecting toward the street, the attachment shall be installed no less than eighteen and half (18.5) feet above the ground to the bottom of the node, for the safety and protection of the public and vehicular traffic.

2. The City encourages Collocation of more than one Network Node on any one pole.

16.2.01.C Network Poles:

1. Node Support Poles and Repeater Poles:

a. Wooden poles are prohibited in the clear zone as defined in AASHTO Green Book.

b. All new poles and substitution poles located in the clear zone are required to be breakaway poles. All breakaway poles shall weigh less than 992 lbs. as described in Section 12 “Breakaway Supports” of AASHTO’s Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signal.

c. The style and color of proposed Node Support Poles and Repeater Poles shall match existing Node Support Poles and Repeater Poles in order to blend into the surrounding environment and be visually unobtrusive. The proximity of the existing pole from the proposed pole will be established by the following criteria:

16.2.01.C.1.c continued

(1) Within Design Districts and Historic Districts:

(a) Node Support Poles and Repeater Poles must meet Design District or Historic District requirements.

(2) Outside Design Districts and Historic Districts:

(a) Proposed Node Support Poles and Repeater Poles shall be generally consistent with color and height of existing Node Support Poles and Repeater Poles within a 1,000 feet radius and shall be subject to City approval.

(b) When different types of existing poles are in the 1,000 ft radius area, type of new proposed poles within that area will be subject to City approval.

d. All attachments for the Network Node shall also match the color of the Node Support Pole or Repeater Pole.

e. It is preferred that Node Support Poles and Repeater Poles shall be installed along arterials or residential collectors.

f. For any Public Right-of-Way that is fifty (50) feet wide or less:

(1) No new Node Support Poles and Repeater Poles shall be installed on either side of the Public Right-of-Way that includes a street that is next to or in Residential Areas or undeveloped land that is platted for residential use.

g. For any Public Right-Of-Way that is more than fifty (50) feet wide:

(1) Node Support Poles and Repeater Poles can be installed in Residential Areas but must be installed at the lot line if both sides of the street are residential.

(2) If one side of the street is commercial, then the Node Support Poles or Repeater Poles shall be located on the commercial side of the street.

h. Node Support Poles and Repeater Poles shall be set back a minimum of fifteen (15) feet from any pedestrian ramp.

i. Node Support Poles, Repeater Poles and accessory equipment shall be located at least ten (10) feet from a driveway.

j. No Node Support Poles or Repeater Pole(s) are to be installed in front of the front door or entry way of any single-family, multi-family, town home, duplex, apartment, or any other residential configuration, either on the same side of the street or directly across from the structure’s door or entry way.

16.2.01.C.1 continued

k. Existing poles that are determined to be structurally inadequate, will be replaced with a new pole or reinforced by the provider at the cost of the provider.

(1) If pole reinforcement is necessary, Network Provider shall provide Drawings for the proposed alteration to the existing pole.

2. Utility Poles: Existing Utility Poles (electric and telephone poles) are the most preferred support pole for Network Nodes and related equipment.

3. City-Owned Service Poles:

a. City Service Poles can be used for installation of Network Nodes and related equipment, if approved by the City.

b. Any reinforcement or replacement of a pole shall match the color of the existing pole.

c. Any pole reinforcement or replacement shall be at Network Provider's sole cost.

16.2.01.D Network Pole Load Analysis and Design Criteria:

1. Analysis and design of pole and device attachments must be according to the latest edition of any of the following applicable codes:

a. International Building Code (IBC) and, City of Houston Construction Code Amendments;

b. AASHTO Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals;

c. Structural Standard for Antenna Supporting Structures, Antennas and Small Wind Turbine Support Structures (TIA-222); and

d. Any other relevant codes required.

2. Basic wind speed used for design must be according to the adopted City of Houston Construction Code Amendments to the International Building Code (IBC).

3. The analysis and design must include all structural elements, including but not limited to, the concrete foundation, base plate, anchor bolts, pole, mast arm and device connection.

16.2.01.D.3 continued

a. Include a summary of critical unity checks for all components of the structure and device connections. The reported values shall correlate with the pole analysis report and documented device specifications. Analysis must clearly show that all members have adequate size and reinforcement to withstand all imposed:

(1) Gravity and lateral loads;

(2) Bending stresses;

(3) Shear stresses;

(4) Deflection; and

(5) Fatigue due to stress fluctuations. (A dynamic analysis of structures may be performed), where applicable.

4. Summary of criteria used in pole analysis and analysis results including, at a minimum, material properties, loadings, load combinations, reactions, deflections and dimensions assumed.

16.2.01.E Ground Equipment:

1. Ground equipment near street corners and intersections:

a. Ground equipment shall be minimal and the least intrusive.

b. Ground equipment shall be installed outside of visibility/sight triangles for safe travel of vehicular and pedestrian traffic.

2. Ground equipment shall be neutral color, and of material compatible with the surrounding structures as determined by the City.

3. Ground equipment near public parks: The Network Provider shall not install ground equipment in a Public Right-of-Way that is within a park or within two hundred and fifty (250) feet of the boundary line of a park, unless approved by the City.

4. Minimize ground equipment density: The City may deny a request for a proposed location if the Network Provider installs Network Node ground equipment where existing ground equipment within three hundred (300) feet already occupies a footprint of twenty-five (25) square feet or more.

16.2.01.F Underground Facilities:

1. Perform field surveys for all underground facility projects to verify depths and horizontal locations of all utilities in the vicinity of the proposed scope of work. Refer to Chapter 2 for surveying requirements.

16.2.01.F continued

2. Underground installations for communications equipment, cables and conduits shall be per Texas Utilities Code, Chapter 251 - Underground Facility Damage Prevention and Safety.

3. Underground facilities must have a minimum three (3) feet of vertical clearance and four (4) feet of horizontal clearance from outside diameter of any utility lines (not centerline). Where minimum clearances in other chapters of this manual conflict, the strictest requirement shall govern. In addition, the underground facilities must be located vertically so that service connections to the public storm sewer line and public sanitary sewer line on either side of the right of way are not occluded or blocked vertically.

16.2.01.G Subsurface Utility Exploration (SUE): SUE is required for all underground installations of communication equipment, cables, and conduits. Refer to Chapter 6 for SUE requirements.

16.2.02 SUBMITTALS

16.2.02.A Installations on all City Service Poles shall be in accordance with a written agreement with the City.

16.2.02.B Drawings:

1. Network Provider shall submit Drawings prior to:

   a. Installation of proposed Network Node, Node Support Pole and Repeater Pole;

   b. Installation, modification, or relocation of Network Node on an existing pole or structure;

   c. Modification or relocation of an existing Node Support Pole or Repeater Pole; or

   d. Installation of any other Communication Facility in the City’s right-of-way.

2. All existing utilities must be shown on Drawings. Sources of data include survey, record drawings, graphical information systems, and field visits. Field visits must be made to verify the Drawings accurately portray the existing conditions, and the field visit date shall be listed on the Drawings. Refer to Chapter 3 for exceptions.

3. For existing poles, submit applicable design detail drawings, site plan and pictures of the specific pole and surrounding area.

   a. Pictures shall show any existing pole damage or oxidation if it exists.

   b. Pictures shall show an unobstructed view of the entire pole and mast arm.

16.2.02.B continued

4. Drawings must show type, height, size and location of all existing and proposed devices and signs on the pole.

5. Identify proposed location and method of proposed installation (trench, bore, existing conduit pull) of proposed and existing Communication Facilities necessary to connect the Network Node to the public switched telephone network.

6. Provide specific location with X, Y coordinates (northing and easting) and Pole ID.

7. Identify on Drawings existing and proposed placement of Network Node, devices and equipment on pole, and any ground equipment, cabinets, and appurtenances.

8. Show vertical and horizontal distances of all existing and proposed signs and devices that are attached to the pole as measured from the bottom of the pole's baseplate.

9. Show each proposed device attachment and physical specifications. Drawings must include the device quantity, description, manufacturer, model number, azimuth, cable length, weight and dimensions.

10. Show proposed device attachment details.

16.2.02.C Specifications:

1. Provide pole manufacturer drawings and specifications (height, class, material properties);

2. Provide electrical and any other device specifications upon request by the City.

16.2.02.D Pole Load Analysis:

1. Pole load analysis reports must be submitted with each Permit application for proposed or replaced Network Nodes to be placed on proposed or existing poles.

2. Pole load analysis must be for the actual pole, device configuration and device attachment.

3. Engineer's cover letter, pole load analysis, design calculations and Drawings must be signed, and sealed by a Texas Registered Civil/Structural Professional Engineer.

   a. Engineer cover letter for pole design must indicate that it is in full accordance with the analysis and design criteria as established in 16.2.01.D.

4. All codes and design criteria used for design and analysis must be indicated on Drawings, engineer's cover letter and within the pole load analysis report.

16.2.02.E SUE Deliverable:

16.2.02.E continued

1. SUE reports are required for quality level A SUE. Reports shall include general locations, photographs of test holes, test hole data sheets (x, y and z coordinates, utility type, size, and material). Refer to Chapter 6 for additional SUE requirements.

16.2.02.F Geospatial Data Deliverables:

1. Provide GIS datasets in accordance with Chapter 13 – Geospatial Data Deliverables.

16.2.03 QUALITY ASSURANCE

16.2.03.A Calculations, reports and Drawings must be prepared, signed, and sealed by a Texas licensed Professional Engineer.

16.2.03.B The City may perform visual inspections of any Micro Network Node, Network Node, Node Support Pole, Repeater Pole, or related ground equipment located in the Public Right-of-Way as the City deems appropriate without notice. If the inspection requires physical contact with the Micro Network Node, Network Node, Node Support Poles, Repeater Poles, or related ground equipment, the City will provide written notice to the Network Provider. Network Provider may have a representative present during such inspection. In the event of an emergency, the City may, but is not required to, notify Network Provider of an inspection. The City may take action necessary to remediate the emergency and the City will notify Network Provider as soon as practically possible after remediation is complete.

END OF CHAPTER

City of Houston

Design Manual

Chapter 17

PEDESTRIAN, BICYCLE, AND TRANSIT DESIGN REQUIREMENTS

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Chapter 17

PEDESTRIAN, BICYCLE, AND TRANSIT DESIGN REQUIREMENTS

SECTION 1 - PEDESTRIAN, BICYCLE, AND TRANSIT OVERVIEW

17.1.01 CHAPTER INCLUDES

17.1.01.A Standards and guidelines for the design of complete streets that are safe, accessible and enjoyable for Vulnerable Road Users who walk, use a mobility aid, bike, and take transit. By improving the street for its most Vulnerable Road Users, we improve safety for everyone.

17.1.01.B Standards and guidelines for pedestrian, bicycle and transit infrastructure including but not limited to new streets/ full street reconstruction, Retrofit projects, and street rehabilitation.

17.1.02 POLICY

17.1.02.A Designing complete streets with space for pedestrians, bicyclists, transit users, and other Vulnerable Road Users is necessary to meet the goals and commitments established by the City of Houston in the Houston Vision Zero Action Plan, Houston Bike Plan, Houston Climate Action Plan, and Resilient Houston strategy. Combined, these plans aim to fulfill a need for Houston to be a safe, resilient city for everyone.

17.1.02.B Roadway projects are an opportunity to increase the overall resilience of our streets to serve multimodal needs, adapt to climate change, and improve safety, accessibility, and equity.

1. New streets or fully reconstructed streets provide the opportunity to reimagine the right-of-way and implement infrastructure that provides space for multiple uses and functions, such as pedestrian, bicycle, and transit facilities for people of all ages and abilities; Green Infrastructure to manage stormwater, shade structures to decrease urban heat island effects; and Placemaking that incorporates universal design principles.

2. Retrofit projects provide the opportunity to reconfigure existing roadways using a range of temporary or permanent solutions to meet multimodal transportation needs of the most Vulnerable Road Users and mitigate the impact and rate of future climate change.

17.1.02.C The City of Houston will approve pedestrian, bicycle, and transit facilities that are safe and accessible for people of all ages and abilities. This means that street design must meet the needs of children, who have less ability to detect risks or negotiate conflicts; older adults who have lower visual acuity and slower riding and walking speeds; and people who may use mobility aids or adaptive bicycles which are wider, lower to the ground, and operate at lower speeds. The standards in the following sections aim to establish all ages and abilities design criteria.

17.1.03 REFERENCES

17.1.03.A References listed are the latest edition, version, amendments, and recodifications unless otherwise noted.

1. AASHTO Guide for the Development of Bicycle Facilities
2. Americans with Disabilities Act (ADA, Standards for Transportation Facilities)
3. City of Houston Code of Ordinances [1]:
    a. Chapter 40 – Streets and Sidewalks
    b. Chapter 42 – Subdivisions, Developments and Platting
4. FHWA Separated Bike Lane Planning and Design Guide
5. Highway Capacity Manual
6. Houston Bike Plan and Houston Bike Plan Network [2]
7. Houston Climate Action Plan [3]
8. Houston Vision Zero Action Plan [4]
9. Major Thoroughfare Freeway Plan (MTFP) [5]
10. NACTO, Urban Street Design, Urban Bikeway Design, and Transit Street Design Guide

Refer to the weblink for reference:
[1] https://www.houstontx.gov/codes/
[2] https://houstonbikeplan.org/
[3] http://greenhoustontx.gov/
[4] https://www.houstontx.gov/visionzero/
[5] https://www.houstontx.gov/planning/transportation/MTFP.html

17.1.03.A continued

11. Resilient Houston [6]
12. Texas Accessibility Standards (TAS)
13. Texas Manual on Uniform Traffic Control Devices (TMUTCD), TXDOT
14. Texas Transportation Code, Chapter 552 - Pedestrians

17.1.04 DEFINITIONS

17.1.04.A Bicycle Corral – A group of bike racks installed adjacent to the curb in the parking lane of the roadway or in the area of Curb Extensions. They are often sited near the intersection in areas where space behind the curb is limited. See Figure 17.17 for a conceptual design of Bicycle Corrals.

17.1.04.B Bicycle Facility - A portion of the right-of-way for bicyclists that is either off-street and adjacent to the Sidewalk (Dedicated Bike Path), shared with pedestrians (Shared Use Path), on-street and separated from vehicle traffic with striping, physical delineation (Protected Bike Lane), above-grade features (Raised Bike Lane) or shared with motorists (Neighborhood Bikeway).

17.1.04.C Bike Boxes - A designated area at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible way to be ahead of queuing traffic during the red signal phase.

17.1.04.D Corridor Crossing Analysis – Identifies safe and convenient locations for Vulnerable Road Users to cross streets. Any crossing that provides a type of treatment as recommended by this analysis will be known as an Enhanced Crossing.

17.1.04.E Crossing Treatments – Traffic control proposed at unsignalized crossings for Vulnerable Road Users. Crossing Treatments are based on traffic data and context and may include a variety of design elements to facilitate safe crossings, either as standalone treatments or grouped together.

17.1.04.F Curb Extensions – Also known as bulb-outs. Tools that add space for pedestrians along a roadway by extending the Pedestrian Realm from the Sidewalk into the street. This narrows the roadway width, which can improve pedestrian safety by increasing visibility, shortening the crossing distance, and reducing exposure time to traffic.

[6] https://www.houstontx.gov/policies/executive_orders.html

17.1.04.G Curb Management – Proactively determining the function of curbside street space for a variety of specified uses such as transit, municipal services, commercial loading zones, parklets, non-vehicular transportation, or parking based on the priorities for the corridor. These uses may change over time to improve safety, accessibility, or other needs defined for the location.

17.1.04.H Daylighting – A design strategy to increase visibility and sight distance at intersections, typically achieved by removing parking near the intersection.

17.1.04.I Dedicated Bicycle Facility - A portion of the right-of-way dedicated exclusively for bicyclists (e.g. Dedicated Bike Path, Raised Bike Lane, and Protected Bike Lane).

17.1.04.J Dedicated Bike Paths – Bicycle Facilities that run alongside a roadway behind the curb within the right-of-way. Dedicated Bike Paths are at the same grade as the Sidewalk and increase safety by grade-separating bicyclists and people driving and provide a physical buffer or detectable warning surface to separate pedestrian traffic in the Sidewalk.

17.1.04.K Desire Lines - Also known as a desire path or goat path. An unplanned route, typically in a grassy area, created by human or animal traffic in preference to or in the absence of a designated alternative, such as a paved Walkway. The desire line usually represents the shortest or most easily navigated route between an origin and destination.

17.1.04.L Enhanced Crossing – Any crossing that provides a type of treatment as recommended by the Corridor Crossing Analysis.

17.1.04.M Floating Bus Stop –Floating Bus Stops have a layout that allows pedestrian and Bicycle Facilities to locate behind the bus boarding pad, safely separating different modes of transportation while reducing bus delays by remaining in-lane.

17.1.04.N Frontage Buffer – The area between the outermost edge of the Sidewalk and the edge of the right-of-way or easement that is designed to improve visibility and reduce potential conflicts between Vulnerable Road Users and motorists.

17.1.04.O Green Infrastructure – The range of measures that use plant or soil systems; permeable pavement or other permeable surfaces or substrates; and stormwater harvest and reuse, or landscaping to store, infiltrate, or evaportranspirate stormwater and reduce flows to sewer systems or to surface waters.

17.1.04.P High-Comfort (HC) Bicycle Facility – A Bicycle Facility that provides comfortable, low stress bicycling conditions for people of all ages and abilities based on contextual factors like vehicle speeds and volumes, operational uses, and observed sources of bicycling stress.

17.1.04.Q High-Visibility Crosswalk – Use patterns (bar pairs, continental, ladder) that are visible to both the driver and pedestrian from farther away compared to traditional transverse line crosswalks.

17.1.04.R Houston Bike Plan – Establishes the vision and goals for the City of Houston to be a safer, more accessible, bike-friendly city. The Houston Bike Plan will change over time.

17.1.04.S Houston Bike Plan Network – A map developed as part of the Houston Bike Plan and establishes where neighborhood, on-street, and off-street bicycle facilities are existing, programmed, and planned. Streets indicated as planned are intended to be a guide for future Bicycle Facilities. The Houston Bike Plan Network will change over time.

17.1.04.T Median Refuge Islands – Protected spaces located in the center of the roadway to allow for safe crossings at midblock locations. They enable bicyclists and pedestrians to cross a single direction of traffic at a time, thereby limiting pedestrian and bicyclist exposure to traffic. May also be called pedestrian refuge islands. A crosswalk across a full median on a median-divided roadway is not considered a Median Refuge Island.

17.1.04.U Micromobility – Transportation that includes small, lightweight vehicles operating at slow speeds. It may include bicycles, e-bikes, electric scooters, and skateboards.

17.1.04.V Neighborhood Bikeways – Also known as bicycle boulevards. Low speed, typically residential streets shared by motorists and bicyclists.

17.1.04.W Off-Street Bicycle Facility - Dedicated space for bicyclists that is separate from vehicle traffic outside of the roadway. Off-Street Bicycle Facilities may be outside of street right-of-way like trails in Harris County Flood Control District; within the street right-of-way but outside the roadway and shared with pedestrians (Shared Use Path); or adjacent to the sidewalk (Dedicated Bike Path).

17.1.04.X Off-Street Bicycle Facility Bus Stop – Allows for a bus stop at the standard location on the curb of the vehicular travel lane while the Bicycle Facility travels at Sidewalk grade adjacent to, and behind, the bus pad.

17.1.04.Y On-Street Bicycle Facility – Dedicated space for bicyclists that is separate from vehicle traffic within the roadway. Separation may be created with striping, physical delineation (Protected Bike Lane), or above-grade features (Raised Bike Lane).

17.1.04.Z On-Street Shared Bus Stop – A shared space between buses and road-grade Dedicated Bicycle Facilities.

17.1.04.AA Pedestrian Hybrid Beacons (PHBs or HAWKS) – Special type of traffic control device used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk. PHBs are made up of a signal head in three sections, consisting of two horizontally arranged circular red sections over a single circular yellow section that is centered between the red lights.

17.1.04.BB Pedestrian Realm - Area within a public right-of-way or easement between the back of curb (or Curb Extension) or edge of the roadway and outermost edge of the public right-of-way or easement. The Pedestrian Realm provides the necessary space for safe, comfortable, and accessible pedestrian activity, and may accommodate other approved public amenities, infrastructure, or uses. It consists of a Frontage Buffer, Sidewalk and Safety Buffer.

17.1.04.CC Placemaking – Participatory process for shaping public space that harnesses the ideas and assets of the people who use it. An effective Placemaking process capitalizes on a local community's assets, inspiration, and potential and it results in the creation of quality public spaces that contribute to people's health, happiness and well-being.

17.1.04.DD Protected Bike Lanes – On-Street Bicycle Facilities between curb faces with physical delineation between the vehicle lane and bike lane. In Retrofit projects where a Dedicated Bike Path is not feasible, Protected Bike Lanes provide enhanced safety for bicyclists.

17.1.04.EE Protected Intersections – Reduce conflicts at intersections by providing safe, separated bikeways that set the bikeway back from parallel motor vehicle traffic so that bicyclists are not forced to merge into mixed traffic. Bicyclists can safely move straight and make two-stage turns through a Protected Intersection.

17.1.04.FF Raised Bike Lanes – Grade-separated Bicycle Facilities that are at a level between the Sidewalk and the roadway.

17.1.04.GG Raised Crosswalks – Provide a crossing that brings the level of the roadway up to the level of the Sidewalk. Raised Crosswalks increase visibility of Vulnerable Road Users, which can improve safety for all road users.

17.1.04.HH Retrofit – In the context of streets, any reconfiguration of the street and/or components in the right-of-way that is not part of a full street reconstruction. Typically, Retrofits use low-cost measures to improve existing infrastructure.

17.1.04.II "S" Dimensions – Defines the total space in the public right-of-way behind the face of curb on a roadway.

17.1.04.JJ Safety Buffer – Area between the back-of-curb or the edge of roadway and the edge of the Sidewalk nearest the back-of-curb or the edge of roadway.

17.1.04.KK Seamless Curb Extensions – Also known as seamless curb. A continuation of the Pedestrian Realm or median such that the grade, concrete, sodding and other components are consistent.

17.1.04.LL Shared Raised Bus Stop – Allows for a bus stop to be in line with a Dedicated Bicycle Facility without altering the Pedestrian Realm and allows for bus boarding at the Sidewalk level by ramping up the Dedicated Bicycle Facility to the curb.

17.1.04.MM Shared Use Paths – Combined bicycle and pedestrian facilities that run alongside a roadway behind the curb within the right-of-way.

17.1.04.NN Sidewalk – Publicly accessible firm-and-stable path as defined in the City of Houston Code of Ordinances, Chapter 40 – Streets and Sidewalks, Article XXII, Section 40-551.

17.1.04.OO Sidewalk Easement – Grants to the public a perpetual, non-exclusive right to cross or otherwise use someone else's land for a specified purpose as defined in the City of Houston Code of Ordinances, Chapter 40 – Streets and Sidewalks, Article XXII, Section 40-551.

