City of Liberty

CONSTRUCTION

AND DESIGN

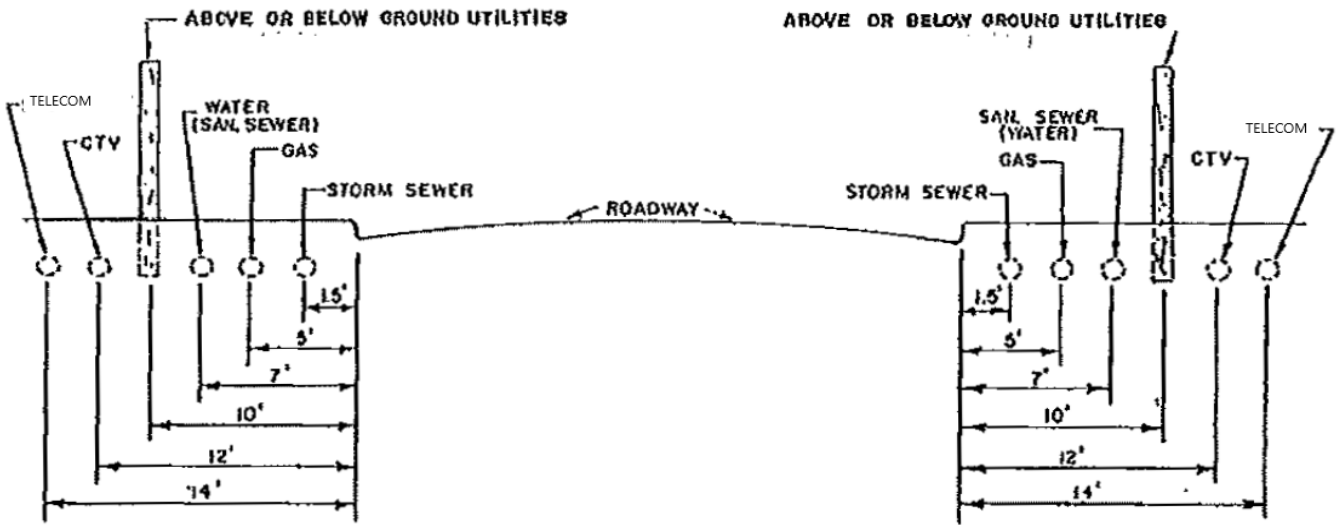
STANDARDS

2022

STREET CONSTRUCTION AND DESIGN STANDARDS

CITY OF LIBERTY

SECTION 1

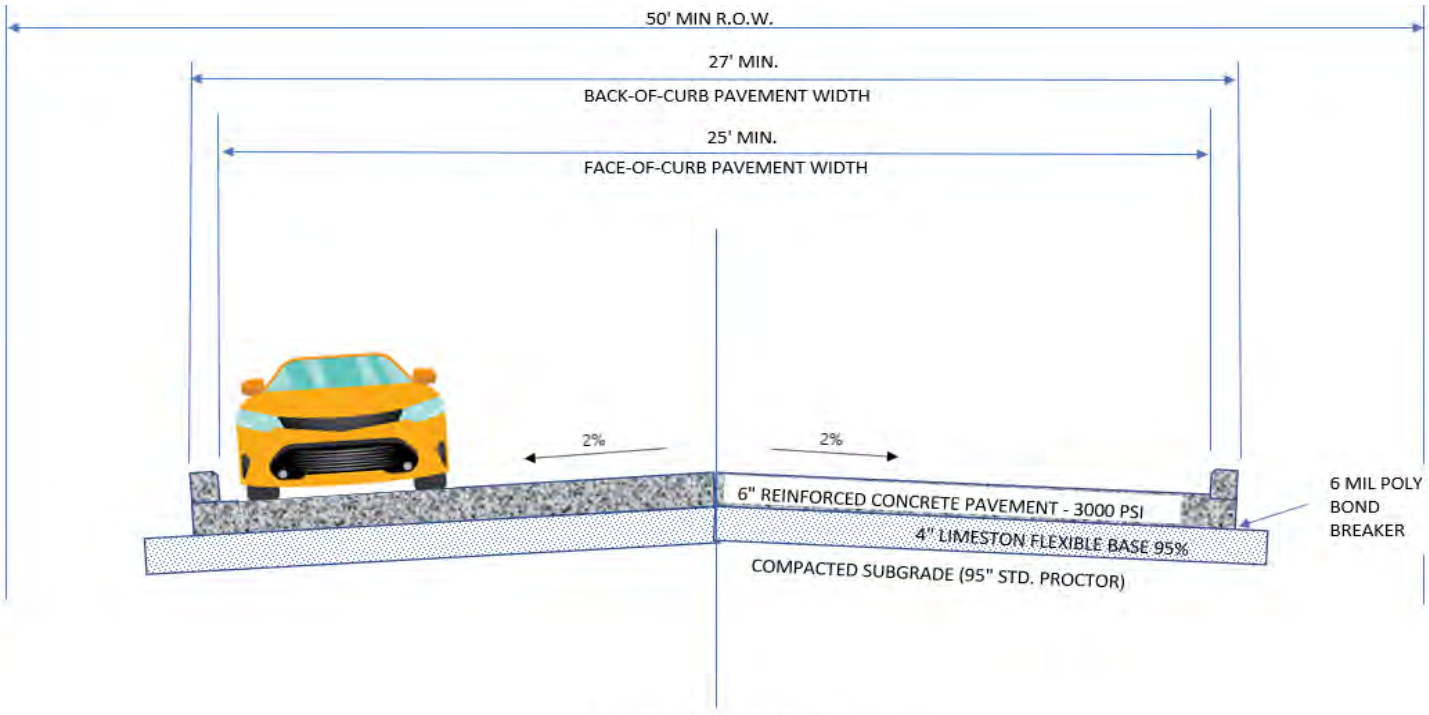


CITY OF LIBERTY

DESIGNATED UTILITY LOCATIONS IN STREET RIGHT-OF-WAY OF PROPOSED SUBDIVSION

PUBLIC WORKS

SCALE: N.T.S.