17.1.04.PP Traffic Calming – Range of visual and physical elements used to slow vehicle speeds. Traffic Calming methods may include devices, roadway geometry adjustments, and/or other physical elements. Methods may be implemented temporarily or permanently to mitigate speeding.

17.1.04.QQ Transit-Oriented Development (TOD) Street – Public street designated as a primary TOD street or secondary TOD street on the transit-oriented development plan.

17.1.04.RR Two-Stage Turn Queue Boxes – Offer bicyclists a designated way to make left turns at multi-lane signalized intersections from a right-side Dedicated Bicycle Facility, or right turns from a left-side Designated Bicycle Facility. Two-Stage Turn Queue Boxes may also be used at unsignalized intersections to simplify turns from a Dedicated Bicycle Facility onto a Neighborhood Bikeway.

17.1.04.SS Vulnerable Road Users – Those most at risk in traffic. Vulnerable Road Users are mainly those unprotected by an outside shield, namely pedestrians, bicyclists, and people with disabilities, as they sustain a greater risk of injury in any collision against a vehicle and are therefore highly in need of protection against such collisions.

17.1.04.TT Walkable Places (WP) Street – Public street designated as a primary WP street or secondary WP street on the Walkable Places plan.

17.1.04.UU Walkway – Also known as “walkable surface”. Portion of the right-of-way or easement that is for pedestrian traffic. A Walkway may not include a clearly defined Sidewalk.

SECTION 2 - GENERAL REQUIREMENTS FOR PEDESTRIAN, BICYCLE, AND TRANSIT DESIGN

17.2.01 APPLICABILITY OF CHAPTER 17 DESIGN REQUIREMENTS

17.2.01.A Design requirements of Chapter 17 apply to any project that builds or impacts pedestrian, bicyclist, and transit infrastructure in the public right-of-way. All pedestrian, bicyclist, and transit infrastructure shall satisfy the requirements of this chapter.

17.2.01.B All street projects shall submit all required reports as defined in Chapter 15, Section 15.2.02 – Traffic and Design Studies and comply with all applicable Multimodal Service Standards (MMSSs) as defined in Chapter 15, Section 15.2.01 - Multimodal Service Standards.

17.2.01.C Design of pedestrian, bicycle, and transit facilities must consider the users perceived safety, also known as subjective safety. Using minimum values without consideration of facility context may result in ineffective facility use. The dimensional values in this chapter fall under two categories and should be used as follows:

1. In general, preferred values should be used to maximize the safety and comfort benefits for pedestrians, bicyclists and other users. Alternative values should only be used in locations where it is not possible to use preferred values due to social, economic, and environmental impacts. Where the Pedestrian Realm is wide enough to accommodate preferred values, preferred values shall be used.

2. Minimum values should not automatically be considered a default for pedestrian, bicycle, and transit elements due to the inherent vulnerability of its users.

3. Where ranges are presented within the chapter, the most conservative value is considered the preferred value, while the least conservative value in the range is considered the minimum value.

17.2.01.D All street projects shall ensure that all new or modified pedestrian, bicyclist, and transit elements are designed to minimize conflict with motorists, maximize safety for all road users, and meet the all ages and abilities design criteria established in the following sections.

17.2.02 SHADE AND GREEN INFRASTRUCTURE

17.2.02.A Shade, either from trees and vegetation or from structures, is important for pedestrian, bicyclists, and transit users and should be included wherever possible in infrastructure built for those users. Although street trees are desirable, this section does not specifically require their planting.

17.2.02.B Trees shall be selected and planted so that they:

1. Maximize shade for pedestrian Walkways and bicycle infrastructure;
2. Maximize the health of the tree;
3. Minimize damage to infrastructure including Sidewalks, curbs, pavement, foundations, and underground utilities. Tree selections and plans shall be reviewed and approved by the Houston Parks and Recreation Department and City Engineer;
4. Maintain all required clear zones from overhead utilities when trees achieve mature tree height; and
5. Will not cause damage to buses or other vehicles at any stage of the tree lifecycle.

17.2.02.C Trees and plants shall be selected and planted such that they ensure proper clearance for vehicular and infrastructure safety and ensure they do not interfere with visibility and sight line requirements at any stage of their lifecycles. Visibility obstructions from both the foliage of individual plants as well as clumping of multiple plants, including trees, can create safety concerns and shall be avoided.

17.2.02.D Root barriers shall be used whenever the health of the tree and impact to adjacent infrastructure cannot otherwise be mitigated. Refer to City Standard Details 02912-01 and 02912-02.

17.2.02.E For additional information regarding allowed installations and planting in the Safety Buffer between the Sidewalk and the roadway, see section 17.3.01.D.6.

17.2.02.F Pedestrian, bicycle, and transit infrastructure provides an opportunity for Green Infrastructure for stormwater management. This may include permeable surfaces, which are encouraged to be used on pedestrian and bicycle paths to promote water infiltration and reduce ponding and general street runoff.

17.2.03 PEDESTRIAN AND BICYCLE TEMPORARY TRAFFIC CONTROL

17.2.03.A Temporary traffic control must be provided for all pedestrian and bicyclists that are impacted or obstructed.

17.2.03.B Justification for type of temporary traffic control for pedestrian and bicyclists shall be provided to the City for review and approval. Temporary traffic control must follow the requirements listed in the order provided in this section.

17.2.03.C Options for Pedestrian and Bicycle Traffic Control (Ordered from Most to Least Preferred)

17.2.03.C continued

1. Option 1: Provide protection for pedestrians and bicyclists from debris in their present-day path using scaffolding, fencing or other barriers.

2. Option 2: Temporary Pedestrian and Bicyclist Traffic Diversions.

    a. Diversion may be provided on-street depending on local conditions to be determined by Houston Public Works. If on-street space is used for a diversion, barriers shall delineate vehicle travel lanes from pedestrians and/or bicyclists. See Chapter 15 requirements for type of barriers allowed.

    b. ADA compliant temporary curb transition ramps shall be provided for pedestrian or bicycle diversions that include a movement over a curb or other vertical barrier.

    c. Clear pedestrian and bicycle diversion signage shall indicate a diversion ahead, and along diversion route at all changes in direction and at regular intervals as necessary to highlight the diversion.

    d. Pedestrians and bicyclists may share the same diversion if approved by Houston Public Works.

3. Option 3: Pedestrian and Bicycle Detours

    a. Pedestrian and bicycle detours shall satisfy all design requirements for pedestrian and bicycle infrastructure as defined in this chapter.

    b. Pedestrian and Bicycle Facility detours shall provide the most direct route possible.

    c. Any closure of a pedestrian or Bicycle Facility shall require the shortest detour that maintains the safety of pedestrians and/or bicyclists.

    d. If detour users must cross the street, an existing safe crossing shall be used or a temporary safe crossing shall be provided.

    e. ADA compliant temporary curb transition ramps shall be provided for pedestrian or bicycle detours that include a movement over a curb or other vertical barrier.

    f. Clear pedestrian and bicycle detour signage shall indicate a detour ahead, and along detour route at all changes in direction and at regular intervals as necessary to highlight the detour.

    g. Pedestrians and bicyclists may share the same detour if approved by Houston Public Works.

17.2.04 BRIDGE CROSSINGS AND TUNNELS

17.2.04.A All new bridges and tunnels shall accommodate multimodal transportation usage by implementing the following requirements.

1. When the approach roadway to the bridge/tunnel has an existing or planned Bicycle Facility, the bridge/tunnel shall provide a Bicycle Facility that satisfies all current IDM requirements.

2. When the approach roadway to the bridge/tunnel does not have either an existing or planned Bicycle Facility, a 10-ft or greater Sidewalk that is accessible to bicyclists shall be provided. This ensures that, at a minimum, a Shared Use Path will be available if a Bicycle Facility is ever planned for the corridor.

3. Bridge Sidewalks and Shared Use Paths shall be physically separated from the vehicle pavement, either by a grade difference or physical delineation.

17.2.04.B Exterior bridge railings adjacent to a pedestrian/Bicycle Facility shall meet the following standards:

1. Maintain a minimum height of 42-inches. A height of 48-inches shall be used in the following cases:

   a. Speed of adjacent traffic exceeds 35 mph.

   b. Width of pedestrian/Bicycle Facility is less than 10-ft.

2. The railing design shall minimize opportunities for bicycle handlebars to get caught in the railing.

3. A railing or delineator may be used to separate bicycle traffic from pedestrian traffic to improve bicycle/pedestrian safety and comfort where appropriate.

SECTION 3 - PEDESTRIAN ELEMENTS REQUIREMENTS

17.3.01 PEDESTRIAN REALM

17.3.01.A For Pedestrian Realm components see Figure 17.1.

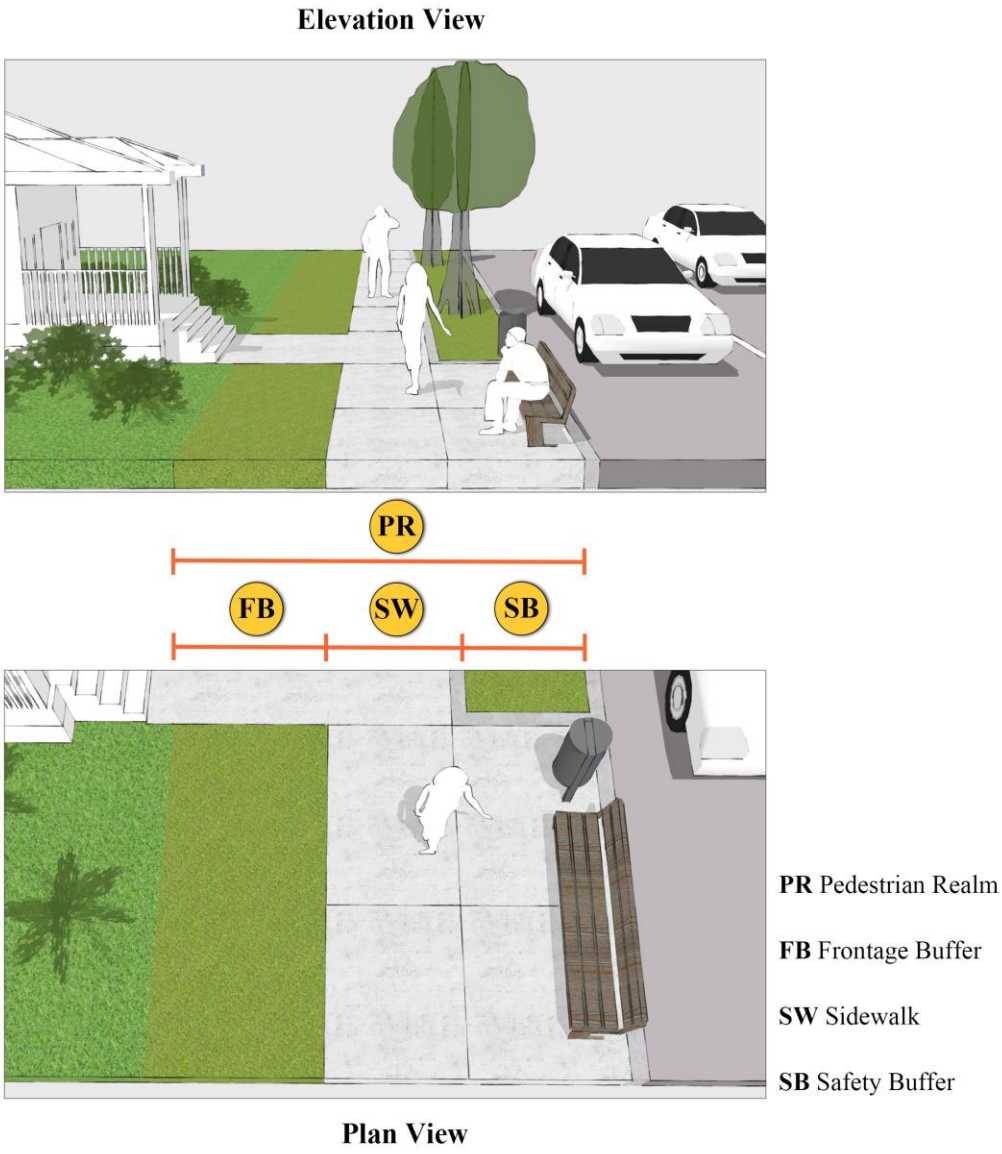


Figure 17.1 – PEDESTRIAN REALM COMPONENTS

17.3.01.B Frontage Buffer

1. The Frontage Buffer is the area between the outermost edge of the Sidewalk and the edge of the right-of-way or easement that is designed to improve visibility and reduce potential conflicts between Vulnerable Road Users and motorists.

2. The Frontage Buffer preferred width is three (3) feet. The Frontage Buffer shall maintain a minimum width of one (1) foot. See Table 17.2.

3. The Frontage Buffer shall be kept free from visual obstructions in the space above twenty four (24) inches and below eight (8) feet in height as measured vertically from the surface of the adjacent Sidewalk.

4. The Frontage Buffer may be paved or unpaved. If paved, it will be indistinguishable from the Sidewalk. Alternative materials of Frontage Buffer construction, such as permeable materials, may be used to support resiliency goals. All alternatives shall meet minimum Frontage Buffer requirements and shall be coordinated and approved by the City Engineer.

5. The intersection of the Pedestrian Realm with a driveway is subject to a pedestrian safety and visibility buffer in accordance with Chapter 40, Article I of the Code of Ordinances and illustrated in Figure 17.2 and Figure 17.3. The Frontage Buffer of the Pedestrian Realm as defined in this chapter may be used to satisfy the pedestrian safety and visibility buffer requirements.

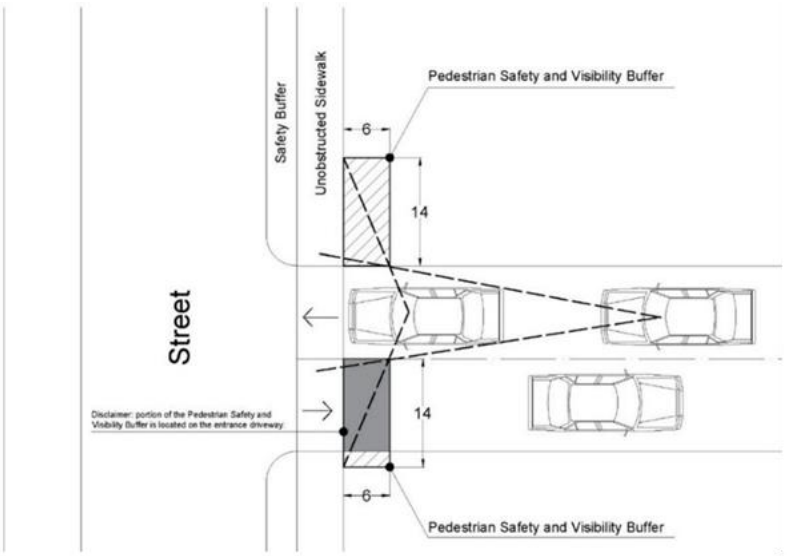


Figure 17.2 – PEDESTRIAN SAFETY AND VISIBILITY BUFFER (TWO-WAY DRIVEWAY) [7]

[7] City of Houston Code of Ordinances Section 40-32

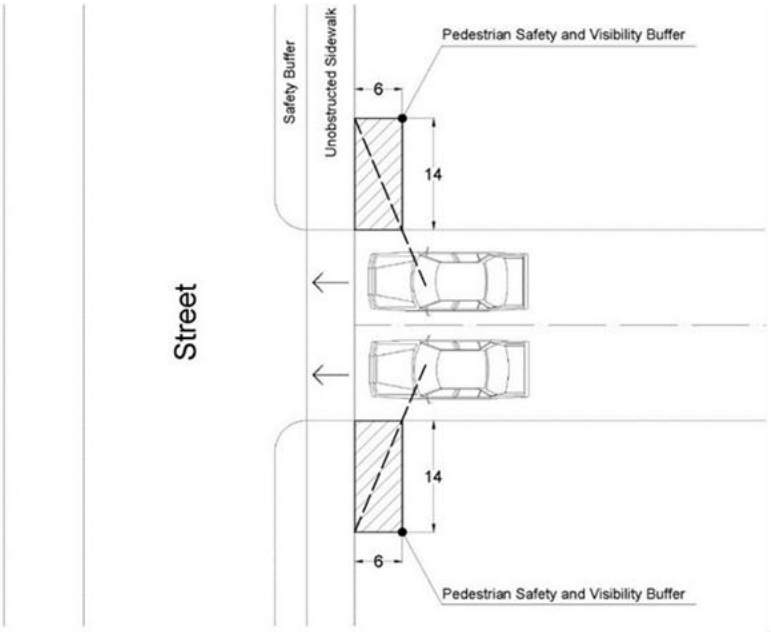


Figure 17.3 – PEDESTRIAN SAFETY AND VISIBILITY BUFFER (ONE-WAY DRIVEWAY) [8]

17.3.01.C Sidewalk

1. The Sidewalk is a publicly accessible path designed to ensure that a person has a safe and comfortable place to walk or use a mobility aid. The Sidewalk must be free of obstructions and encroachments and shall be designed as a continuous, obstacle-free space that maintains adequate drainage. Sidewalks shall adhere to standards in Table 17.1.

2. The Sidewalk cross slope shall be 2% to maintain ADA access and ensure that water flows across the Sidewalk without pooling in the Walkway.

3. The Sidewalk must be constructed in accordance with Houston Public Works standards, Texas Accessibility Standards (TAS), and Americans with Disabilities Act (ADA) requirements. If there is a conflict in the requirements, the strictest requirement(s) shall govern.

[8] City of Houston Code of Ordinances Section 40-32

17.3.01.C continued

4. The minimum unobstructed vertical clearance of a Sidewalk is eight (8) feet as measured vertically from the surface of the Sidewalk. Additional vertical clearance requirements apply for certain improvements constructed over a Sidewalk along a designated WP Street or TOD Street in accordance with the Enhanced Pedestrian Realm Standards of Chapter 42, Article IV of the Code of Ordinances.

5. The design of a Sidewalk near an approved bus or transit stop must meet the requirements in this section, Chapter 10 subsection 10.3.03.B.2 and be coordinated with METRO or other transit operators.

6. Sidewalks should be continuous and follow Desire Lines. When a Sidewalk must deviate to circumnavigate obstructions, transition curves should avoid sharp turns and be as long as necessary to ensure the highest comfort pathway.

7. The placement of a new above-grade feature within the minimum required Sidewalk width or within an existing substandard Sidewalk is prohibited unless a modification is granted under the Modification of Standards process detailed in Chapter 40, Article XXII of the Code of Ordinances or otherwise expressly authorized by law.

8. Sidewalks Traversing Driveways:

    a. Sidewalks should maintain Sidewalk grade across driveways.

    b. Sidewalks should be differentiated from driveways through pavement materials or Sidewalk edge delineation.

9. Sidewalks traversing a railroad track must be at 0% slope for a distance of five (5) feet from the centerline of the track in each direction. The Sidewalk should cross the railroad track as close to 90-degrees as possible.

10. Sidewalk Materials

    a. Sidewalks should typically be concrete.

    b. Alternative methods of Sidewalk construction may be used in places where tree preservation is of concern.

    c. Alternative materials for Sidewalk construction, such as permeable materials, may be used to support resiliency goals.

    d. If alternative material is selected by the Engineer, the Engineer shall create and submit an alternative material Sidewalk construction specification as a part of the design submittal. The specification shall include measurement and payment, material requirements, and instructions on execution.

17.3.01.C.10 continued

e. All alternatives shall meet minimum Sidewalk requirements and shall be coordinated and approved by Houston Public Works.

11. Sidewalks may be paired or combined with off-street bike paths. These Sidewalks shall comply with all requirements of this section and Section 17.4.02, High-Comfort Facility Type Standards.

Table 17.1 – MINIMUM SIDEWALK WIDTH STANDARDS

Street Type	Type	Minimum Width
Within Central Business District [9]	All	8 feet
Major Thoroughfare	WP Street	As designated by the Walkable Places Plan
	TOD Street	8 feet
	All Others	6 feet
All Other Public Streets	WP Street	As designated by the Walkable Places Plan
	TOD Street	6 feet
	All Others	6 feet preferred / 5 feet minimum

17.3.01.D Safety Buffer

1. The Safety Buffer is the area between the back-of-curb or the edge of roadway, and the edge of the Sidewalk nearest the back-of-curb or the edge of roadway. [10]

   a. The Safety Buffer creates a safe and comfortable distance between a person using the Sidewalk and vehicles on the adjacent roadway.

   b. The Safety Buffer also provides the opportunity to use Green Infrastructure to manage stormwater and reduce the urban heat island effect through the use of shade trees.

   c. The Safety Buffer may be utilized to accommodate different utilities; pedestrian, bicycle or transit amenities; or other approved uses.

[9] "Central Business District" is defined in Chapter 42, Article I of the Code of Ordinances.
[10] City of Houston Code of Ordinances: Section 40-551

17.3.01.D.1 continued

d. The Safety Buffer shall not be used for vehicle purposes including but not limited to parking, loading/unloading, valet zones, and ride share zones.

2. Safety Buffers shall adhere to the width standards in Table 17.2.

3. Safety Buffers greater than 2-feet wide may be paved or unpaved, unless otherwise stated in Chapter 15, Table 15.7.

   a. If paved, it may be indistinguishable from the Sidewalk.

4. Safety Buffers less than or equal to 2-feet wide shall be paved, unless otherwise stated in Chapter 15, Table 15.7.

   a. Pavement may be indistinguishable from the Sidewalk.

5. Alternative methods of Safety Buffer construction, such as permeable materials, may be used to support resiliency goals. All alternatives shall meet minimum Safety Buffer requirements and shall be coordinated and approved by the City Engineer.

6. Where the Safety Buffer width is at least four (4)-ft or greater, trees should be planted to provide Sidewalk shade. Trees shall not be planted in a Safety Buffer that is narrower than four (4)-ft. The selected tree variety shall be chosen to maximize shade coverage for pedestrians while also maximizing tree health and minimizing impact to infrastructure. For more information on providing shade and trees, see Section 17.2.02 - Shade and Green Infrastructure.

7. A combination Sidewalk and paved Safety Buffer is acceptable adjacent to dedicated on-street parking or valet zones. The entire Pedestrian Realm must still satisfy all requirements of this chapter.

   a. The resulting combined width of the Sidewalk and paved Safety Buffer in this scenario must be at least ten (10) feet.

   b. Subject to approval by both the Traffic Engineer and City Engineer, the minimum width of the Safety Buffer may be reduced or eliminated adjacent to the section of the Sidewalk designed to create a continuous path of travel to connect to an existing Sidewalk.

8. Approved above-grade features may be placed within the Safety Buffer.

Table 17.2 – FRONTAGE BUFFER AND SAFETY BUFFER WIDTH STANDARDS

Classification	**Preferred**	**Minimum**
Safety Buffer	6 feet or more	4 feet
Frontage Buffer	3 feet or more	1 foot

17.3.01.E Other Pedestrian Realm Requirements

1. The Pedestrian Realm at an intersection corner is formed by the intersection of Pedestrian Realms on the cross streets plus the additional right-of-way for corner cut-back as required by Chapter 10, Section 10.3.02.B. The entire space should be made available for a combination of Safety Buffer, curb ramps, Walkway, and other approved Pedestrian Realm features.