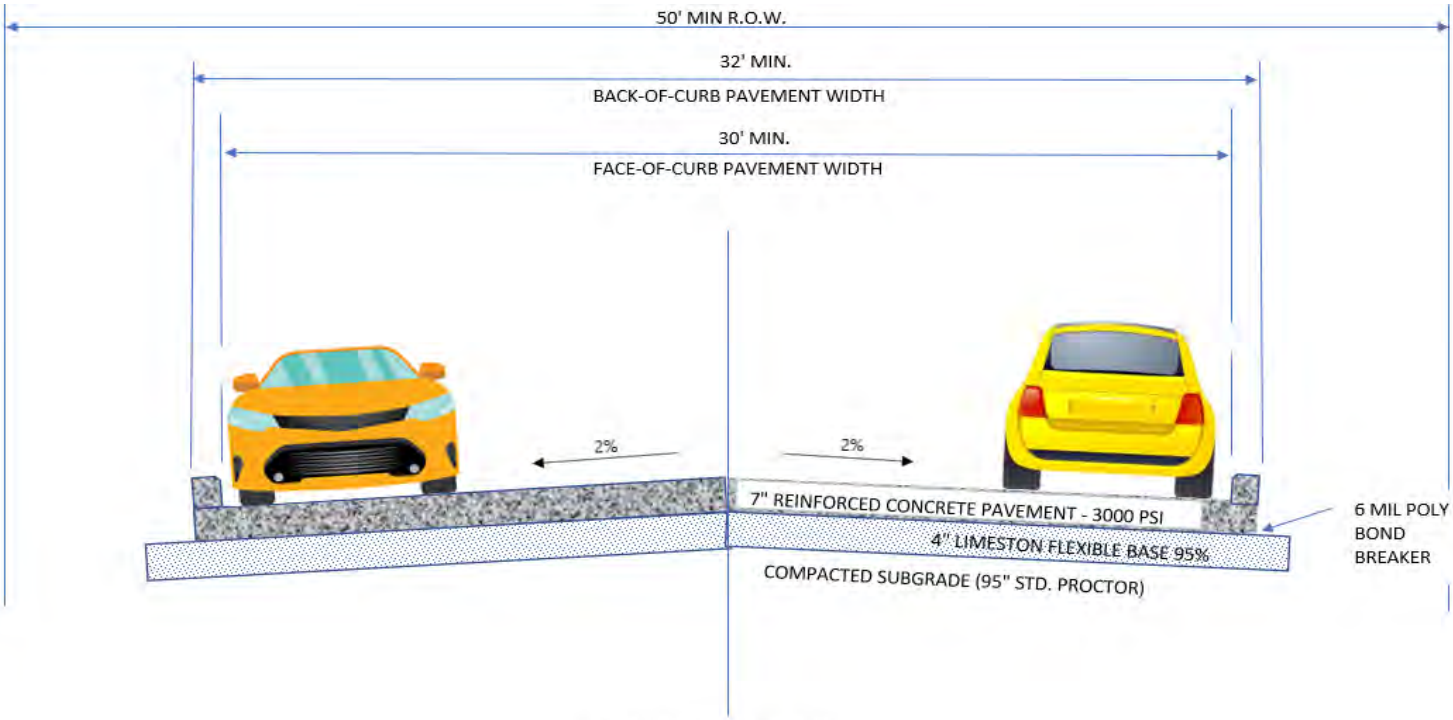
TYPICAL SECTION
MINOR LOCAL STREET - ONE SIDE STREET PARKING

CITY OF LIBERTY

MINOR LOCAL STREET - CURB AND GUTTER
ONE-SIDE PARKING ONLY

PUBLIC WORKS

SCALE: N.T.S.



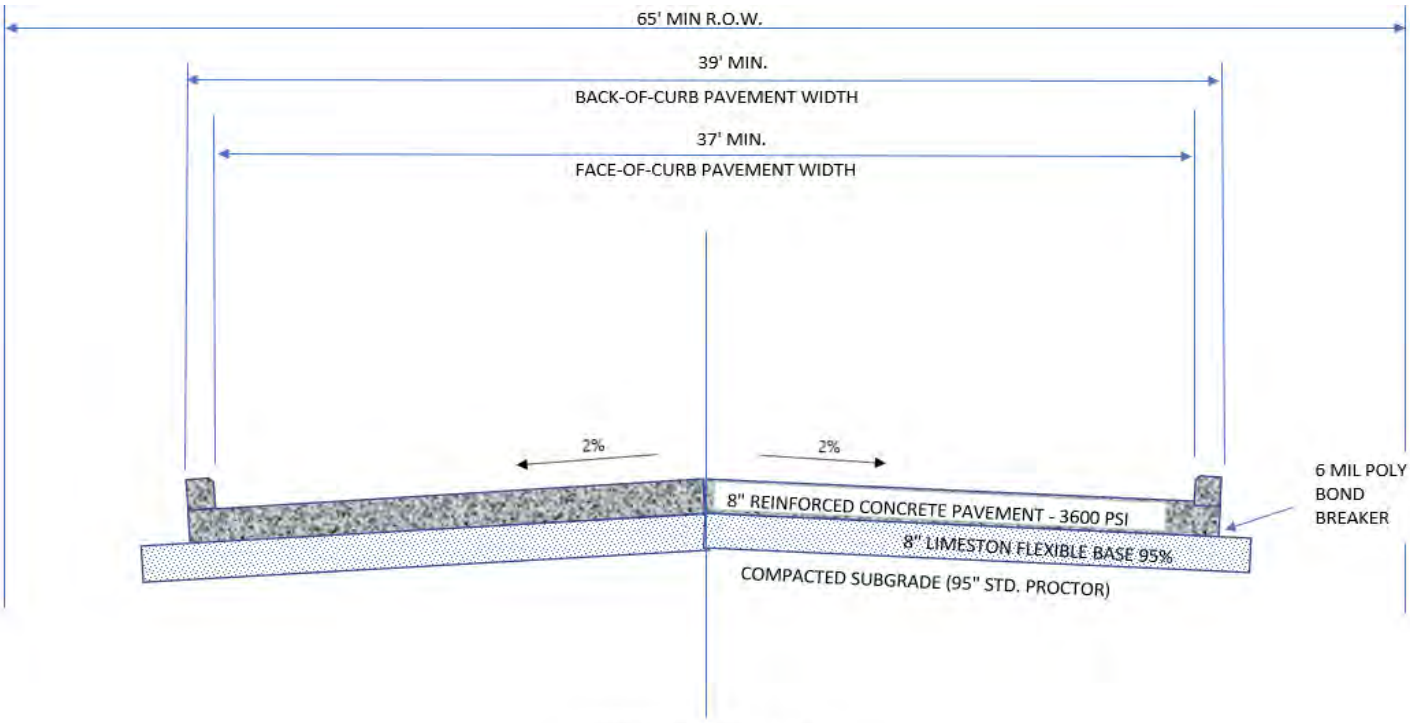
TYPICAL SECTION
LOCAL STREET - TWO SIDED STREET PARKING

CITY OF LIBERTY

LOCAL STREET - CURB AND GUTTER
TWO-SIDED PARKING

PUBLIC WORKS

SCALE: N.T.S.