2. New development and certain redevelopment along a designated TOD Street or WP Street must meet additional requirements for the Pedestrian Realm and private property adjacent to the public street. These requirements are detailed in Chapter 42, Article IV of the Code of Ordinances.

3. "S" Dimension, Easements and Pedestrian Realm:

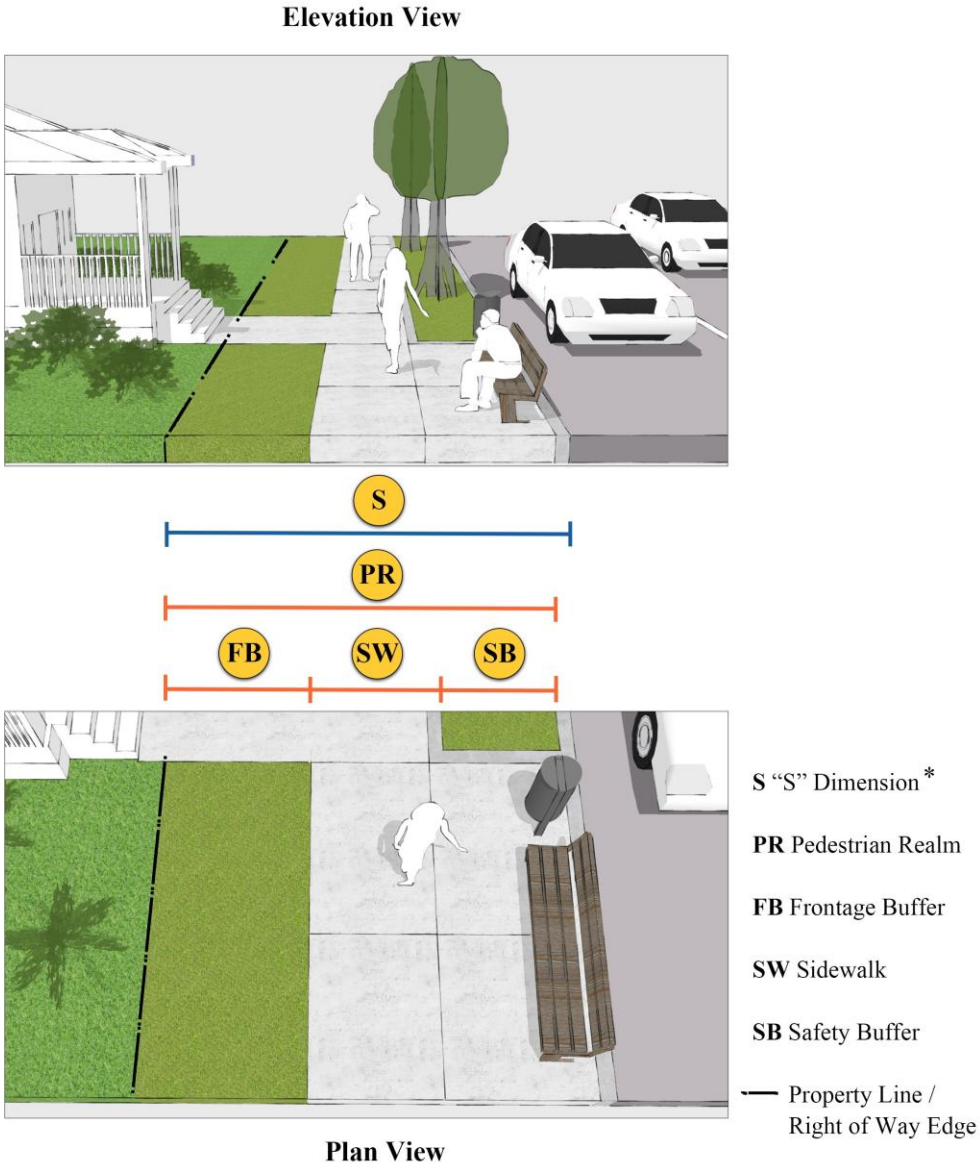
   a. The "S" Dimension may be smaller than or sufficient for the required Pedestrian Realm.

      (1). When the "S" Dimension is wide enough to accommodate the required Pedestrian Realm, the Pedestrian Realm will be located within the public right-of-way. See Figure 17.4.

      (2). When the "S" Dimension is not wide enough to accommodate the required Pedestrian Realm components, part of the Pedestrian Realm will need to be within a public Sidewalk Easement on the private property. See Figure 17.5.

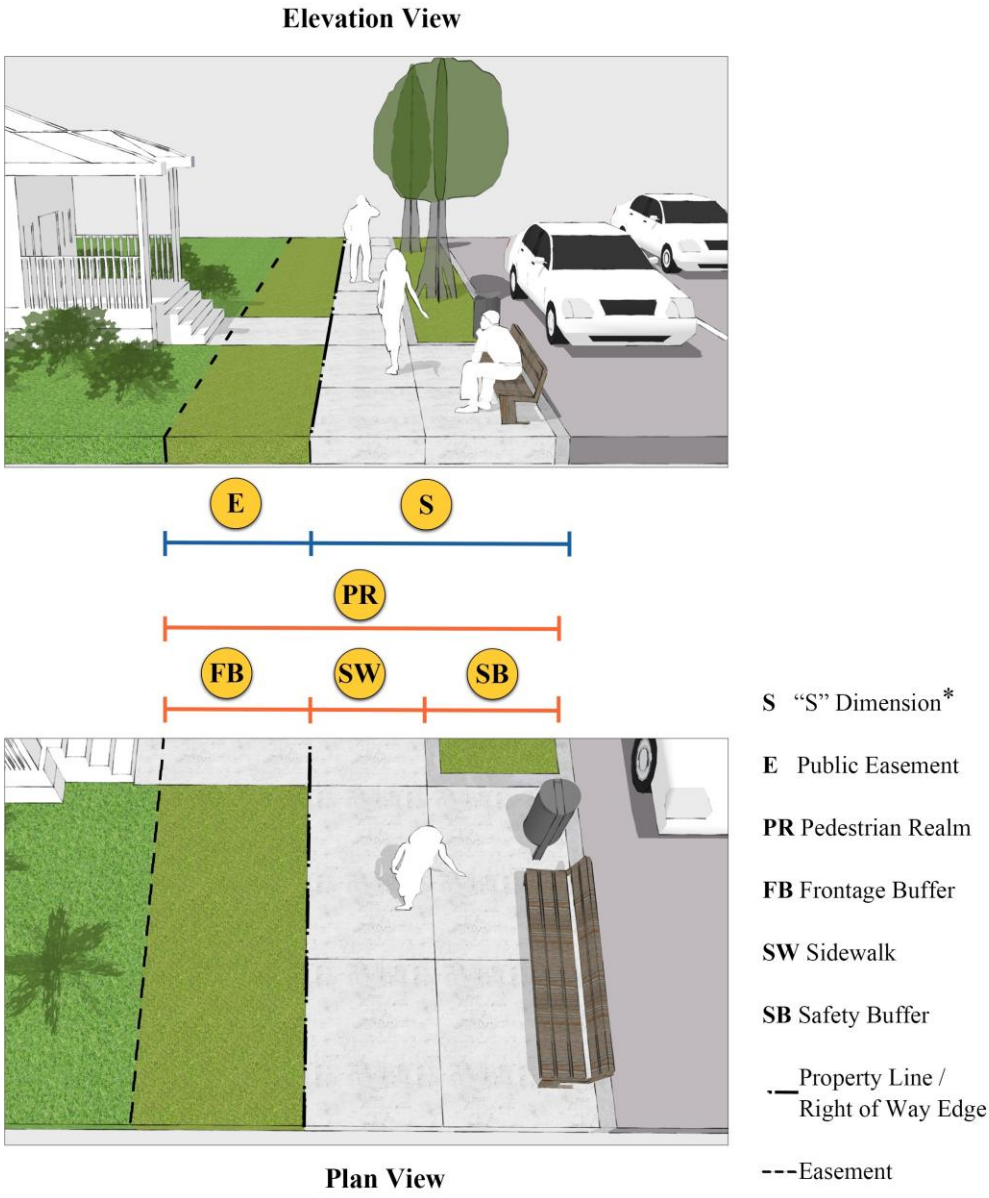
   b. The duly recorded easement must grant the public a perpetual, non-exclusive easement on, over, and across the private land for the construction, maintenance, and use of a Sidewalk.

   c. See Figure 17.4 and Figure 17.5 for conceptual designs of the Pedestrian Realm and "S" Dimensions. All IDM conceptual designs are for reference only and do not constitute design standards.



Note: "S" Dimension is measured from the face of curb as defined in Chapter 10 of this manual.

Figure 17.4 – ENTIRE PEDESTRIAN REALM LOCATED WITHIN PUBLIC RIGHT-OF-WAY



Note: "S" Dimension is measured from the face of curb as defined in Chapter 10 of this manual.

Figure 17.5 – PORTION OF PEDESTRIAN REALM LOCATED WITHIN PRIVATE PROPERTY

17.3.02 INTERSECTIONS AND MIDBLOCK CROSSINGS

17.3.02.A Curb Ramps and Corner Treatments

1. Curb ramps provide accessible connections across roadways by creating a slope from the Pedestrian Realm to the street. Properly designed curb ramps ensure a high level of comfort and safety for Vulnerable Road Users. Figure 17.6 shows conceptual designs of intersection curb ramps that satisfy the pedestrian elements standards and guidelines defined in this section. This figure is for reference only and does not constitute design standards.

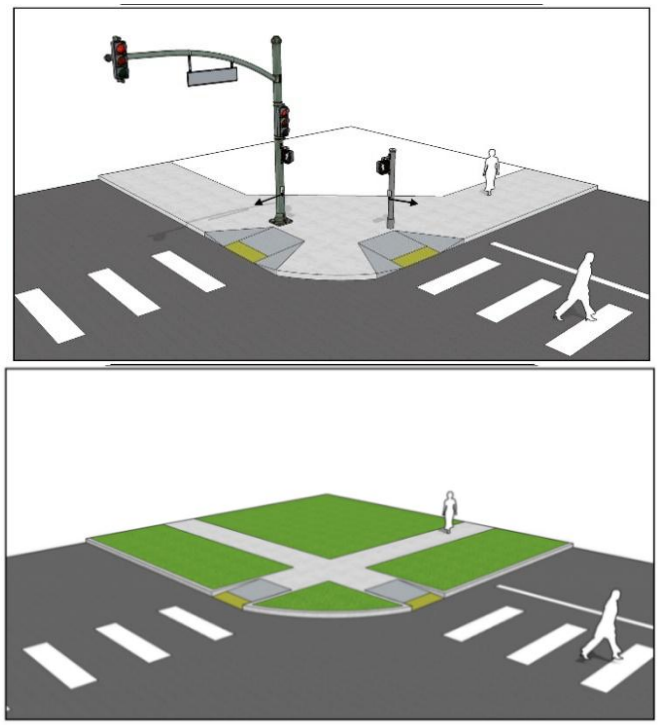


Figure 17.6 – EXAMPLES OF PREFERRED CURB RAMPS TREATMENTS

2. Curb ramps shall be constructed at all intersection corners and midblock crossing locations for any approach that includes a Sidewalk and/or that serves a legal crosswalk. Typically, this means that each corner should have curb ramps serving two crossings, regardless of traffic control.

3. All Curb Ramps shall be constructed in accordance with Houston Public Works standard details, Texas Accessibility Standards (TAS), and Americans with Disabilities Act (ADA) requirements. If there is a conflict in the requirements, the strictest requirements shall govern. At absolute minimum, all curb ramps must comply with all applicable ADA and TAS requirements.

17.3.02.A continued

4. All curb ramps constructed as part of an adjacent development or as part of a capital project with the capacity for right-of-way acquisition must comply with the curb ramp standards and guidelines.

5. Curb Ramp and Corner Treatment Design Standards

   a. For openings that are perpendicular (90 degrees) to the centerline of street, curb ramps shall not point into the center of the intersection.

   b. Minimum width shall be 5-ft, not including curb (see Figure 17.7).

   c. Maximum slope shall be 1:12. Small/flatter slopes are strongly preferred. See Figure 17.7.

   d. Provide a minimum 5-ft by 5-ft clear and level landing space at the top of every curb ramp (see Figure 17.7).

   e. Provide detectable warning strip of 2-ft at the interface with the roadway (see Figure 17.7). Every pedestrian-accessible trail, Walkway, or ramp shall meet this requirement.

   f. Ramps and the 5-ft x 5-ft level landing shall be free of obstructions, utilities, and hardware. Any obstructions, utilities, or hardware installed in an approved area shall maintain a minimum 5-ft clearance zone (see Figure 17.8).

   g. Curb ramp flares shall be provided for any side of a curb ramp that is adjacent to the walkable surface.

   h. The walkable surface shall be maximized at every corner of a signalized location and other pedestrian-dense areas to safely and comfortably accommodate pedestrians waiting to cross the street.

   i. See Figure 17.7 and Figure 17.8 for curb ramp dimensions and clearance zones, respectively.

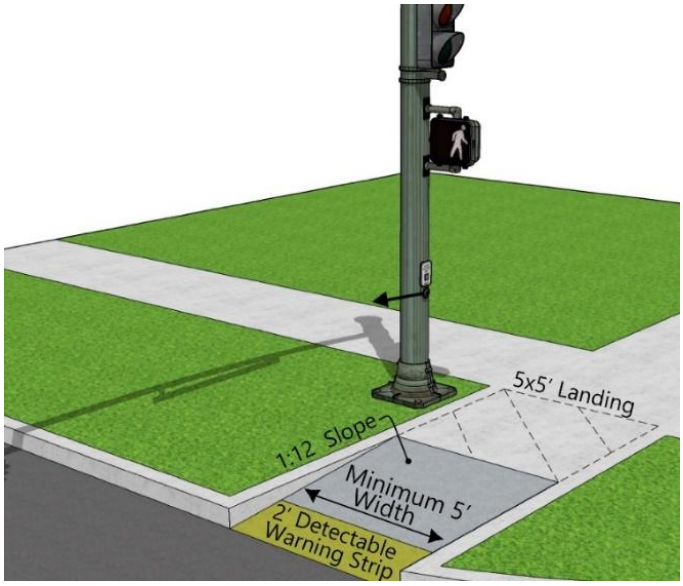


Figure 17.7 – CURB RAMP DIMENSIONS

17.3.02.A
continued

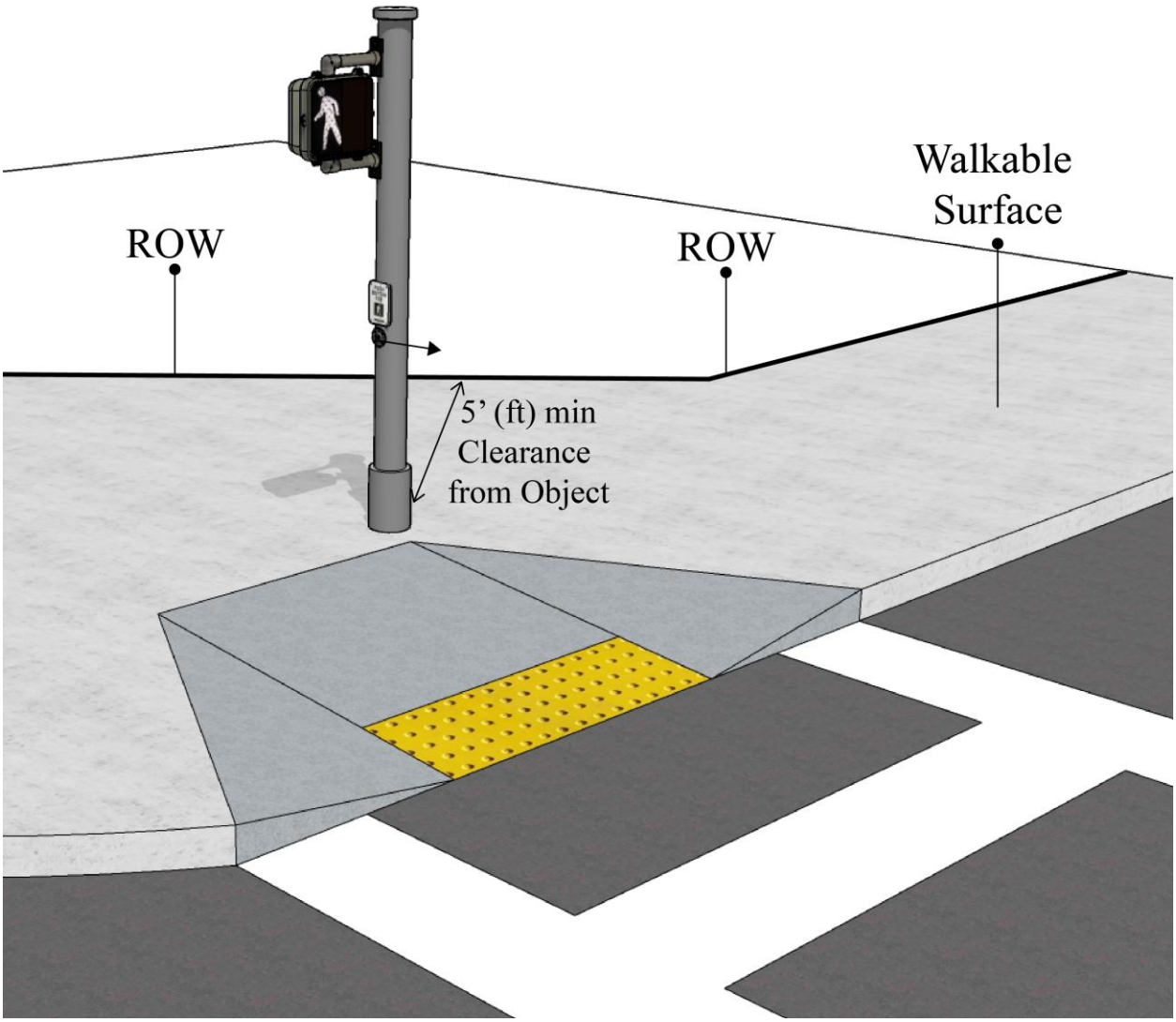


Figure 17.8 – CURB RAMP CLEARANCE ZONE

6. Curb Ramp Design Guidelines

   a. Curb ramps should be directional so that a person traveling down the ramp is directed towards a legal crosswalk and towards a receiving ramp.

   b. Curb ramp construction on an intersection corner should be interconnected to facilitate a walking route around the corner that does not require a pedestrian to utilize a ramp or enter the street.

17.3.02.A.6 continued

c. Where a curb ramp serves a Walkway, Bicycle Facility or trail that is directed toward the ramp, the width of the ramp should generally match the width of the Walkway, Bicycle Facility and/or trail.

d. Curb ramps should be designed so that water does not pool on or at the bottom of the ramp. This may require minor pavement work around the ramp to ensure adequate gutter flow.

e. Presence of a curb ramp does not in and of itself require crosswalk markings. Legal crosswalks exist at most intersections regardless of installation of crosswalk markings.

f. Pedestrian pushbuttons should be placed adjacent to a level Walkway that directs a pedestrian crossing in the direction served by the pushbutton. See Figure 17.9 for a conceptual design of pedestrian pushbuttons. This figure is for reference only and does not constitute design standards.

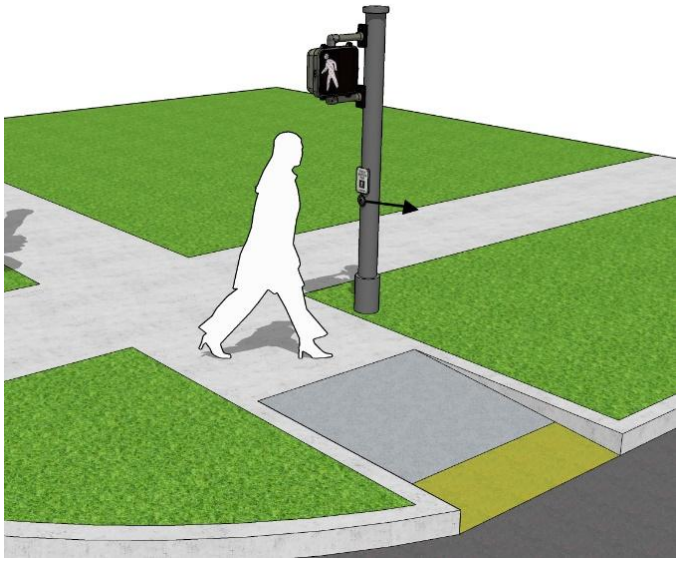


Figure 17.9 – EXAMPLE OF A PEDESTRIAN PUSHBUTTON LOCATED IN THE DIRECTION SERVED BY THE PUSHBUTTON

g. Pedestrian pushbuttons should be located so that they are equally accessible for pedestrians traveling via any Sidewalk and/or crosswalk served by the corner.

h. Signal poles without pedestrian pushbuttons should be installed in a fashion that maximizes the surrounding walkable surface.

i. Signal equipment may be installed in the walkable surface if doing so provides a net gain in space for pedestrians.

17.3.02.B Crosswalk Markings (see Chapter 15.2.06.B.4)

17.3.02.C Curb Extensions

1. Curb extensions (also known as bulb-outs) are tools that add space for pedestrians along a roadway by extending the Pedestrian Realm from the Sidewalk into the street. This narrows the roadway width, which can improve pedestrian safety by increasing visibility, shortening the crossing distance, and reducing exposure time to traffic.

    a. Curb Extensions can achieve Daylighting, which is a safety measure that improves visibility and comfort for all road users at intersections by eliminating visual barriers between motorists and Vulnerable Road Users on the cross street.

2. Curb Extensions can be added at intersections, midblock crossings, and where travel lanes are reduced or reconfigured.

    a. Streets with 24-hour on-street parking shall have Curb Extensions at intersections and midblock crossings. Curb Extensions can be implemented at midblock crossings and intersections where construction would not require obstructing a travel lane.

    b. See Section 17.3.03 - Corridor Crossing Analysis and Treatments for additional guidelines on Curb Extension placement.

3. Curb Extensions should be added at all intersections with excess width where roadway geometry allows. Excess width is present when a roadway cross section meets the following condition:

$$If, x > (y \times 11) + m$$

$$Then, e = x - \big((y \times 11) + m\big)$$

Where: x = face of curb to face of curb width (ft)
y = number of through and turn lanes
m = median width (ft)
e = excess width (ft)

4. Curb Extensions should be a minimum twenty (20)-ft in length from a point beginning at the crosswalk, marked or unmarked. The length may be altered if driveways, bus stops or other uses of the curb-adjacent area are present.

17.3.02.C continued

5. Curb Extensions shall maintain or improve existing crosswalk and curb ramp widths. Curb Extensions shall not impede pedestrian travel paths.

6. Curb Extensions can be made from corner reconstruction and extend the Sidewalk into the roadway, or they may be defined with the use of pavement markings, curbs, bollards, planters, or a combination of the aforementioned.

7. Materials for Curb Extensions:

   a. Seamless Curb Extensions shall be used in new or full street reconstruction projects and may be used in Retrofit projects. Seamless Curb Extensions should be a continuation of the Pedestrian Realm such that the grade, concrete, sodding, and other components are consistent. See Figure 17.10 for a conceptual design of an intersection with Seamless Curb Extensions. This figure is for reference only and does not constitute design standards.



Figure 17.10 – SEAMLESS CURB EXTENSION WITH ON-STREET PARKING

   b. Median concrete (also known as floating curb) can only be used in Retrofit projects.

      (1). On curb and gutter streets, median concrete shall maintain an eighteen (18)-in wide gutter flow area.

      (2). Median concrete may be installed on open ditch streets subject to Houston Public Works review and approval.

   c. Precast or cast-in-place curb can only be used in Retrofit projects. The length and openings of precast and cast-in-place curb will vary depending on context but generally should be placed such that vehicles cannot encroach.

17.3.02.C.7 continued

d. Bollards or flexible posts with pavement markings can only be used in Retrofit projects. Hatched pavement markings (see 17.3.02.C.7.e) shall create a buffer and the bollards or flexible posts shall be placed on the inside edge of the buffer. Spacing between individual bollards or flex-posts will vary depending on context but generally should be placed such that vehicles cannot encroach.

e. Hatched pavement markings alone may only be used where all other Curb Extension treatments are not feasible. Curb Extensions that consist only of hatched pavement markings are subject to approval by City Traffic Engineer.

(1). Hatched pavement markings shall consist of twenty-four (24)-in diagonal white stripes spaced at eight (8)-ft bounded by a six (6)-in solid white line.

f. Other materials may be considered to delineate Curb Extensions, such as planters. Alternative materials are subject to approval by the City Traffic Engineer.

8. Curb Extensions may include street furniture, bike racks/corrals (see section 17.4.01.C), or other amenities to enhance the public realm. The City of Houston will maintain standard Curb Extension delineation (see subsections 17.3.02.C.7.a-d) and bike racks ('U' Racks, refer to Standard Detail 02871-01) within Curb Extensions. Other amenities require a maintenance agreement.

9. Where Curb Extensions intersect with Dedicated Bicycle Facilities, see Protected Intersections, Section 17.4.03.A11.

10. Drainage

a. On curb and gutter streets, Curb Extensions should include a new stormwater inlet on the upstream side of the Curb Extensions. If a new inlet is not feasible, the Curb Extensions shall at a minimum maintain the existing gutter flow line. This may be achieved through cuts in median concrete or curb spacing.

b. Curb Extensions on open ditch streets are subject to Houston Public Works review and approval.

17.3.02.D Median Refuge Islands

1. Median Refuge Islands are protected spaces located in the center of the roadway to allow for safe crossings in stages. Median Refuge Islands enable bicyclists and pedestrians to cross a single direction of traffic at a time, thereby limiting pedestrian and bicyclist exposure to traffic.

17.3.02.D continued

2. Median Refuge Islands at unsignalized locations must be recommended as part of a Corridor Crossing Analysis report, as defined in Section 17.3.03.

3. Crossings through an existing median or at an unsignalized intersection with an existing median are not considered Median Refuge Islands for the purpose of these standards; however, many of the standards and guidelines presented here may be utilized as applicable for those crossings.

4. Materials

   a. Median Refuge Islands shall be constructed with a suitable material to discourage driver encroachment.

   b. The preferred treatment is standard concrete curb with a fill of sod or other Green Infrastructure. Concrete fill may be used.

5. Geometry

   a. Median Refuge Island dimensions shall meet the minimums established in Table 17.3.

   b. The front edge of the Median Refuge Island shall be rounded to discourage the accumulation of roadway debris.

   c. The Walkway through the Median Refuge Island may be either cut-through or ramped:

      (1). For Median Refuge Islands less than 20-ft width, a cut-through design is required.

      (2). For Median Refuge Islands greater than 20-ft width, a Walkway with ramps shall be used to keep debris from accumulating and to increase the height of pedestrians to make them more visible to drivers.

   d. Detectable warning surfaces shall be provided at the entrance and exit of the Median Refuge Island and at both roadway edges as part of accessible curb ramps.

6. See Figure 17.11 for a conceptual design of a Median Refuge Island. This figure is for reference only and does not constitute design standards.

17.3.02.D
continued

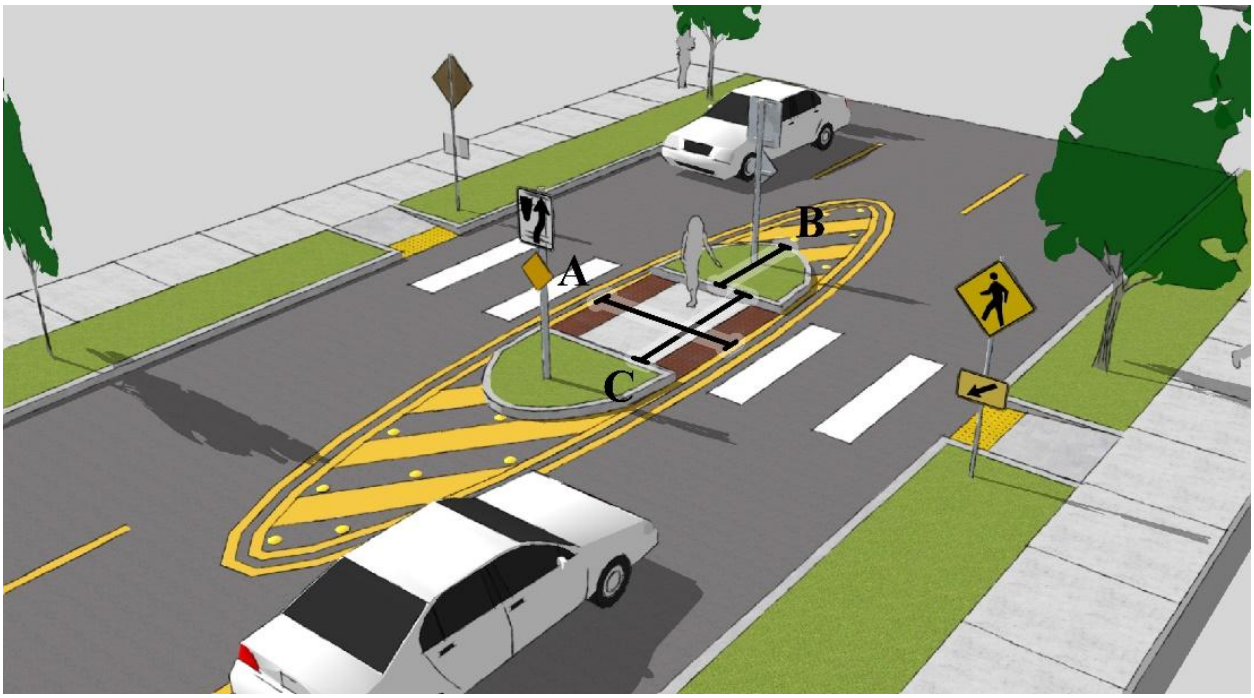


Figure 17.11 – MEDIAN REFUGE ISLAND WITH WIDTH (A), LENGTH (B) AND WALKWAY WIDTH (C)

Table 17.3 – MINIMUM DIMENSIONS FOR MEDIAN REFUGE ISLANDS

Design Element[2]	Label	Minimum (ft) [1]
Median Refuge Width	A	8
Median Refuge Length	B	6
Walkway Width	C	6

Notes:

(1) Dimensions measured from face of curb to face of curb.

(2) See Figure 17.11 for an example of design elements

7. Signage and Pavement Markings

17.3.02.D.7 continued

a. Median Refuge Islands installed on undivided roadways will be treated as a roadway obstruction and shall follow all TMUTCD requirements for markings and signage.

b. The approach edge of the Median Refuge Island shall utilize retroreflective treatments. If it is a curb, the curb shall be painted with retroreflective paint. Yellow paint shall be used when the Median Refuge Island is located between opposing directions of traffic. White paint shall be used when the Median Refuge Island is located between lanes in the same direction.

c. A Keep Right sign (R4-7) shall be installed in the center of the Median Refuge Island near the approach edge.

d. Signing and striping for the crosswalks shall comply with Section 17.3.03.C - Crossing Treatments.

8. Street lighting shall be installed in the vicinity of the Median Refuge Island. See Chapter 15, Section 15.2.13 - Streetlight Design Requirements.

9. The height of any Median Refuge Island features, such as landscaping, that could restrict visibility of road users shall be no greater than four (4)-ft from the roadway surface.

10. All Median Refuge Islands must comply with all requirements defined in 17.3.02 - Intersections and Midblock Crossings and with Standard Details 02760-10, 02760-11 and 02760-12.

11. Guidelines

a. Median Refuge Islands can be located at intersections or midblock.

b. Z-style Walkways within the Median Refuge Islands are preferred to increase the chance that a pedestrian can see a conflicting vehicle before entering the road and to slow movements by bicyclists and other higher-speed users.

c. When extra visibility is required, such as when site conditions make street lighting challenging, reflective bollards should be installed along the approach edge of the Median Refuge Island.

d. A Median Refuge Island should not be placed in front of or near a driveway unless access control into or out of the driveway is specifically desired. Coordination with Houston Public Works will be required whenever access to a driveway is impacted.

17.3.02.D continued

12. Sod or other LID features may be preferable in the median if adequate drainage is provided and with Houston Parks and Recreation Department approval. Additional landscaping shall require an approved maintenance agreement.

17.3.02.E Raised Crosswalks

1. Raised Crosswalks provide a crossing that brings the level of the roadway up to the level of the Sidewalk. Raised Crosswalks increase visibility of Vulnerable Road Users, which can improve safety for all road users. Figure 17.12 and Figure 17.13 show conceptual designs of Raised Crosswalks. These figures are for reference only and do not constitute design standards.



Figure 17.12 - RAISED CROSSWALK ON A TWO-WAY, UNDIVIDED ROADWAY

17.3.02.E
continued



Figure 17.13 - RAISED CROSSWALK ON A ONE-WAY ROADWAY WITH A Z-STYLE CROSSING

2. Raised Crosswalks may be installed at intersections, midblock, as part of trail crossings, pedestrian and bicyclist crossings at roundabouts, or other locations where approved by City Traffic Engineer or designated approver.

3. Raised Crosswalks at unsignalized locations, shall only be installed where determined by Corridor Crossing Analysis report and approved by City Traffic Engineer, as defined in 17.3.03.B.

4. Geometry

   a. Raised Crosswalks shall follow the design standards established in Table 17.4.

   b. Figure 17.14 demonstrates the platform width (W), approach slope (S_a) and departure slope (S_d) and Figure 17.15 demonstrates the height (H).

   c. Raised Crosswalks on undivided roadways shall have an identical approach and departure slope. On divided and one-way roadways, the approach and departure slopes shall vary according to Table 17.4.

Table 17.4 – RAISED CROSSWALK DIMENSIONS AND SLOPE

Classification & Speed (85th % or posted)	Platform Width W (ft)	Height H (in)	Undivided	Divided/ 1-Way	
			Approach & Departure Slope S_a & S_d	Approach Slope S_a	Departure Slope S_d
Unclassified 30 MPH or less	10	6	1:15	1:15	1:35
Classified 30 MPH	20	4	1:20	1:15	1:35
Classified 35 MPH	20	4	1:25	1:20	1:35
Classified 40 MPH	20	4	1:25	1:25	1:35

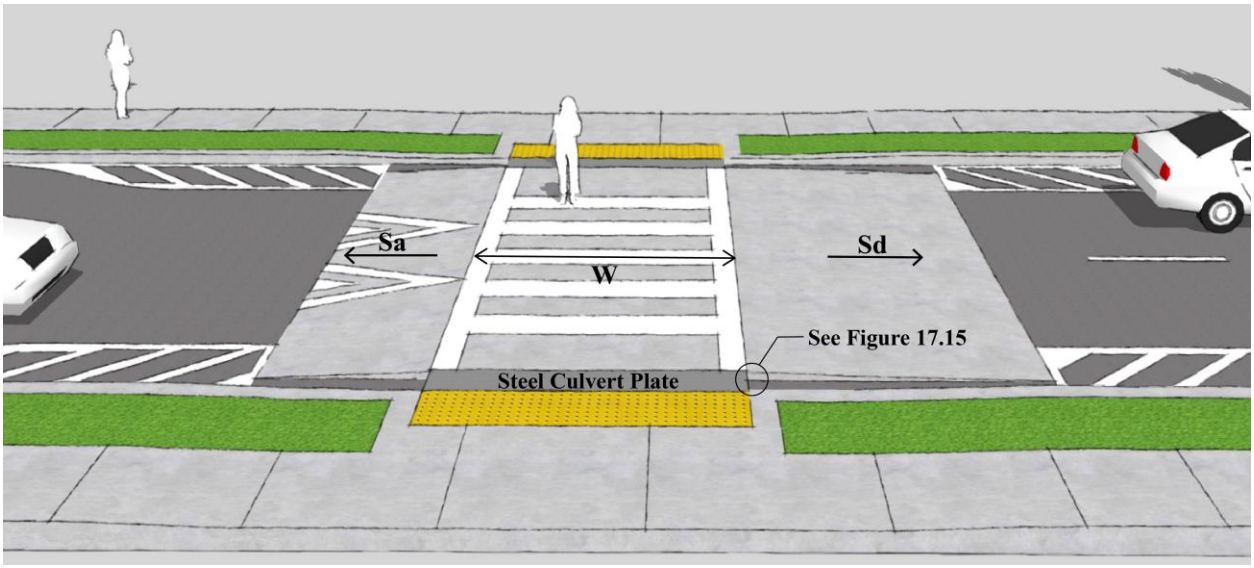


Figure 17.14 – RAISED CROSSWALK ON A ONE-WAY ROADWAY WITH THE APPROACH SLOPE (S_a), DEPARTURE SLOPE (S_d) AND PLATFORM WIDTH (W)

17.3.02.E
continued

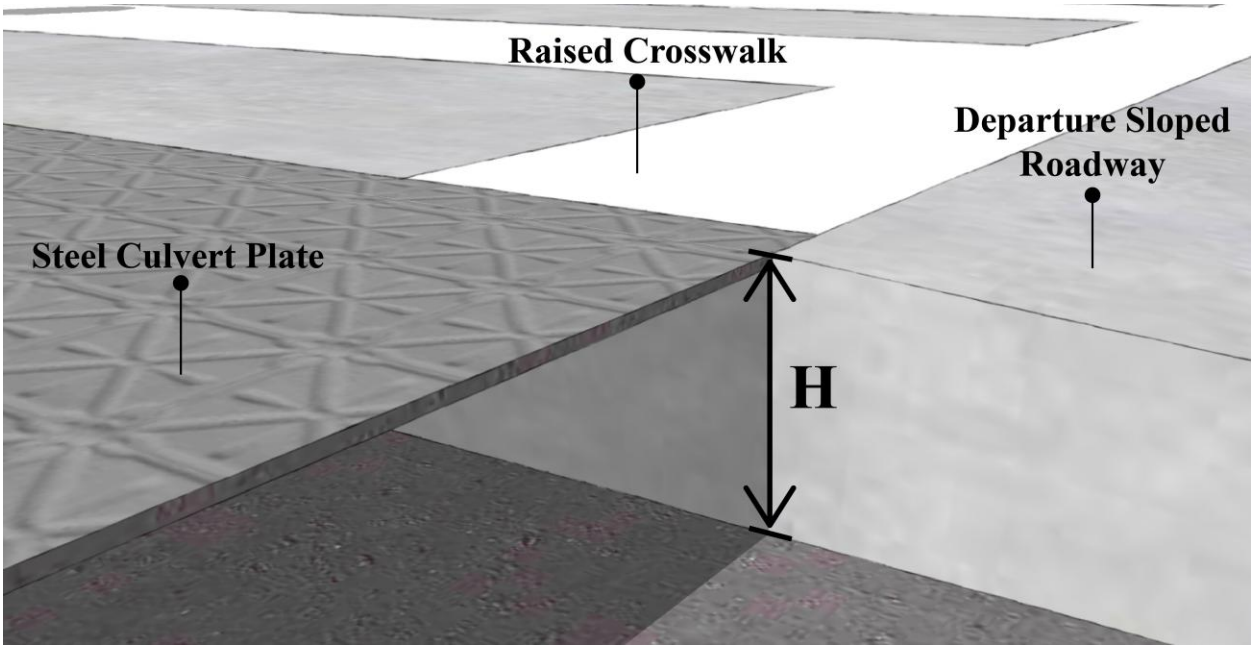


Figure 17.15 – DEMONSTRATION OF RAISED CROSSWALK HEIGHT (H)

5. Signage and Pavement Markings

    a. All Raised Crosswalks shall provide High-Visibility Crosswalk or dual-use crossing markings.

    b. White retroreflective chevron markings, consistent with those shown on Standard Detail 13501-01, shall be installed on the sloped part of the Raised Crosswalk on the approach section.

    c. Whenever a drainage gap is approved, drivers shall be guided away from the gap. At a minimum, pavement markings shall be provided consisting of retroreflective edge lines and white hatched tapers compliant with lane narrowing requirements in the Texas Manual on Uniform Traffic Control Devices.

    d. Signing and striping for the crosswalks shall comply with Chapter 15, Section 15.2.06.B.4 - Crosswalks and Section 17.3.03.C - Crossing Treatments.

6. Drainage

    a. Raised Crosswalk design shall fully accommodate drainage. A Raised Crosswalk shall not create new ponding of stormwater.

17.3.02.E.6 continued

b. For classified collector and major thoroughfare streets and any street with a posted speed of 35 mph or higher:

(1). Raised Crosswalks shall be installed on a high point of the gutter flow line or a new storm inlet with appropriate connections installed on the upstream side of the Raised Crosswalk.

c. For Local Streets:

(1). Raised Crosswalks should be installed on a high point of the gutter flow line or a new storm inlet with appropriate connections installed on the upstream side of the Raised Crosswalk.

d. Roundabouts with Raised Crosswalks shall include inlets upstream on the legs of the roundabout to avoid ponding in the inscribed circle.

e. A minimum eighteen (18)-in gap shall be provided to preserve the gutter flow. An easily removable steel plate shall be provided over the drainage gap at the level of the Raised Crosswalk. Retroreflective edge lines and hatch markings shall be provided to guide drivers away from the gap.

7. Street lighting shall be installed in the vicinity of the Raised Crossing. See Chapter 15, Section 15.2.13 – Streetlight Design Requirements.

8. Guidelines

a. Raised Crosswalks can be located at intersections or midblock.

b. Raised Crosswalks may be placed on median-divided roadways such that a Z-style Walkway is created within the median (see Figure 17.13). Z-style crossings are preferred to increase the chance that a pedestrian can see a conflicting vehicle before entering the road and to slow movements by bicyclists and other higher-speed users.

c. A Raised Crosswalk shall not be placed in front of a driveway unless access control into or out of the driveway is specifically desired. Coordination with Houston Public Works will be required whenever access to a driveway is impacted.

17.3.02.F For safe crossings at Roundabouts see Chapter 10, Section 10.3.02.F - Roundabout Intersections.

17.3.03 CORRIDOR CROSSING ANALYSIS AND TREATMENTS

17.3.03.A General

1. Legal crosswalks exist at most intersections, regardless of presence of signage or striping (Texas Transportation Code Chapter 552.003). Most crosswalks across minor streets do not require any special treatment.

2. New crossings or modifications to existing crossings for Vulnerable Road Users at unsignalized locations must be recommended as part of a Corridor Crossing Analysis as defined in 17.3.03.B and require approval by Houston Public Works.

3. Trail crossings at classified roadways (MTFP) shall follow the general crossing analysis methodology described below. Trail crossings at local streets should follow the criteria in Section 17.3.03.D - Special Case: Midblock Trail Crossing at Local Streets.

17.3.03.B Corridor Crossing Analysis

1. Applicability and Scope

   a. All new marked crosswalks at unsignalized locations must be recommended as part of a Corridor Crossing Analysis. All enhancements to an existing marked crosswalk shall also require a Corridor Crossing Analysis to justify the enhancements.

   b. The requirements of this section apply to improvements to a single location and to a corridor with multiple crossing locations. Both situations require an assessment of corridor conditions between existing crossing locations that meet the requirements of this section. A full corridor assessment assures that new crossing locations do not preclude other high-demand crossing locations.

   c. Special cases may be appropriate for the assessment of a single crossing location instead of a corridor assessment. Such cases may include a trail crossing location that is dictated by the geometric constraints of the trail corridor. Any Crossing Analysis of a single site instead of a full corridor requires Transportation and Drainage Operations approval.

   d. Note: This section does not provide requirements for the installation timeline of any crossing improvement. It only provides the requirements for acceptable locations for crossings and infrastructure treatments.

2. Corridor Crossing Analysis Report

17.3.03.B.2 continued

a. A Corridor Crossing Analysis report shall summarize all data, analysis, and recommendations required by this section. The report must be signed/sealed by a registered Professional Engineer and submitted to Houston Public Works for approval by the City Traffic Engineer or designated approver.

b. Corridor Crossing Analysis Reports shall recommend locations for crossings using the methodology in this section and shall recommend treatments for each crossing using the methodology in Section 17.3.03.C - Crossing Treatments.

3. Siting of Enhanced Crossings

a. Crossing enhancements may be provided midblock or at an unsignalized intersection. New midblock crossings shall be at least 100-ft from an intersection.

b. A Corridor Crossing Analysis shall result in safe, convenient crossings for Vulnerable Road Users spaced approximately every 500-720 feet. This distance ensures that no Vulnerable Road User must travel more than 360 feet (approximately two (2) minutes at three (3) ft/s walking speed) out of their way to reach an established crossing location. Closer spacing may be appropriate depending on land use and context.

(1). Note: Traffic signals, all-way stops, and modern roundabouts may be considered roadway treatments with acceptable crossings.

c. The locations of Enhanced Crossings recommended by a Corridor Crossing Analysis shall:

(1). Maintain spacing standards for the next adjacent designated crossing on either side of the proposed crossing location.

(2). Ensure that future, potentially desirable crossing locations can be installed according to the spacing standards.

(3). Use the following criteria to identify and prioritize crossing locations:

(a). Trail crossings

(b). Bus/transit stops

(c). Houston Bike Plan

17.3.03.B.3.c.(3) continued

(d). Schools, especially where students are expected to cross at the location

(e). Adjacent parks

(f). Adjacent churches

(g). Other significant pedestrian generators

(h). High-crash location along the corridor

(i). Desire Lines or other indications of existing pedestrian activity.

17.3.03.C Crossing Treatments

1. General Considerations for Crossing Treatments

   a. Crossing Treatments define the details of traffic control associated with various types of unsignalized crossings for Vulnerable Road Users. Specific Crossing Treatment requirements are included in Section 17.3.03.C.3.

   b. All new or enhanced marked crossings at unsignalized locations shall comply with these standards. The type of crossing and specific location of an Enhanced Crossing shall be defined by a Corridor Crossing Analysis (see Section 17.3.03.B).

   c. All Enhanced Crossings must be recommended by a Corridor Crossing Analysis or required by another section of this manual. All other Enhanced Crossings require approval by Transportation and Drainage Operations.

   d. Street lighting shall be provided at Enhanced Crossings to illuminate the crosswalk where approved by Houston Public Works.

   e. Pavement markings shall be used to define all midblock crossing locations.

   f. All Enhanced Crossings shall be fully ADA-compliant and provide curb ramps that meet design requirements of Section 17.3.02.A.

2. Selection of Appropriate Crossing Treatments:

   a. An existing or proposed treatment shall satisfy all applicable City standards for that treatment before it may be considered an Enhanced Crossing.

17.3.03.C.2 continued

b. New crossings shall provide a pedestrian Level of Service (LOS) E or better and have a calculated pedestrian delay less than 30 seconds based on the Pedestrian Mode methodology in the Two-Way STOP-Controlled Intersections chapter of the Highway Capacity Manual (latest edition). This methodology applies to Two-Way STOP-Controlled intersections and midblock crossings.

c. The simplest option that would achieve the required pedestrian LOS shall be used.

d. Prior to choosing a Crossing Treatment, alternatives shall be considered for reducing the crossing distance for the Vulnerable Road User, which impacts the pedestrian LOS. This reduction can be achieved with lane narrowing, lane repurposing, and curb extensions.

e. Crossings at existing medians shall be considered a two-stage crossing for the analysis if the crossing satisfies or will be retrofitted to satisfy all applicable requirements for a Median Refuge Island.

f. A combination of Crossing Treatments may be utilized; the highest yield rate of the combination should be used for the analysis unless a justifiable combined yield rate is available.

g. Other treatments may be acceptable; however, it will be the responsibility of the requestor to present justifiable yield rates.

h. Satisfaction of these requirements shall constitute an acceptable Corridor Crossing Analysis for the approved toolset defined above. The Corridor Crossing Analysis must be approved by Houston Public Works before the treatment may be installed.

3. Enhanced Crossing Treatments

a. High-Visibility Signs and Markings. See Section 17.3.03.C.4 - High-Visibility Signs and Markings.

b. Raised Crossing. See Section 17.3.02.E - Raised Crosswalks.

c. Curb Extensions. See Section 17.3.02.C - Curb Extensions.

d. Median Refuge Islands. See Section 17.3.02.D - Median Refuge Islands.

e. Rectangular Rapid Flashing Beacons (RRFBs)

17.3.03.C.3.e continued

(1). RRFBs are pedestrian-actuated enhancements used in combination with a pedestrian, school, or trail crossing warning sign to improve safety at uncontrolled, marked crosswalks. The device includes two rectangular-shaped yellow indications, each with an LED-array-based light source, that flash with high frequency when activated.

(2). RRFBs shall include Level B or C high-visibility signs and markings, as defined in Section 17.3.03.C.4 - High-Visibility Signs and Markings.

(3). RRFB indicators shall be provided on both sides of the road for each approach, to ensure that drivers are aware that pedestrians may begin crossing from either side. This applies to both divided roads and undivided roads.

f. Pedestrian Hybrid Beacons (PHBs or HAWKS) are a special type of traffic control device used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk. PHBs are made up of a signal head in three sections, consisting of two horizontally arranged circular red sections over a single circular yellow section that is centered between the red lights.

4. High-Visibility Signs and Markings

a. Where a Corridor Crossing Analysis recommends high-visibility signs and markings, or where another kind of Crossing Treatment requires high-visibility signs and markings, the signs and markings shall follow the requirements of this section.

b. General Signage and Pavement Marking Requirements:

(1). For pedestrian-only crossings, white High-Visibility Crosswalk markings shall be used.

(2). For shared use midblock crossings, dual use markings shall be used, consisting of a series of white strips flanked by square bicycle-green pavement markings (refer to Standard Detail 02760-10).

(3). For median-divided roadways, all signs required by this standard shall be mirrored on either side of a direction of travel.

17.3.03.C.4.b continued

(4). Roadways with more than one lane in each direction, require R1-5b "Stop Here to Pedestrians" (pedestrian-only crossing) or R1-5PBb "Stop Here to Pedestrians and Bicyclists" (shared-use crossing) signage and stop bars (refer to Standard Detail 02760-10).

Table 17.5 – LEVEL OF TREATMENT CRITERIA SUMMARY

ADT	Speed Limit	4 Lanes with Median	2 Lanes without Median	4 Lanes without Median
≤5,000	≤ 30 mph	A	A	A
	> 30 mph	A	B	C
5,000 – 15,000	≤ 30 mph	B	B	B
	> 30 mph	C	C	C*
>15,000	≤ 30 mph	C	C*	C*
	> 30 mph	C*	C*	C*

* Indicates that high-visibility signs and markings may not be sufficient for these crossings and should be combined with higher level treatments.

c. The following levels of treatment are specified for pavement markings and signage at locations with characteristics specified by Table 17.5.

(1). Level A = Crossing pavement markings only

(a). Install, as appropriate, white High-Visibility Crosswalk markings (pedestrian-only crossing) or dual use crossings (shared-use crossing).

(2). Level B = Advance warning signage + Level A

(a). Install, as appropriate, white High-Visibility Crosswalk markings (pedestrian-only crossing) or dual use crossings (shared-use crossing).

(b). Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-9P AHEAD (plaque) mounted on the side of the roadway in advance of the crossing.

17.3.03.C.4.c.(2) continued

(c). Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-7PL diagonal downward arrow plaque mounted on the side of the roadway at the crossing.

(3). Level C = Additional pavement markings + Level B

(a). Install, as appropriate, white High-Visibility Crosswalk markings (pedestrian-only crossing) or dual use crossings (shared-use crossing).

(b). Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-9P AHEAD (plaque) mounted on the side of the roadway in advance of the crossing.

(c). Install W11-2 pedestrian warning sign (pedestrian-only crossing) or W11-15 pedestrian/bicycle warning sign (shared-use crossing) with W16-7PL diagonal downward arrow (plaque) mounted on the side of the roadway at the crossing.

(d). Install "PED XING" (pedestrian-only crossing) or "BIKE XING" (shared-use crossing) advanced pavement marking.

17.3.03.D Special Case: Midblock Trail Crossings at Local Streets

1. Trails that cross classified roadways (MTFP) shall follow the Corridor Crossing Analysis methodology described above. Trails that cross midblock on local streets (i.e. not on the MTFP) shall follow the below criteria.

2. Trails that cross local streets should first determine whether the trail, street, or both are stop-controlled.

   a. If the street ADT is greater than 1,000, then the general crossing analysis methodology should be used to determine appropriate Crossing Treatments.

   b. If the street ADT is less than or equal to 1,000, then the road shall be stop-controlled and the trail shall be free-flow, unless there is an identified visibility concern, in which case the trail should also be stop-controlled.

17.3.03.D.2 continued

c. If the street is proposed to be stop-controlled, stop bars, stop ahead signage, and pedestrian/bicycle warning signage shall be provided on the street approaches.

d. Install dual use crossings (shared-use crossing) for the trail crossing.

SECTION 4 - BIKEWAY FACILITY REQUIREMENTS

17.4.01 GENERAL BIKEWAY FACILITY REQUIREMENTS

17.4.01.A Guides and Standards

1. The City of Houston uses the Houston Bike Plan as a guide to determine type and location of Bicycle Facilities. Street design should incorporate the Houston Bike Plan Network. Any street can include safe Bicycle Facilities even if not on the Houston Bike Plan Network.

2. The City of Houston encourages Bicycle Facility design standards that exceed the requirements in this section. The following standards should be utilized when designing Bicycle Facilities: AASHTO Guide for the Development of Bicycle Facilities, FHWA Separated Bike Lane Planning and Design Guide, and NACTO Urban Bikeway Design Guide.

3. The type of Bicycle Facility shall be determined using the Bicycle Facility Type Decision Matrix (see Figure 17.16).

4. Bicycle Facilities that change the number/type/width of existing lanes shall require a Traffic and Design Study as defined in Chapter 15, Section 15.2.02.

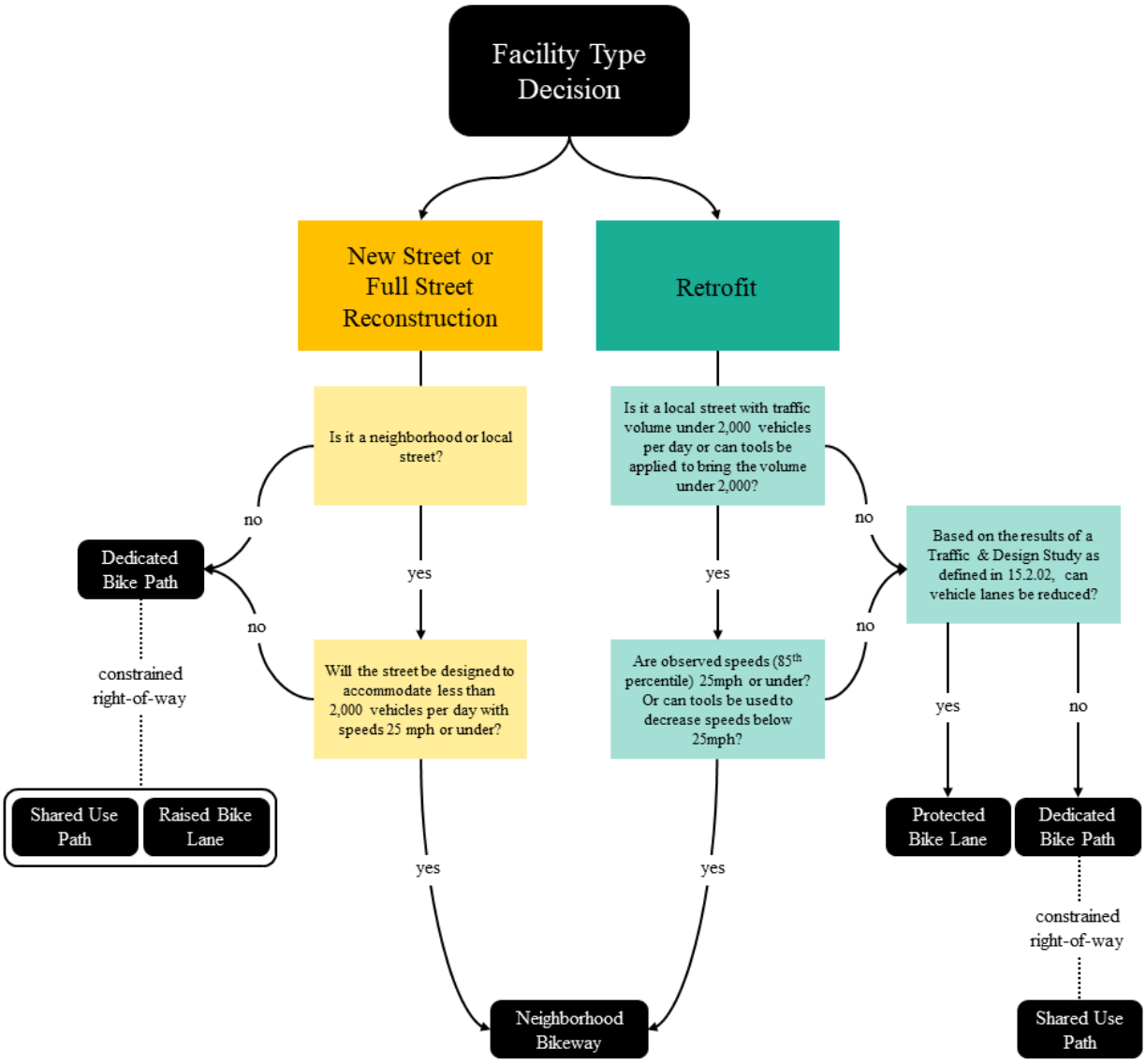


Figure 17.16 - BICYCLE FACILITY TYPE DECISION MATRIX

17.4.01.B Curb Management

1. Curb Management shall be incorporated in all Bicycle Facility designs.

2. Curb Management may consist of solid waste, recycling, and heavy trash services, school queues, parcel and mail delivery, and loading zones.

17.4.01.C Bicycle Parking

1. Bicycle parking includes bike racks, Bicycle Corrals and any other designated space to store bicycles.

17.4.01.C.1 continued

a. Bike Rack: A fixture upon which one or more bicycles may be parked.

b. Bicycle Corral – A group of bike racks installed adjacent to the curb in the parking lane of the roadway or in the area of Curb Extensions (see Section 17.3.02.C). Bicycle Corrals are often sited near the intersection in areas where space behind the curb is limited.

2. Bicycle parking shall be included in the design of all Bicycle Facilities where feasible. Bicycle parking may be added to existing Bicycle Facilities.

3. Bicycle parking may be provided in many configurations subject to City of Houston approval. The City of Houston preference is a 'U' rack (refer to Standard Detail 02871-01). The guidelines for spacing of multiple 'U' racks is available in Table 17.6 – 'U' Rack Spacing Standards and Standard Detail 02871-01.

Table 17.6– 'U' RACK SPACING STANDARDS

Location	Orientation	Minimum	Preferred
Between Racks	Side-by-Side	3'-0"	4'-0"
	End-to-end	6'-0"	8'-0"
From Back of Curb	Perpendicular	2'-0"	3'-0"
	Parallel	2'-0"	3'-0"
From Wall	Perpendicular	4'-0"	-
	Parallel	3'-0"	-
From Obstruction*	All	3'-0"	4-0"
From Crosswalk	Perpendicular	5'-0"	-

* Streetlights, trees, sidewalk furniture, traffic signs or posts, parking meters, utility facilities/covers, etc.

4. Bicycle Parking Siting Guidelines

a. Land Use: Sites along a Bicycle Facility should be prioritized based on nearby land uses. These land uses include commercial, retail, libraries, parks, community centers, other public institutions, medical centers and sports facilities.

17.4.01.C.4 continued

b. Transportation: Locations that allow for connections to additional transportation opportunities should be prioritized, such as METRO bus; Bus Rapid Transit (BRT) or Light Rail Transit (LRT) stations; Houston Bicycle stations; a high density of Micromobility options; or car sharing locations.

c. Existing Conditions: Avoid locating bike racks in areas where public utilities or emergency services are present or in locations that are prone to flooding.

d. Bicycle Facility Type: Bike racks may be installed off-street (see 17.4.01.C.5) or on-street (see 17.4.01.C.6).

e. Lighting is an important component of safe and secure bicycle parking. If good nighttime lighting does not already exist, then nighttime lighting shall be provided wherever bike parking is installed.

5. Off-Street Bicycle Parking

a. Bike racks shall not impede the minimum Sidewalk width and shall have a clearance zone of 4-ft x 6-ft (refer to Standard Detail 02871-01).

b. Racks must be oriented so that users can safely enter and exit without conflicting with motorists or pedestrians.

c. Bicycle parking should have a minimum of two (2) ‘U’ racks installed per bicycle parking location.

d. Bicycle parking installed by any entity besides the City of Houston or an entity with an established maintenance agreement shall apply for a bike rack encroachment permit with the Office of the City Engineer.

e. Custom elements, such as non-standard racks or bicycle parking shelters, are subject to approval by the City of Houston and require a maintenance agreement.

6. On-Street Bicycle Parking (aka “Bicycle Corrals”)

a. Bicycle Corrals will consist of bike racks located within the public right-of-way at street grade. See Figure 17.17 for a conceptual design of Bicycle Corrals. This Figure is for reference only and does not constitute design standards.

17.4.01.C.6
continued



Figure 17.17 – ON-STREET BICYCLE PARKING

b. All proposed Bicycle Corrals require approval by the City Traffic Engineer.

c. Bicycle Corrals should be installed near intersections or driveways to create necessary sight distance clearances for motorists (see subsection 17.3.02.C - Curb Extensions). Bicycle Corrals may be installed in place of on-street parking, including midblock locations.

d. Bicycle Corrals must be oriented so that bicyclists can safely enter and exit without conflicting with motor vehicles or pedestrians.

e. Bicycle Corrals should provide six (6) or more 'U' racks for bicycle parking. The minimum number of 'U' racks installed at a Bicycle Corral shall be three (3).

f. Bicycle Corrals must include delineation that complies with the delineation requirements of Curb Extensions. See Section 17.3.02.C - Curb Extensions.

g. Custom elements, such as non-standard racks or bicycle parking shelters, are subject to approval by the City of Houston. Custom elements require a maintenance agreement.

17.4.01.D Wayfinding

17.4.01.D continued

1. Wayfinding is made up of directional signage, confirmational signage, decision signage and pavement markings that guide bicyclists along High-Comfort Bicycle Facilities and to certain destinations such as neighborhoods, parks, and trail entry points.

    a. Directional signs indicate to bicyclists the direction in which a Bicycle Facility continues.

    b. Confirmational signs indicate to bicyclists that they are on a Bicycle Facility and make motorists aware of the Bicycle Facility.

    c. Decision signs mark the junction of two or more bikeways and inform bicyclists of the designated bike route to access key destinations.

2. Wayfinding signage and pavement markings shall be provided for all Bicycle Facilities in addition to regulatory signage and standard bike facility pavement markings.

3. This section applies generally to all Bicycle Facility types. Individual Bicycle Facilities may have additional wayfinding requirements. See Bicycle Facility design standards for more details.

4. General requirements for usage of Houston Bikeways signage:

    a. The Houston Bikeways Bike Route, Bike Route Ahead and Bike Route Ends signs shall only be used along High-Comfort Bicycle Facilities.

    b. The Houston Bikeways Bike Route sign (D11-1 MOD HB) shall be used along all High-Comfort Bicycle Facilities as a confirmational, directional, and decision sign and shall be placed at regular intervals no more than ½ mile apart and directly preceding all intersections with other High-Comfort Bicycle Facilities.

    c. A Houston Bikeways Bike Route Ahead (D11-1 MOD HB-A) confirmational and directional sign shall be included at the beginning of all High-Comfort Bicycle Facilities. This shall be substituted with a Bike Lane Ahead sign on Raised or Protected Bike Lanes.

    d. A Houston Bikeways Bike Route Ends (D11-1 MOD HB-E) sign shall be included at the end of all High-Comfort Bicycle Facilities. This shall be substituted with a Bike Lane Ends sign on Raised or Protected Bike Lanes.

5. At all intersections of multiple High-Comfort Bicycle Facilities:

17.4.01.D.5 continued

a. Include Houston Bikeways Bike Route sign on all bicycle approaches to the intersection.

b. A modified Houston Bikeways Bike Route directional sign shall indicate with arrows the direction of all High-Comfort Bicycle Facilities (e.g. left, right and forward arrows).

c. Destination placards (D1-1c, 2c, 3c) shall be added underneath the Houston Bikeways Bike Route sign as decision signs to indicate the direction and distance of destinations.

(1). Destinations should generally be neighborhoods; public parks; nearby streets; trail entrances; Bus Rapid Transit (BRT) or Light Rail Transit (LRT) stations; or other locations of community importance; and be accessible via High-Comfort Bicycle Facilities from the sign location.

(2). Other destination types shall require approval by Houston Public Works.

17.4.01.E Railroad Crossings

1. Where Bicycle Facilities cross a street-surface rail track, bicyclists should be directed to cross tracks at a safe angle (90 degrees preferred, 60 degrees minimum) so that bicycle tires do not become stuck in rail flanges.

2. If preferred crossing angle is not possible, a warning sign (W10-1 or W10-12) shall be placed in advance of the rail crossing alerting the bicyclist of skewed railroad crossing.

3. In the presence of uneven railroad tracks, a warning sign (W10-6) should be installed.

4. Where Bicycle Facilities cross Light Rail Transit (LRT) tracks, a warning sign (W10-1) shall be placed in advance of the rail crossing alerting the bicyclist of the railroad crossing.

17.4.02 HIGH-COMFORT FACILITY TYPE STANDARDS

17.4.02.A Figure 17.18 shows a summary of the types of bicycle facilities as defined by the City and their level of roadway separation. See the following section for a detailed description of each type of facility.

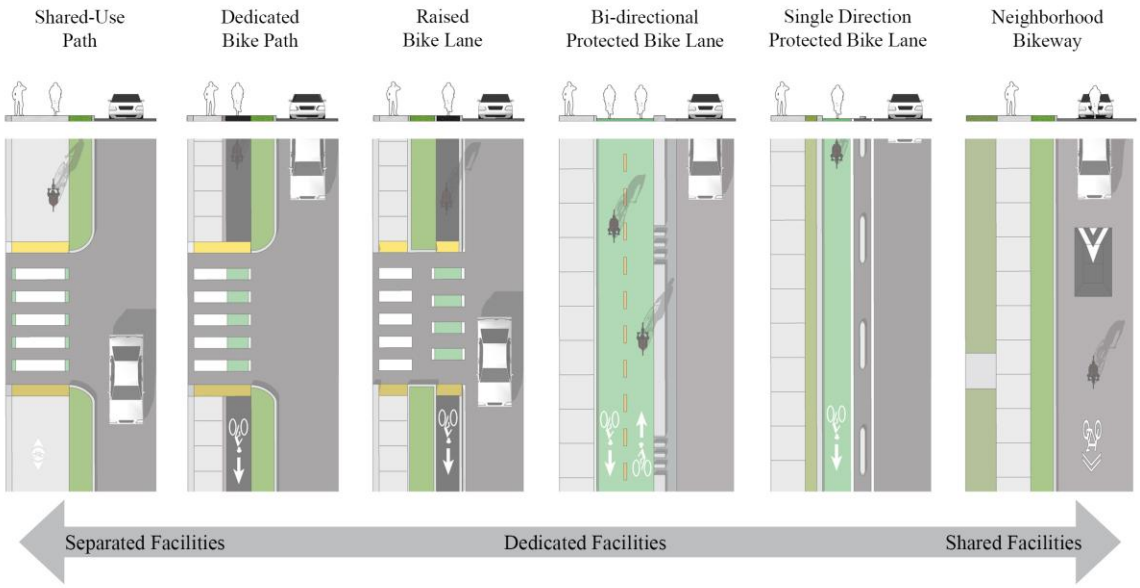


Figure 17.18 – BICYCLE FACILITY TYPES BY LEVEL OF SEPARATION

17.4.02.B Dedicated Bike Path

1. Dedicated Bike Paths are Bicycle Facilities that run alongside a roadway behind the curb within the right-of-way. See Figure 17.19 for a conceptual design of a Dedicated Bike Path. This figure is for reference only and does not constitute design standards.

17.4.02.B
continued

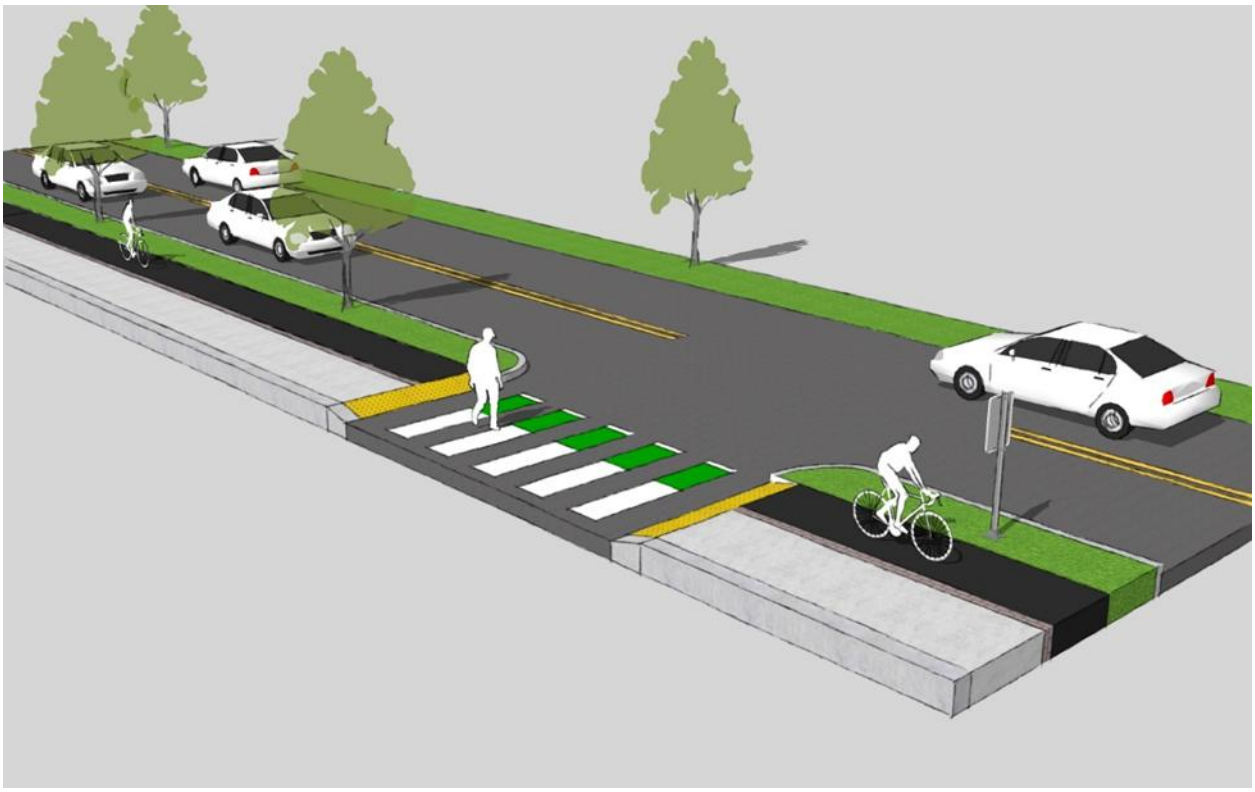


Figure 17.19 – DEDICATED BIKE PATH

2. Dedicated Bike Paths must be at the same grade as the Sidewalk and increase safety by grade-separating bicyclists and people driving.

3. Dedicated Bike Paths must be separated from pedestrian traffic with a physical buffer or with a detectable warning surface.

4. Dedicated Bike Paths may provide single or bidirectional bicycle traffic flow.

5. A Dedicated Bike Path shall maintain a minimum width of six (6)-ft for a single directional bicycle traffic flow and a twelve (12)-ft preferred, ten (10) ft minimum width for bidirectional traffic flow. This is in addition to the width of the pedestrian travel area.

6. A Safety Buffer of at least four (4)-ft shall be provided between the side path and the adjacent motor vehicle lane.

17.4.02.B continued

7. Driveways: Dedicated Bike Paths shall maintain bikeway facility grade at driveways. Dedicated Bike Path pavement materials and striping shall continue across driveways. Warning signage may be placed facing driveways depending on width, traffic volume, and visibility. Refer to Figure 17.2 and Figure 17.3 for pedestrian safety and visibility buffer requirements.

8. Signage:

    a. A Dedicated Bike Path may include signage to indicate separation between the bicyclist and pedestrian facility.

    b. A Bicycle Warning sign (W11-1) shall be implemented at all intersecting streets along the corridor preceding the intersection with the Dedicated Bike Path.

9. General Pavement Markings

    a. Pavement Marking (Symbols): A bicycle symbol and arrow markings shall be used to define Dedicated Bike Paths. Alternative pavement marking symbols are subject to the approval of Houston Public Works. Symbols shall be placed at the beginning of a Bicycle Facility and the start of every block or at regular intervals as necessary to reinforce the intended use. Refer to Standard Detail 02760-04.

    b. Longitudinal Pavement Markings: A dashed yellow line may be used to separate two-way bicycle traffic.

10. Ramps: See Section 17.3.02.A - Curb Ramps and Corner Treatments.

11. Wayfinding:

    a. Signage: See Section 17.4.01.D.

    b. The Pavement Markings required in Section 17.4.02.B.9 are sufficient for Wayfinding.

12. For Dedicated Bike Path design criteria, refer to City of Houston Standard Detail 02760-09.

13. See Section 17.4.01 - General Bikeway Facility Requirements and Section 17.4.03 - Bikeways at Intersections for General Facility Requirements that apply to all bikeway facility types.

17.4.02.C Shared Use Path

1. Shared Use Paths are combined bicycle and pedestrian facilities that run alongside a roadway behind the curb within the right-of-way. See Figure 17.20 for a conceptual design of a Shared Use Path. This figure is for reference only and does not constitute design standards.



Figure 17.20 – SHARED USE PATH

2. Shared Use Paths may provide single or bidirectional bicycle traffic flow.

3. A Shared Use Path shall maintain a minimum width of ten (10)-ft. A width of fourteen (14)-ft in contexts with high pedestrian or bicyclist traffic is preferred.

4. A Safety Buffer of at least four (4)-ft shall be provided between the Shared Use Path and the adjacent motor vehicle lane.

5. Driveways: Shared Use Paths shall maintain bikeway facility grade at driveways. Shared Use Path pavement materials and striping shall continue across driveways. Warning signage may be placed facing driveways depending on width, traffic volume, and visibility.

17.4.02.C continued

6. Signage: A Bicycle Warning sign (W11-1) shall be implemented at all intersecting streets along the corridor preceding the intersection with the Shared Use Path.

7. General Pavement Markings

   a. Pavement Marking (Symbols): A bicycle dot shall be used to define Shared Use Paths. The arrows on the bicycle dot shall be used to guide bicyclists in the direction of the facility. Symbols shall be placed at the beginning of a bike facility and the start of every block or at regular intervals as necessary to reinforce the intended use. Refer to Standard Detail 02760-04.

   b. In a bidirectional Shared Use Path, a bike dot with arrows in both directions of travel is required.

   c. In a single direction Shared Use Path, a bike dot with one or more arrows pointing in the direction of bicycle traffic shall be used.

   d. Alternative pavement marking symbols for single direction Shared Use Paths and/or where there may be opportunities for Placemaking are subject to approval by Houston Public Works.

8. Wayfinding:

   a. Signage: See Section 17.4.01.D.

   b. The Pavement Markings required in Section 17.4.02.C.7 are sufficient for Wayfinding.

9. Ramps: See Section 17.3.02.A - Curb Ramps and Corner Treatments.

10. See Section 17.4.01 - General Bikeway Facility Requirements and Section 17.4.03 - Bikeways at Intersections for General Facility Requirements that apply to all bikeway facility types.

17.4.02.D Raised Bike Lane

1. Raised Bike Lanes are grade-separated Bicycle Facilities that shall be at a level between the Sidewalk and the roadway with a minimum three (3)-in and maximum six (6)-in grade separation from the roadway surface. See Figure 17.21 for a conceptual design of a Raised Bike Lane. This figure is for reference only and does not constitute design standards.

17.4.02.D
continued

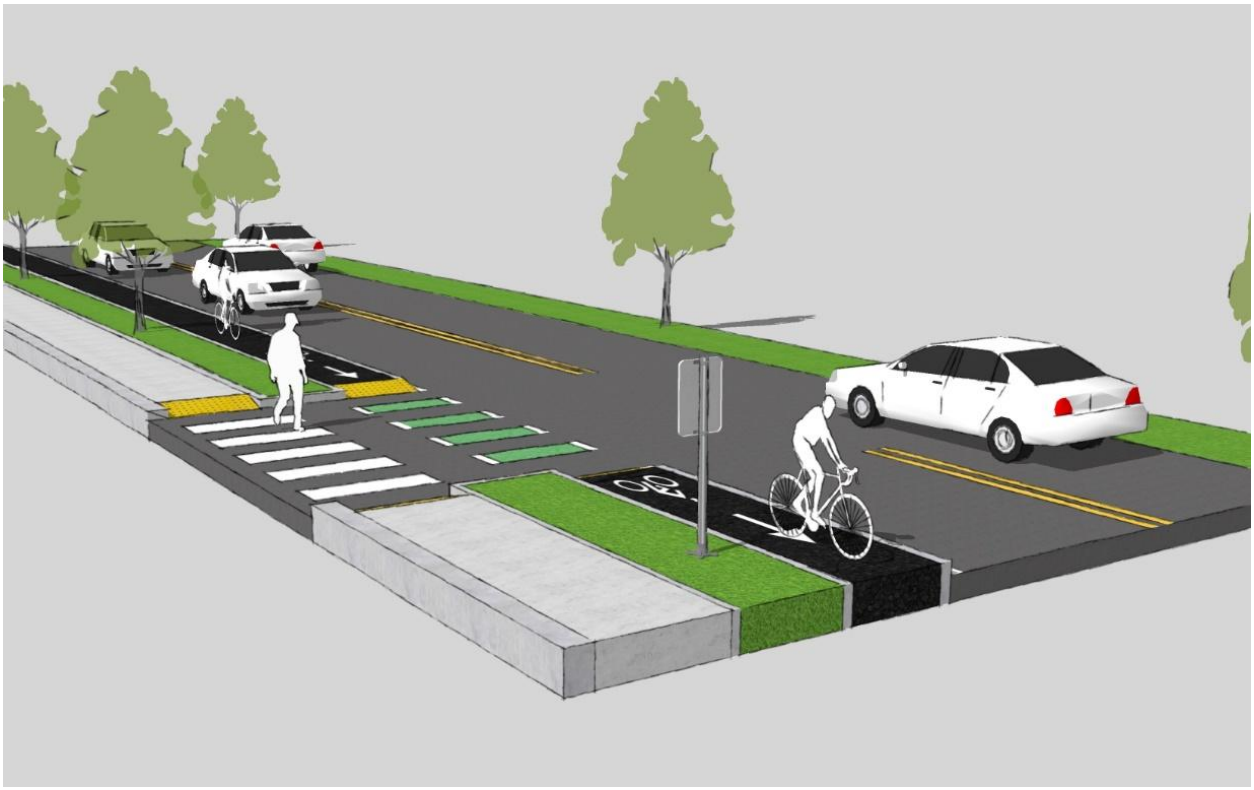


Figure 17.21 – RAISED BIKE LANE

2. Raised Bike Lanes shall be placed immediately adjacent to the vehicle lane.

3. Parking shall be prohibited along Raised Bike Lanes.

4. Raised Bike Lanes shall provide single direction bicycle traffic flow (one-way) only.

5. Raised Bike Lanes should maintain a standard width of six (6)-ft. Raised Bike Lanes cannot be narrower than five (5)-ft. The effective width of the bike lane shall not include the mountable curb.

6. General Pavement Markings

    a. Pavement Markings (Buffer): A six (6)-in solid white line is required between the Raised Bike Lane and the vehicle lane.

17.4.02.D.6 continued

b. Pavement Marking (Symbols): A bicycle symbol and arrow markings shall be used to define bicycle lanes and shall be placed at the beginning of a Bicycle Facility and at the start of every block and at regular intervals as necessary to reinforce the intended use. Refer to Standard Detail 02760-04 for pavement marking details.

c. Pavement Markings (Driveways): Conflict markings shall be used at driveways with high traffic uses, with a width greater than thirty-five (35)-ft, or where consecutive adjacent driveway openings are greater than fifty (50)-ft.

7. Signage:

a. A Bicycle Warning sign (W11-1) shall be implemented at all intersecting streets along the corridor preceding the intersection with the raised bikeway.

b. No Parking in Bike Lane signs (R7-9) should be placed on every block and at regular intervals no more than ½ mile apart.

8. Wayfinding

a. Signage: See Section 17.4.01.D.

b. Pavement Markings: The Pavement Markings required in Section 17.4.02.D.6 are sufficient for Wayfinding.

9. See Section 17.4.01 - General Bikeway Facility Requirements and Section 17.4.03 - Bikeways at Intersections for General Facility Requirements that apply to all Bicycle Facility types.

17.4.02.E Protected Bike Lane (Retrofit)

1. Protected Bike Lanes are On-Street Bicycle Facilities between curb faces with physical delineation between the vehicle lane and bike lane. In Retrofit projects where a Dedicated Bike Path is not feasible, Protected Bike Lanes provide enhanced safety for bicyclists. See Figure 17.22 and Figure 17.23 for conceptual designs of Protected Bike Lanes. These figures are for reference only and do not constitute design standards.

17.4.02.E
continued

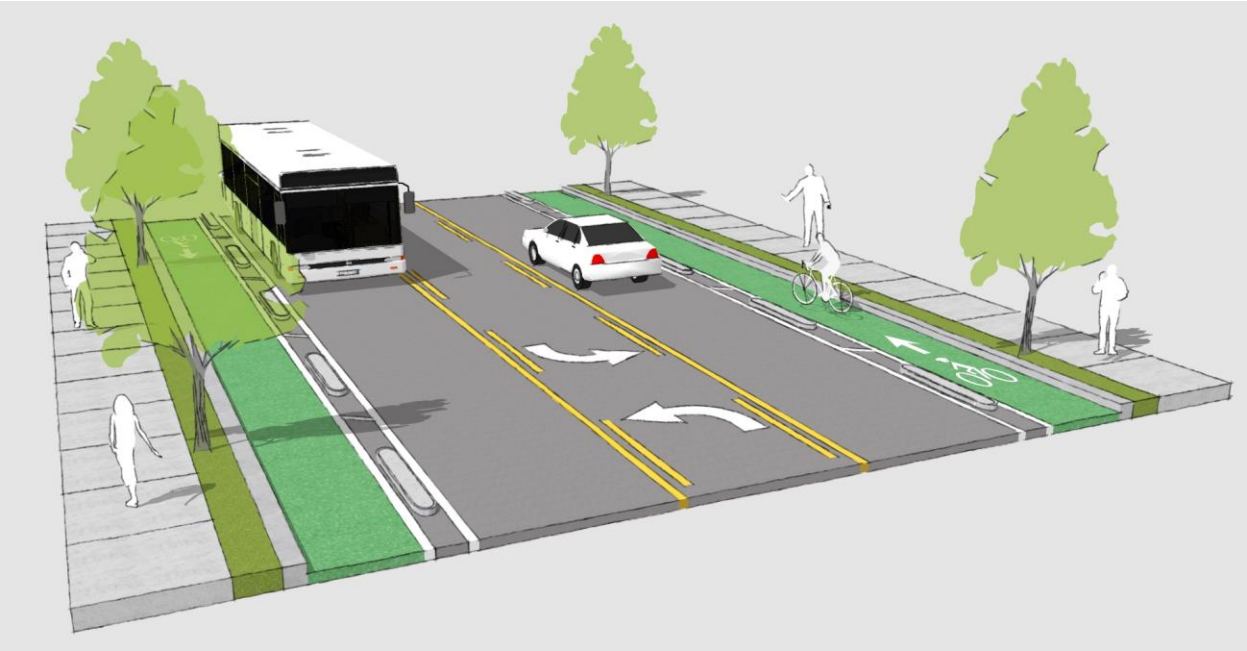


Figure 17.22 – SINGLE DIRECTION PROTECTED BIKE LANE WITH PRE-CAST CURB



Figure 17.23 – BIDIRECTIONAL PROTECTED BIKE LANE WITH CAST-IN-PLACE CURB

2. Protected Bike Lanes may provide single or bidirectional (two-way) bicycle traffic flow.

3. A bidirectional Protected Bike Lane shall maintain a standard width of ten (10)-ft. A one-way Protected Bike Lane shall maintain a standard width of six (6)-ft.

17.4.02.E continued

4. Delineator: A vertical barrier shall be provided to physically separate the bike lane and vehicle lane. Delineators are generally placed in the center of the striped buffer.

    a. The vertical barrier may be discrete elements, such as curb stops or bollards, or a continuous element, such as a concrete median. Delineator selection shall require approval from Houston Public Works.

    b. Delineators shall maintain existing stormwater flow or include improvements to the stormwater drainage system where necessary per Chapter 9. Delineators shall accommodate stormwater runoff at all drainage inlets.

    c. A continuous delineator shall have ten (10)-ft wide openings at least every two hundred fifty (250)-ft to enable bicyclists to exit the bike lane.

        (1). Openings at driveways, intersections and inlets can be used to satisfy this requirement.

    d. Breaks in delineation shall be provided at all driveways. Refer to detail 02760-11 for requirements on placement.

    e. Delineator placement should consider Curb Management such as driveways, solid waste and recycle collection, bus stops, and mail delivery. Use of mountable curb may be desirable to accommodate heavy trash pick-up.

5. General Pavement Markings

    a. Pavement Markings (Buffer): The buffer shall be designed to accommodate and complement the selected delineator device and shall typically be at least three (3)-ft.

        (1). For delineators that are discrete elements, a striped buffer shall be utilized and shall consist of two six (6)-in solid white lines, with six (6)-in diagonal white hatching of three (3)-ft in width or wider. Spacing of hatching should be between ten (10) and forty (40)-ft.

        (2). For delineators that are continuous elements, a six (6)-in solid white line shall be striped on either side.

17.4.02.E.5 continued

b. Pavement Marking (Symbols): A bicycle symbol and arrow markings shall be used to define bicycle lanes and shall be placed at the beginning of a Bicycle Facility and at the start of every block and at regular intervals as necessary to reinforce the intended use. Refer to Standard Detail 02760-04 for pavement marking details.

c. Pavement Markings (Driveways): Conflict markings shall be used at driveways with high traffic uses, with a width greater than thirty-five (35)-ft, or where consecutive adjacent driveways cause a gap in protection greater than fifty (50)-ft.

d. Pavement Markings (Longitudinal): For bidirectional Protected Bike Lanes, a dashed yellow line shall be used to separate two-way bicycle traffic.

6. Signage: Bike Lane signs (R3-17 series) are required at the start, end, and throughout a Bicycle Facility in the direction of travel.

a. Bike Lane signs (R3-17) are required and should be spaced at the start of every block and at regular intervals as necessary to reinforce the intended use.

b. Bike Lane signs (R3-17) and plaques (R3-17aP) are required preceding the Bicycle Facility.

c. Bike Lane signs (R3-17) and plaques (R3- 17bP) are required at the end of a Bicycle Facility.

d. A Bicycle Warning sign (W11-1) shall be implemented at all intersecting streets along the corridor preceding the intersection with the protected/separated bikeway.

7. Wayfinding:

a. Signage: See Section 17.4.01.D.

b. Pavement Markings: The Pavement Markings required in Section 17.4.02.E.5 are sufficient for Wayfinding.

8. For Protected Bike Lane design criteria, refer to City of Houston Standard Detail 02760-09.

9. See Section 17.4.01 - General Bikeway Facility Requirements and Section 17.4.03 - Bikeways at Intersections for General Facility Requirements that apply to all Bicycle Facility types.

17.4.02.F Neighborhood Bikeway (Local Streets Only)

17.4.02.F continued

1. Neighborhood Bikeways, also known as bicycle boulevards, are low speed, typically residential streets shared by motorists and bicyclists. See Figure 17.24 for a conceptual design of a Neighborhood Bikeway. This figure is for reference only and does not constitute design standards.



Figure 17.24 – NEIGHBORHOOD BIKEWAY

2. Neighborhood Bikeways should only be installed on local/unclassified streets without marked lanes.

3. Neighborhood Bikeways should include measures to improve bicycle safety along streets and intersections as recommended in a traffic engineering report. Such measures include:

   a. Curb Extensions (see section 17.3.02.C)

   b. Median Refuge Islands (see section 17.3.02.D)

   c. Raised Crosswalks (see section 17.3.02.E)

   d. Median Closures (see section 17.4.03.F)

   e. Mini Roundabouts

   f. Traffic Calming (see Chapter 15, Section 15.2.11 for suggested tools). Traffic Calming elements require specific approval by Houston Public Works.

4. General Pavement Markings

17.4.02.F.4 continued

a. Pavement Markings: Shared lane markings shall be placed at the beginning of a Neighborhood Bikeway and at the start and end of every block and at regular intervals as necessary to reinforce the intended use. Refer to Standard Detail 02760-04.

5. Signage:

a. May Use Full Lane signs (R4-11) shall be placed on every other block and at regular intervals to reinforce the intended use.

b. A majority of stop signs on the Neighborhood Bikeway shall provide priority to the bikeway over intersecting local streets to minimize bicycle stops.

c. A Bicycle Warning sign (W11-1) shall be implemented at all intersecting streets along the corridor preceding the intersection with the Neighborhood Bikeway.

6. Wayfinding:

a. Signage: See Section 17.4.01.D.

b. Shared lane markings (refer to Standard Detail 02760-04) shall be included on every block and no more than ½ mile apart in the direction of the Bicycle Facility.

c. Additional shared lane markings may be necessary where there are many driveways or large traffic generators present.

d. The arrows in the shared lane marking shall generally indicate the forward direction of bicycle movement. At turning locations, the arrow shall indicate the forward direction of all bicycle routes.

7. See Section 17.4.01 - General Bikeway Facility Requirements and Section 17.4.03 - Bikeways at Intersections for General Facility Requirements that apply to all bikeway facility types.

17.4.03 BIKEWAYS AT INTERSECTIONS

17.4.03.A General

1. Intersections present significant challenges to bicyclists, and specific design features should be provided to ensure bicyclist safety and comfort through an intersection. These design features shall also increase pedestrian safety.

17.4.03.A continued

2. Design features shall include roadway geometry alterations, signing, striping, signal modifications, and deliberate transitions from one type of Bicycle Facility to another.

3. At all approaches to a signalized intersection with a cross street with a Dedicated or Off-Street Bicycle Facility, a No Turn on Red sign (R10-11A) shall be mounted on the signal assembly directed towards the motorists on the cross street.

4. Signalized intersections where Bicycle Facilities intersect one another shall be designed to facilitate bicyclist left turns.

    a. Protected Intersections shall be implemented to facilitate safe two-stage left turns.

    b. At intersections with Bicycle Facilities where Protected Intersections cannot be included in the design due to roadway geometry, right-of-way width or other factors, Bike Boxes should be included.

    c. Two-Stage Turn Queue Boxes may be added in certain contexts where additional guidance and space for bicyclists turning movements are needed. Two-Stage Turn Queue Boxes must be approved by Transportation and Drainage Operations.

5. For Protected Bike Lanes, barriers and/or delineators shall extend as close to the intersection without impeding vehicle turning movements or pedestrian crossings. Refer to City of Houston Standard Detail 02760-11 for typical delineator layout.

6. For Raised Bike Lanes, the bike lane shall return to road grade prior to the intersection. Barriers and/or delineators shall extend as close to the intersection without impeding vehicle turning movements or pedestrian crossings. Refer to City of Houston Standard Detail 02760-11 for typical delineator layout.

7. Green bicycle pavement markings shall be used at intersections to increase Bicycle Facility visibility and identify potential conflict areas between motorists and bicyclists. Green bicycle pavement markings should not be used in lieu of but in addition to white pavement markings. Refer to City of Houston Standard Detail No. 02760-10 and 02760-11.

8. Bicycle Facility crossings where the cross street is free flow shall follow the Enhanced Crossing requirements in Section 17.3.03.C - Crossing Treatments.

9. Where a Bicycle Facility includes physical delineation, delineation shall continue to the approach edge of the intersecting pedestrian crosswalk or bicycle box, whichever comes first.

17.4.03.A continued

10. Bicycle Facilities should not terminate at intersections.

    a. At intersections where On-Street Bicycle Facilities cannot be extended to the intersection because of geometric or right-of-way constraints, Off-Street Bicycle Facility transitions should be explored.

    b. Where On-Street Bicycle Facilities end at an intersection, and Off-Street Bicycle Facility transitions are not feasible, at a minimum, Bike Lane Ends signage (R3-17, R3-17b) shall be placed preceding the intersection.

11. Wayfinding signage is required at intersections. See Section 17.4.01.D.

17.4.03.B Protected Intersections

1. Protected Intersections reduce conflicts between motorists, bicyclists, and pedestrians by providing safe, separated waiting areas for each mode. See Figure 17.25 and Figure 17.26 for conceptual designs of Protected Intersections. These figures are for reference only and do not constitute design standards.



Figure 17.25 - PROTECTED INTERSECTION

17.4.03.B
continued



Figure 17.26 - PROTECTED INTERSECTION (RETROFIT)

2. Protected Intersections are an intersection improvement that sets the bikeway back from parallel motor vehicle traffic so that bicyclists are not forced to merge into mixed traffic.

3. Protected Intersections allow bicyclists to safely move straight and make two-stage turns through an intersection. They are given a dedicated path through the intersection and have the right-of-way over motorists making turns.

4. For siting requirements, see Section 17.4.03.A - General Bikeways at Intersections.

5. Design

    a. Protected Intersections shall consist of pavement markings and concrete median or other physical delineation.

    b. Protected Intersections shall include green bicycle pavement markings with an approved material that provides adequate surface traction.

17.4.03.B.5 continued

c. Protected Intersections shall include Curb Extensions. See Section 17.3.02.C - Curb Extensions.

(1). Protected Intersections shall have barrier-protected bicycle queue areas on all corners of the intersection where there will be a designated two-stage turn onto a Bicycle Facility.

(2). Protected Intersections shall include barrier-protected pedestrian islands on all corners of the intersection where a barrier-protected bicycle queue area is present.

(3). Barriers at Protected Intersections may be made up of concrete curb, vertical flex posts, bollards, or other delineation.

(4). Barriers at Protected Intersections may contain mountable elements so that smaller curb radii can accommodate large vehicles.

d. Protected Intersections shall include crosswalk markings adjacent to the bikeway crossing markings. See Section 17.3.03.C - Crossing Treatments.

e. Protected Intersections may include bicycle symbols and turn arrow pavement markings to assist in bicyclist navigation through the intersection.

6. Protected Intersection materials and design are subject to approval by Houston Public Works.

17.4.03.C Two-Stage Turn Queue Boxes

1. Two-Stage Turn Queue Boxes are an intersection improvement consisting of pavement markings and signage that accommodate a safe left turn for bicyclists by providing space for crossing in two stages.

2. Two-Stage Turn Queue Boxes allow bicyclists to make the turn in two movements: first, proceeding through the intersection in the bike lane, then turning ninety degrees within the queue box to face in the desired direction in front of motorists on the cross street.

3. For siting recommendations, see Section 17.4.03.A - General Bikeways at Intersections.

4. Design

a. Two-Stage Turn Queue Boxes shall be placed in a protected zone that will not be encroached upon by motorists or bicyclists along the origin street.

17.4.03.C.4.a continued

(1). Depending on the intersection geometry, this zone may be located between the lateral extension of the Bicycle Facility and the adjacent travel lane on the origin street when a buffer exists or between the pedestrian crosswalk and the lateral extension of the bicycle facility.

b. Two-Stage Turn Queue Boxes shall be green bicycle pavement markings with an approved material that provides adequate surface traction.

c. Two-Stage Turn Queue Boxes shall include a bicycle symbol and turn arrow pavement markings to designate the space for turning bicycle use only. Refer to City of Houston Standard Detail No. 02760-04.

5. Two-Stage Turn Queue Boxes shall include a No Turn on Red (R10-11A) sign mounted on the signal assembly directed towards the motorists on the cross street that would stop behind the queue box.

6. Two-Stage Turn Queue Boxes should be positioned to orient the bicyclist towards the receiving Bicycle Facility on the cross street.

17.4.03.D Bike Boxes

1. Bike Boxes are an intersection improvement consisting of pavement markings and signage that safely positions bicyclists in front of vehicular traffic.

2. Bike Boxes consist of pavement markings that enable bicyclists to queue at a red light in front of stopped vehicles in adjacent lanes. Bicycle Boxes facilitate bicyclists moving forward or turning left.

3. For siting recommendations, see Section 17.4.03.A - General Bikeways at Intersections.

a. Bike Boxes shall be allowed only at signalized intersections.

b. Bike Boxes shall only be used in conjunction with On-Street Bicycle Facilities.

4. Design

a. Bike Boxes shall be located between the pedestrian crosswalk and the vehicular stop bar.

b. Bike Boxes shall be filled with bicycle-green pavement markings that provide adequate surface traction.

17.4.03.D.4 continued

c. Bike Boxes shall include a bicycle symbol pavement marker to designate the space for bicycle use only and WAIT HERE pavement marking beneath the stop bar. Refer to Standard Detail 02760-10 for design details.

d. Bike Boxes shall include a No Turn on Red sign (R10-11A) mounted on the signal assembly when those movements would be otherwise allowed across the Bike Box.

e. Bike Boxes shall only be approved across a single direction of general-purpose lanes. A single Bike Box will not be approved across bidirectional travel lanes.

f. A Bike Box may extend across multiple adjacent lanes to facilitate bicyclist left-turn movements.

g. A Bicycle Facility should implement physical delineation devices along the approach to the Bike Box. For physical delineation devices see Section 17.4.02.E.4 - Protected Bike Lane Delineator.

17.4.03.E Bicycle Crossing Pavement Markings

1. Crossing pavement markings for dedicated bicycle lanes and paths shall continue in line with the Bicycle Facility through the intersection with the combination hatched bicycle green and white pavement markings (refer to City of Houston Standard Detail No. 02760-10 Detail “A”).

   a. Bidirectional dedicated bicycle lanes and paths shall include a dashed yellow line to separate the lanes.

   b. Bidirectional dedicated bicycle lanes and paths shall be the greater of ten (10)-ft or the width of the approach facility.

   c. Single direction dedicated bicycle lanes and paths shall be the greater of six (6)-ft or the width of the approaching facility.

2. Crossing pavement markings for Shared Use Paths shall continue in line with the Bicycle Facility through the intersection with the combination enhanced crosswalk and bicycle green pavement markings (refer to City of Houston Standard Detail No. 02760-10 Detail “B”).

   a. Crossing pavement markings for Shared Use Paths shall be the greater of ten (10)-ft or the width of the approach facility.

17.4.03.E continued

3. Bicycle crossing pavement markings shall be included in conflict zones between bicyclists and motorists and shall not be included through crosswalks or in bicycle or pedestrian waiting areas. Bicycle crossing pavement markings may be set back from or adjacent to parallel crosswalk markings.

17.4.03.F Median Closures

1. Median closures prevent motorists from through and left turn movements and maintain pedestrian and bicyclist crossings. Median closures may be included in any Bicycle Facility design to improve safety of pedestrians and bicyclists.

2. Median closures shall only be included on roadways with a median width of eight (8)-ft or greater. Median closures shall match the width of the existing median.

3. Median closures shall be made up of Seamless Curb median extensions that are a continuation of the existing median such that the grade, concrete, sodding, and other components are consistent.

    a. The Seamless Curb median should include permeable treatments where feasible.

    b. For Retrofit roadway construction projects, alternative treatments may be considered. Alternative materials are subject to approval by the City of Houston.

4. Median closures shall include median openings for pedestrians and bicyclists where a pedestrian or bicyclist crossing is located.

    a. The median openings shall be the same width as the approaching pedestrian or Bicycle Facility.

    b. Median opening widths greater than or equal to eight (8)-ft should install a bollard or flex post in the center at both approaches to discourage driver encroachment.

5. Pavement Markings

    a. Pedestrian crosswalk pavement markings shall be included in median closures. See Chapter 15, Section 15.2.06.B.4.

    b. Bicyclist crossing pavement markings shall be included in median closures. See Section 17.4.03.E for bicycle crossing pavement markings.

17.4.03.F continued

6. Signage: A Right Turn Only (R3-5) sign with an Except Bicycle plaque shall be implemented.

17.4.03.G Bicycle Facilities at Roundabouts

1. Bicycle Facilities shall not be provided within the circulatory roadway.

2. Where Bicycle Facilities or shoulders are used on approach roadways, they should be terminated at least one hundred (100)-ft from the edge of the circulatory roadway.

3. A ramp should be provided to allow bicyclists to exit the roadway onto an Off-Street Bicycle Facility and to re-enter the roadway after the roundabout.

4. If a ramp is provided for bicyclists to access the Sidewalk, the slope shall not exceed 1:7.

5. Street lighting should be considered for increased facility safety at transition points.

6. See Section 17.4.03.E for bicycle crossing pavement markings.

7. See Chapter 10 regarding general roundabout considerations for all roadway users.

17.4.03.H Bicycle Facilities Traffic Signals

1. General standards for signalized intersections are defined in Chapter 15 and include signal phasing for Bicycle Facilities. Bicycle-related signal options are summarized below.

2. Bicycle signal heads shall be installed at signalized intersections with On-Street or Off-Street Bicycle Facilities.

3. Bicycle-specific signal strategies (e.g. bicycle-pedestrian leading interval) shall be employed where there are bicycle signal heads at intersections.

4. Bicycle detection shall be used at all Bicycle Facility intersections with actuated traffic signals to alert the signal controller of bicyclist demand.

5. Where bicycle detection is present, a Bicycle Signal Actuation Sign (R10-22) shall be used, and a bicycle detection marking (Standard Detail 02760-10) shall be placed on the pavement indicating the optimal position for a bicyclist to actuate the signal.

17.4.03.H.5 continued

a. Where Bike Boxes are present, utilize bicycle detection that will detect within the entire Bike Box. If bicycle detection is not feasible for the entire Bike Box, indicate bicycle detection location with the bicycle signal actuation sign and bicycle detection marking.

6. Visibility-limited signal faces shall be adjusted to ensure bicyclists can see the signal indications. If the visibility-limited signal faces cannot be aimed to serve the bicyclist, then separate signal faces shall be provided for bicyclists.

SECTION 5 - TRANSIT FACILITY REQUIREMENTS

17.5.01 TRANSIT OVERVIEW

17.5.01.A In coordination with Metropolitan Transit Authority of Harris County (METRO), the City of Houston works to design safe streets that prioritize transit, improve transit service quality, and support other goals related to transit so that everyone may have safe and accessible multimodal transportation options.

17.5.01.B The City of Houston requires designs for city streets and multimodal transportation facilities that meet IDM standards and improve safety for all road users. The City uses other design standards and guidelines to achieve safe streets, including but not limited to, METRO transit design guidelines.

17.5.01.C The METRO transit design guidelines are referenced in the sections below and serve to work in tandem with the City of Houston's design standards, guidelines, and references.

1. The Street-Side Guidelines and Curb-Side Guidelines should be referenced when impacting the City right-of-way.

2. The whole of METRO transit design guidelines should be referenced for any project impacting an existing or future transit facility.

17.5.01.D All projects impacting an existing or future transit facility shall coordinate with METRO and meet design criteria and guidelines that improve safety for all road users.

17.5.02 TRANSIT STOP TYPOLOGIES, CONFIGURATIONS, AND STANDARD DIMENSIONS

17.5.02.A Refer to METRO transit design guidelines for all transit stop typologies, configurations, and standard dimensions.

17.5.02.B Bus Stops on High-Comfort Bicycle Facilities

1. All bus stop locations shall prioritize the safety of pedestrians and bicyclists in the design of High-Comfort Bicycle Facilities.

2. Floating Bus Stops

   a. Floating Bus Stops have a layout that allows pedestrian and Bicycle Facilities to locate behind the bus boarding pad, safely separating different modes of transportation while reducing bus delays by remaining in-lane.

17.5.02.B.2 continued

b. Floating Bus Stops shall be included along Raised Bike Lanes and Protected Bike Lanes (Retrofit). Refer to Figure 17.27 below.

(1). Floating Bus Stop A (see Figure 17.28) is the default, unless conditions in article 17.5.02.B.2.b.(2) or article 17.5.02.B.2.b.(3) apply.

(2). Floating Bus Stop B shall be used where on-street parking or excess pavement width is present. Refer to Figure 17.29 below.

(3). A Shared Raised Bus Stop may be used in right-of-way-constrained settings, subject to approval by Transportation and Drainage Operations.

3. Dedicated Bike Path bus stops shall be included along all Off-Street Bicycle Facilities.

a. A Seamless Curb version of Floating Bus Stop A may be included on Off-Street Bicycle Facilities.

4. Typically, corridors with proposed Neighborhood Bikeways will not have bus stops along them. Houston Public Works will work with METRO for the design of bus stops on these corridors.

5. All METRO bus stop design and location requirements must be met.

a. METRO will review and approve all bus stop locations and design.

b. Planned METRO bus stop improvements and/or optimization shall be incorporated into the Bicycle Facility design.

c. With METRO's approval, new or reconstructed bus stops should be located near safe pedestrian and bicycle crossings, typically intersections.

17.5.02.C Off-Street Bicycle Facility Bus Stop

1. An Off-Street Bicycle Facility Bus Stop allows for a bus stop at the standard location on the curb of the vehicular travel lane. See Figure 17.27 for a conceptual design of Off-Street Bicycle Facility Bus Stop concept. This figure is for reference only and does not constitute design standards.

17.5.02.C
continued

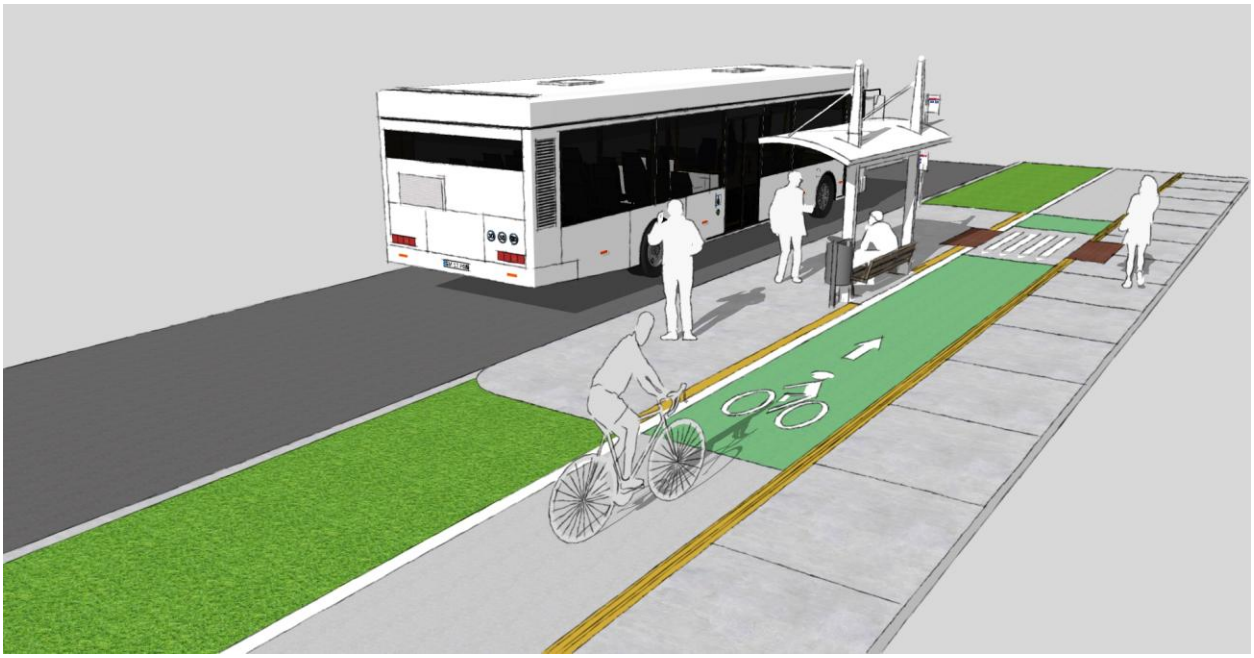


Figure 17.27 – OFF-STREET BICYCLE FACILITY BUS STOP

2. Where an Off-Street Bicycle Facility Bus Stop is present, the Off-Street Bicycle Facility will travel at Sidewalk grade adjacent to the bus pad.

3. Pedestrian Crossings

   a. Off-Street Bicycle Facility Bus Stops adjacent to Shared Use Paths do not require pedestrian crossings.

   b. Off-Street Bicycle Facility Bus Stops adjacent to Dedicated Bike Paths shall have at least one marked pedestrian crossing from the Sidewalk to the bus boarding pad.

      (1). Pedestrian crossings shall be level between the bus boarding pad and the Sidewalk.

      (2). Pedestrian crossings shall be clearly indicated with crosswalks made up of four (4) six (6)-in wide, minimum five (5)-ft long white stripes perpendicular to the Bicycle Facility. Additional stripes may be necessary for wider bicycle paths.

      (3). Yield lines made up of white yield triangles shall be placed in advance of the pedestrian crossing. YIELD TO PEDS pavement markings may be included.

17.5.02.C.3.b continued

(4). Two (2)-ft wide detectable warning surfaces shall be placed on either side of the pedestrian crossing.

4. Pavement Markings

a. Dedicated Bike Paths

(1). Solid bicycle green pavement markings shall be placed over the entire width of the bicycle lane adjacent to the bus boarding pad with breaks provided for pedestrian crossings.

(2). A bicycle symbol and arrow marking shall be included in the segment of the bicycle path adjacent to the bus boarding pad, not conflicting with pedestrian crosswalk pavement markings.

b. In constrained right-of-way settings where an Off-Street Bicycle Facility travels through a bus boarding pad, crosswalk and yield pavement markings shall be included that indicate the conflict zones between pedestrians and bicyclists.

5. Drainage: Off-Street Bicycle Facility Bus Stops shall maintain the existing gutter flow line.

17.5.02.D Floating Bus Stop A

1. Floating Bus Stop A is constructed in line with the Bicycle Facility so that the bicycle lane, and the Sidewalk if necessary, are shifted away from the roadway to accommodate the bus boarding pad. See Figure 17.28 for a conceptual design of Floating Bus Stop A. This figure is for reference only and does not constitute design standards.

17.5.02.D
continued

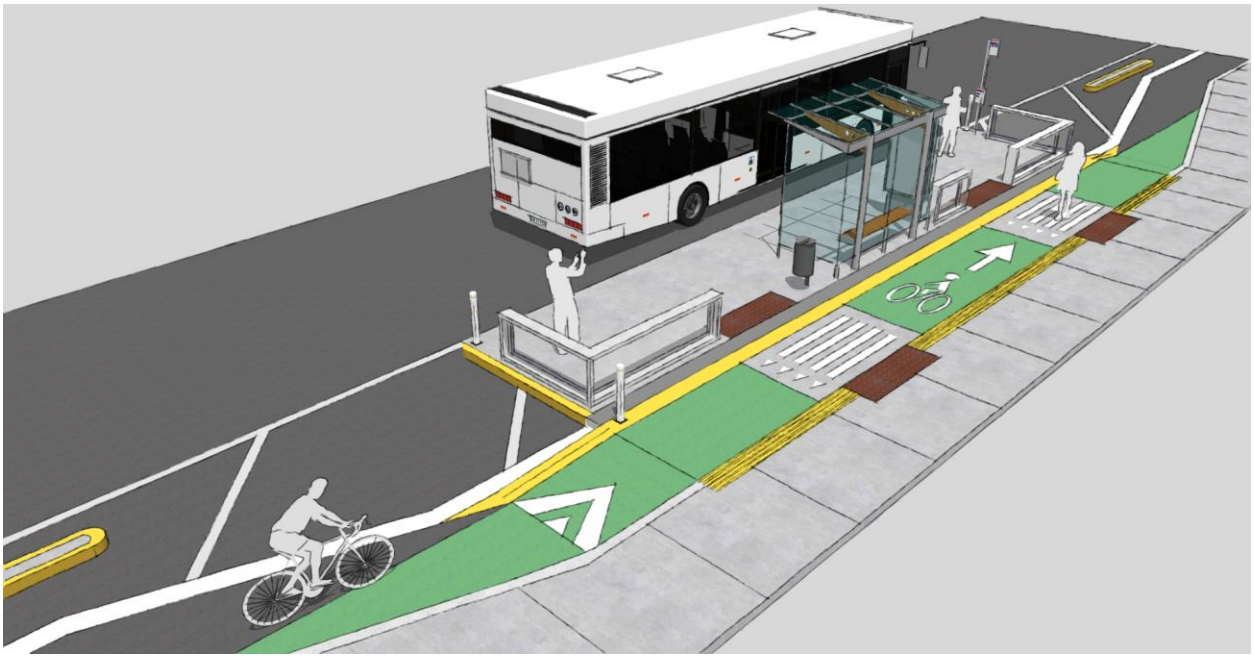


Figure 17.28 – FLOATING BUS STOP A

2. The bicycle lane shall shift away from the roadway to travel between the Pedestrian Realm and the bus boarding pad with transition curves as long as necessary to ensure the highest comfort bicycle movement.

3. For level pedestrian access to the bus pad, the Bicycle Facility shall transition before and after the pedestrian crossings at a maximum slope of 1:7 and a preferred slope of 1:15. The minimum length of the Sidewalk level Bicycle Facility should be twenty-five (25)-ft.

4. Any curb that could be struck by bicyclists because of a deviation of normal path of travel shall be painted yellow.

5. Vertical delineation should be implemented where there may be limited visibility of the curb.

6. Pedestrian Crossings

   a. There shall be at least one marked pedestrian crossing from the Pedestrian Realm to the bus boarding pad.

   b. Pedestrian crossings shall maintain the height of the Sidewalk and curb and have a cross slope of 2%.

17.5.02.D.6 continued

c. Pedestrian crossings shall be clearly indicated with crosswalks made up of four (4) six (6)-in wide, minimum five (5)-ft long white stripes perpendicular to the Bicycle Facility. Additional stripes may be necessary for wider bicycle lanes.

d. Yield lines made up of white yield triangles shall be placed in advance of the pedestrian crossing. YIELD TO PEDS pavement markings may be included.

e. Two (2)-ft wide detectable warning surfaces shall be placed on either side of the pedestrian crossing.

f. A longitudinal detectable warning strip should be placed adjacent to the Sidewalk-grade segment of the bicycle lane.

7. Pavement Markings

a. Solid bicycle green pavement markings shall be placed over the entire width of the bicycle lane behind the bus boarding pad with breaks provided for pedestrian crossings. Bicycle green pavement markings shall extend to include all bicycle lane area behind the gutter line.

b. A bicycle symbol and arrow marking shall be included in the Sidewalk-grade segment of the bicycle lane, not conflicting with pedestrian crosswalk pavement markings.

c. A six (6)-in solid white striped buffer shall delineate the area between the Bicycle Facility and the vehicular lane and shall provide bicycle lane alignment behind the bus boarding pad.

8. Drainage

a. Drainage shall be fully accommodated by the design of Floating Bus Stop A. Implementation of Floating Bus Stop A shall not create new ponding of stormwater.

b. Floating Bus Stop A should be installed on a high point of the gutter flow line.

(1). If it is not feasible to install Floating Bus Stop A on a high point of the gutter flow line, a new storm inlet with appropriate connections should be installed on the upstream side of the bus platform.

17.5.02.D.8.b continued

(2). If article 17.5.02.D.8.b.(1) is not feasible, an eighteen (18)-in gap between the curb and the bus boarding pad shall be provided to preserve the gutter flow. An easily removable steel plate shall be provided over the drainage gap along any walkable surface.

17.5.02.E Floating Bus Stop B

1. Floating Bus Stop B is constructed on-street in line with on-street parking or where a road segment has excess width that allows the bus boarding pad to be constructed on-street. See Figure 17.29 for a conceptual design of Floating Bus Stop B. This figure is for reference only and does not constitute design standards.

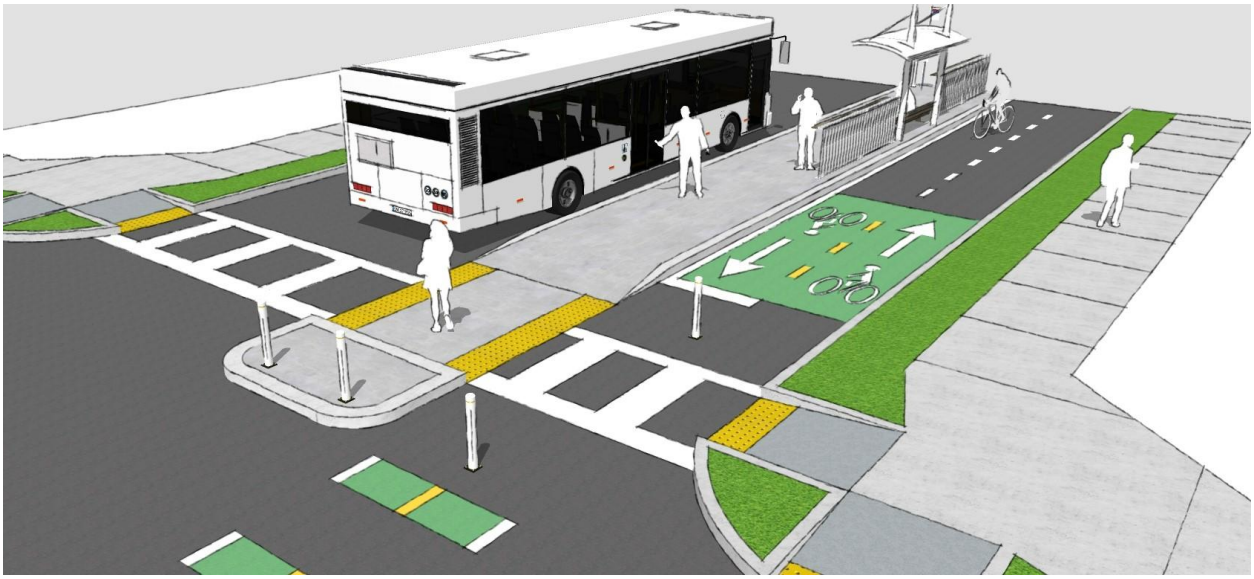


Figure 17.29 – FLOATING BUS STOP B

2. Floating Bus Stop B allows the bicycle lane to continue at roadway grade without shifting significantly around the bus boarding pad.

3. Any curb that could be struck by bicyclists because of a deviation of normal path of travel shall be painted yellow.

4. Vertical delineation should be implemented where there may be limited visibility of the curb.

5. When a Floating Bus Stop B is placed at a marked crosswalk, the existing pedestrian crosswalk and pedestrian ramps should be used as access to the bus boarding pad.

17.5.02.E.5 continued

a. All pedestrian ramps shall meet the requirements in Section 17.3.02.A – Curb Ramps and Corner Treatments.

b. A Median Refuge Island shall be included where the bus boarding pad intersects with the crosswalk. The Median Refuge Island shall meet the requirements in Section 17.3.02.D – Median Refuge Islands.

6. When a Floating Bus Stop B is not placed at a marked crosswalk, accessible pedestrian ramps and pedestrian crosswalk markings shall be provided at Sidewalk grade or at road grade.

a. If a Sidewalk grade pedestrian crossing is provided, use Floating Bus Stop A pedestrian crossing and drainage requirements.

b. If a Sidewalk grade pedestrian crossing is provided, the Bicycle Facility shall transition before and after the pedestrian crossings at a maximum slope of 1:7 and a preferred slope of 1:15. The minimum length of the Sidewalk level Bicycle Facility should be twenty-five (25)-ft.

7. Drainage

a. Drainage shall be fully accommodated by the design of Floating Bus Stop B. Implementation of Floating Bus Stop B shall not create new ponding of stormwater.

17.5.02.F Floating Bus Stop B shall maintain the existing gutter flow line. Shared Raised Bus Stop

1. A Shared Raised Bus Stop allows for a bus stop to be in line with the Bicycle Facility without altering the Pedestrian Realm and allows for bus boarding at the Sidewalk level by ramping up the bicycle lane to the curb. See Figure 17.30 for a conceptual design of a Shared Raised Bus Stop. This figure is for reference only and does not constitute design standards.

17.5.02.F
continued

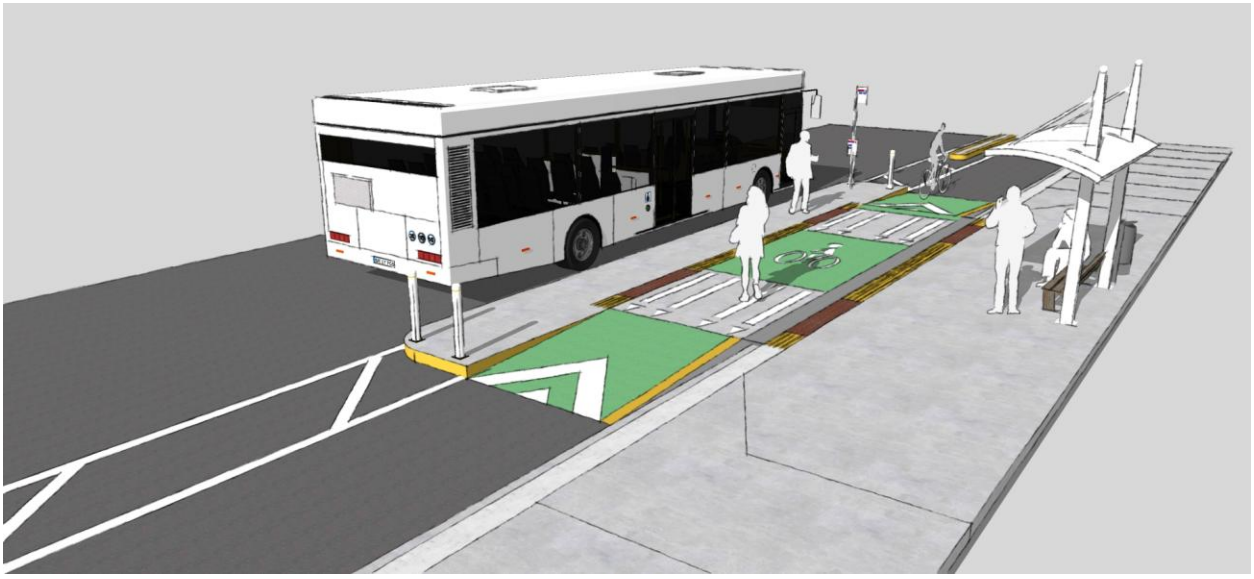


Figure 17.30 - SHARED RAISED BUS STOP

2. Shared Raised Bus Stops should only be used on right-of-way-constrained roadways where the Off-Street Bicycle Facility Bus Stop, Floating Bus Stop A or Floating Bus Stop B is not feasible.

3. Any curb that could be struck by bicyclists because of a deviation of normal path of travel shall be painted yellow.

4. Vertical delineation should be implemented where there may be limited visibility of the curb.

5. Bicycle Facilities shall transition before and after the pedestrian crossings at a maximum slope of 1:7 and a preferred slope of 1:15.

6. Pedestrian Crossings

    a. There shall be at least one marked pedestrian crossing across the Bicycle Facility.

    b. Pedestrian crossings shall maintain the height of the Sidewalk and curb and have a cross slope of 2%.

    c. Pedestrian crossings shall be clearly indicated with crosswalks made up of four (4) six (6)-in wide, minimum five (5)-ft long white stripes perpendicular to the Bicycle Facility. Additional stripes may be necessary for wider bicycle lanes.

17.5.02.F.6 continued

d. Yield lines made up of white yield triangles shall be placed in advance of the pedestrian crossing. YIELD TO PEDS pavement markings may be included.

e. Two (2)-ft-wide detectable warning surfaces shall be placed on either side of the pedestrian crossing.

f. A longitudinal detectable warning strip should be placed on both sides of the Sidewalk-grade segment of the Bicycle Facility.

7. Pavement Markings

a. Solid bicycle green pavement markings shall be placed over the entire width of the Bicycle Facility adjacent to the bus stop. Breaks shall be provided for pedestrian crossings.

b. A bicycle symbol and arrow marking shall be included in the Bicycle Facility adjacent to the bus stop, not conflicting with pedestrian crosswalk pavement markings.

c. A six (6)-in solid white striped buffer shall delineate the area between the Bicycle Facility and the vehicular lane and shall provide bicycle lane alignment behind the bus boarding pad.

d. A six (6)-in solid yellow stripe shall be included on the gutter side of Bicycle Facility ramps.

8. Drainage

a. Drainage shall be fully accommodated by the design of the Shared Raised Bus Stop. Implementation of the Shared Raised Bus Stop shall not create new ponding of stormwater.

b. Shared Raised Bus Stops should be installed on a high point of the gutter flow line.

(1). If it is not feasible to install the Shared Raised Bus Stops on a high point of the gutter flow line, a new storm inlet with appropriate connections should be installed on the upstream side of the bus platform.

(2). If article 17.5.02.F.8.b.(1) is not feasible, an eighteen (18)-in gap between the curb and the Bicycle Facility shall be provided to preserve the gutter flow. An easily removable steel plate shall be provided over the drainage gap along any walkable surface.

17.5.02.G On-Street Shared Bus Stop

17.5.02.G continued

1. On-Street Shared Bus Stops are bus stops where buses share space with road-grade Bicycle Facilities. See Figure 17.31 for a conceptual design of an On-Street Shared Bus Stop. This figure is for reference only and does not constitute design standards.



Figure 17.31 – ON-STREET SHARED BUS STOP

2. Where right-of-way is constrained, bus frequency is greater than or equal to 60 minutes, and the scope of the project does not allow for Shared Raised Bus Stops, On-Street Shared Bus Stops may be used.

3. On-Street Shared Bus stops should be placed on the far side of intersections. Where they are placed at the near side of intersections, they should be placed such that motorists cannot use the bicycle lane to make a right turn.

4. Pavement Markings

    a. On-Street Shared Bus Stops are made up of bicycle green pavement markings adjacent to the bus stop.

    b. There shall be bicycle green pavement markings combined with a bicycle symbol, an arrow and BUS pavement markings preceding the bus stop (refer to Standard Detail 02760-04).

    c. Dashed, white six (6)-in guideline pavement markings shall be placed adjacent to the bus stop area and in advance of the bus stop to allow for bus access to the curb.

5. Delineation

17.5.02.G.5 continued

a. On-street bike lane delineation shall end in advance of the bus stop area. The area without delineation can include driveways.

(1). For near side bus stops, delineation should be placed such that motorists cannot use the bicycle lane to make a right turn.

(2). For far side bus stops, delineation should only be placed following the stop.

17.5.03 TRANSIT STOP PLACEMENT (REFER TO METRO TRANSIT DESIGN GUIDELINES)

17.5.04 PAVEMENT MARKINGS/SIGNAGE (REFER TO METRO TRANSIT DESIGN GUIDELINES)

END OF CHAPTER

City of Houston

Design Manual

Chapter 18

ENCROACHMENT REQUIREMENTS

Chapter 18
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Chapter 18

ENCROACHMENT REQUIREMENTS

SECTION 1 - ENCROACHMENT REQUIREMENTS OVERVIEW

18.1.01 CHAPTER INCLUDES

18.1.01.A General Encroachment requirements and special Encroachment requirements for residential subdivision markers, Skybridges, monitoring wells and environmental test boring Facilities in the Public Right-of-Way.

18.1.01.B This chapter does not cover encroachments into City of Houston easements.

18.1.02 REFERENCES

18.1.02.A Latest revision of the following City of Houston Code of Ordinances:

1. Chapter 40 – Streets and Sidewalks, Article I – In General
2. Chapter 40 – Streets and Sidewalks, Article XII - Monitoring Wells and Environmental Test Boring Facilities

18.1.03 DEFINITIONS

18.1.03.A Encroachments - Private uses into, upon, over, or under the City's right-of-way. The City's Office of the City Engineer (OCE) issues an Encroachment permit including, but not limited to, tunnels, vaults, pedestrian walkways, basements, tiebacks, railroad spurs, utilities, high and low voltage circuits, cables, conduits, signs, tanks, balconies, canopies, planters, columns, sculptures, and pavers.

18.1.03.B Entrance Marker – Ornamental gate(s), column(s), or other ornamental works of wood, iron, masonry, earth, or other materials denoting the entrance to a platted and recorded single family residential subdivision.

18.1.03.C Esplanade - Unpaved area between two paved roadway sections.

18.1.03.D Facility - Any mechanical device or monitoring well and its associated apparatus, placed within a Public Right-of-Way, and designed and constructed to measure or monitor the quality or movement of foreign substances, elements, chemicals, fluids, or pollutants below the surface of the ground; or any mechanical device, method, or apparatus, placed in a Public Right-of-Way and designed and constructed to obtain a sample soil core boring from a depth of greater than one foot below the surface of the ground, for the purpose of removing soil for environmental quality testing.

18.1.03.E Public Right-of-Way - Entire width between the boundary lines of every way which is held by the City or dedication when any part thereof is open to the use of the public.

18.1.03.F Skybridge - A bridge or elevated structure that permits pedestrian and other access between two adjacent structures (not necessarily under the same property ownership) within the Public Right-of-Way.

SECTION 2 – ENCROACHMENT PERMIT REQUIREMENTS

18.2.01 GENERAL ENCROACHMENT PERMIT REQUIREMENTS

18.2.01.A Encroachment permit requirements can be found at the Houston Permitting Center website: https://www.houstonpermittingcenter.org/hpwoce1006

18.2.02 SPECIAL ENCROACHMENT PERMIT REQUIREMENTS

18.2.02.A Residential Subdivision Marker Design Requirements

1. General Considerations/Restrictions

   a. Subdivision markers are considered Encroachments in the Public Right-of-Way and shall meet the Encroachment requirements set out for subdivision markers in Chapter 40 of the City of Houston Code of Ordinances.

   b. Subdivision markers may display the name of the subdivision or neighborhood but shall not contain any commercial advertising, announcement, or other signage.

   c. An electronic sign or marker is not allowed.

   d. Subdivision markers may not be located on, extend on to, nor:

      (1) Intrude upon any portion of a roadway.

      (2) Intrude upon any portion of a sidewalk or pedestrian pathway in the Public Right-of-Way.

      (3) Create any hazardous condition or obstruction for vehicular or pedestrian travel upon a public street.

      (4) Be located within five (5) feet of underground storm, sanitary sewer, water lines and all appurtenances.

      (5) Be located within twenty-five (25) feet of a fire hydrant.

      (6) Restrict or block driver's visibility or sight line of traffic, pedestrians, bikeway travelers, or other public user within the Public Right-of-Way.

      (7) Be located within the visibility triangle.

2. Locations

18.2.02.A.2 continued

a. Subdivision markers may be located at the main entrance to a subdivision and at secondary entrances.

b. The subdivision marker must be within the boundaries of the subdivision or single-family residential development they identify.

c. Locations where multiple subdivisions interface will be reviewed on a first come, first serve basis for purposes of establishing allowable subdivision marker locations.

d. The City Engineer's approval will be required for installation of more than two markers to identify a single subdivision.

e. The following are minimum allowable Entrance Marker location guidelines:

(1) Fifty (50) feet from the median nose for mid-block median openings,

(2) Seventy-five (75) feet from the median nose for intersection openings,

(3) One hundred (100) feet from the median nose of median for left turn lanes,

(4) Seven (7) feet from the inside median curb (this dimension may be reduced if community has entered into maintenance or Adopt-an-Esplanade agreement with Houston Parks and Recreation Department and does not create a hazardous condition),

(5) Within Public Right-of-Way adjacent to property line.

3. Size

a. Maximum height above the ground surface shall not be greater than six (6) feet.

b. Height shall be limited to not obstruct sight lines of vehicular and pedestrian traffic.

c. Maximum horizontal width shall not exceed eight (8) feet.

d. Maximum display area shall not exceed thirty-six (36) square feet.

e. Width shall be limited to not obstruct sight lines of vehicular and pedestrian traffic.

18.2.02.A.3 continued

f. Variances to the size requirements for a proposed subdivision marker must be granted by the City Engineer.

4. Materials

a. Materials for base structure shall be permanent, durable, and weather resistant.

b. Marker shall provide pleasing aesthetic elements, clarity, and professional design appearance.

c. Marker letters and/or other elements shall be of non-corrosive and non-staining materials and coated properly to prevent staining and discoloration.

d. Material shall be capable of clean-up from graffiti .

5. Utilities

a. Marker shall be of size and location to not impede or restrict the City's ability to maintain, repair, or replace the existing utility line(s).

b. Existing utilities shall be field located prior to the construction of the Entrance Marker. It is recommended that existing utilities shall be field located prior to preparation of the measured drawings for the Entrance Marker and its location.

18.2.02.B Skybridge Design Requirements

1. General Requirements

a. Skybridges are considered Encroachments in the Public Right-of-Way and shall meet the Encroachment requirements set out in Chapter 40 of the City of Houston Code of Ordinances including all administrative, permitting and fees.

b. Skybridges may be open air or conditioned space depending upon the specific location and application.

c. Skybridges shall not interfere with the operation of the Public Right-of-Way across which it traverses and is subject to following height restrictions:

(1) The bottom of the lowest portion of the Skybridge over the Public Right-of-Way must be a minimum of eighteen and half (18.5) feet above the roadway surface.

18.2.02.B.1 continued

d. Skybridges proposed to traverse an intersection of two public street rights-of way requires approval of the City Engineer.

18.2.02.C Monitoring Wells and Environmental Test Boring Facilities Design Requirements

1. General Requirements

a. Facilities are considered Encroachments in the Public Right-of-Way and shall meet the Encroachment requirements set out for Facilities in Chapter 40, Section 40-281 of the City of Houston Code of Ordinances.

2. Location on Public Streets

a. A Facility must not be located on, extend on to, nor intrude upon any portion of a roadway or a sidewalk unless the City Engineer determines that no reasonable alternative site exists. In any instance in which a Facility must be situated on a sidewalk or roadway, it shall be installed entirely below the surface and covered in such a manner as to allow normal use of the roadway or sidewalk.

b. A Facility must not create any hazardous condition or obstruction of any mode of travel upon a public street, alley, sidewalk, or bikeway.

c. The design and location of a Facility shall include all reasonable planning to minimize potential harm, injury, or interference to the public in the use of the public streets.

d. Upon its removal, a Facility shall be properly closed by cementing or other sound engineering practice to prevent injuries to persons at the surface and underground contamination.

18.2.03 SUBMITTALS FOR ENCROACHMENT PERMIT

18.2.03.A General Permits Submittal Procedures

1. Complete and submit the Encroachment permit application including additional documents required for approval. The application can be submitted online and can be found at https://www.houstonpermittingcenter.org/hpwoce1006.

2. Drawings shall be submitted to the Office of City Engineer for review and approval.

3. Drawings shall show existing surface and buried Facilities within the Public Right-of-Way or easements in plan view.

18.2.03.A continued

4. If Encroachment area includes landscaping, the growth characteristics of the plants shall be submitted with the drawings and an approval letter is required from Houston Parks and Recreation Department.

18.2.03.B Subdivision Marker Submittal Procedures

1. Complete and submit the Subdivision Marker application including additional documents required for approval. The permit application form and related documents can be found at https://www.houstonpermittingcenter.org/hpwoce1005.

2. A street cut/excavation permit and traffic control permit will be required prior to construction of a subdivision marker within the Public Right-of-Way. The permits will be obtained by the applicant from the Houston Permitting Center, Street Cut Permits Section and Mobility Section, upon obtaining the approved subdivision marker permit. The permit application form and related documents can be found at https://www.houstonpermittingcenter.org/hpwoce1006 and https://www.houstonpermittingcenter.org/hpwmp1001.

3. For subdivision markers within a City of Houston esplanade, provide approved Adopt-an-Esplanade letter from City of Houston Parks and Recreation Department. For more information, e-mail askparks@houstontx.gov.

18.2.03.C Monitoring Wells and Environmental Test Boring Facilities Submittal Procedures

1. Each applicant shall submit detailed plans prepared under the seal of a professional engineer registered as such in Texas with the application. Each set of plans shall show the design, dimension, and depth of the Facility, and the process that will be used for its removal and closure.

2. An approved street cut/excavation permit is required prior to submitting the monitoring wells permit application. The monitoring wells permit application form and related documents can be found at https:///www.houstonpermittingcenter.org/hpwoce1003.

3. A traffic control permit is required prior to construction of a Facility within the Public Right-of-Way or public easement. The traffic control permit can be obtained by the applicant from the Houston Permitting Center, Mobility Section.

18.2.04 QUALITY ASSURANCE

18.2.04.A Have drawings sealed, signed, and dated by the professional engineer responsible for development of the drawings.

END OF CHAPTER