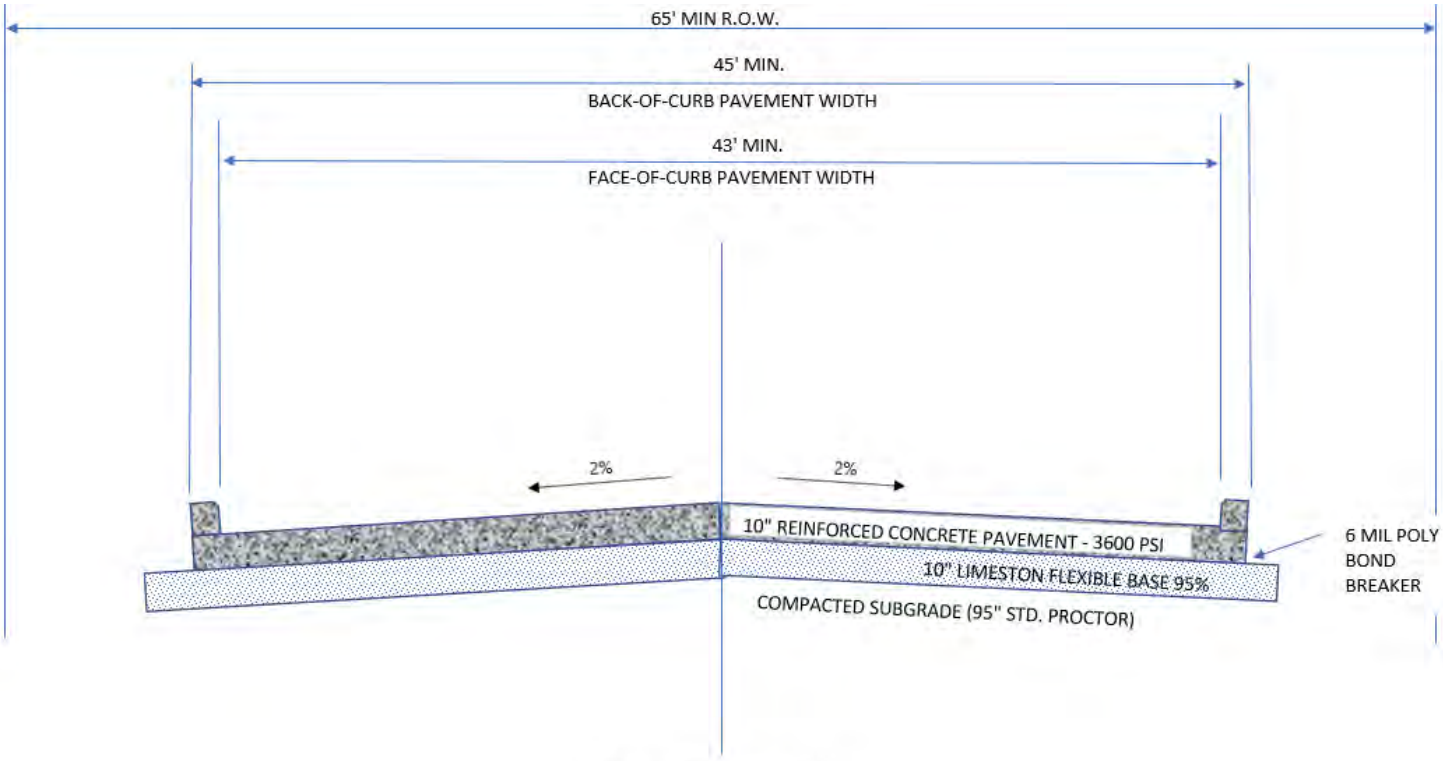
TYPICAL SECTION
COLLECTOR STREET

CITY OF LIBERTY

COLLECTOR STREET

PUBLIC WORKS

SCALE: N.T.S.



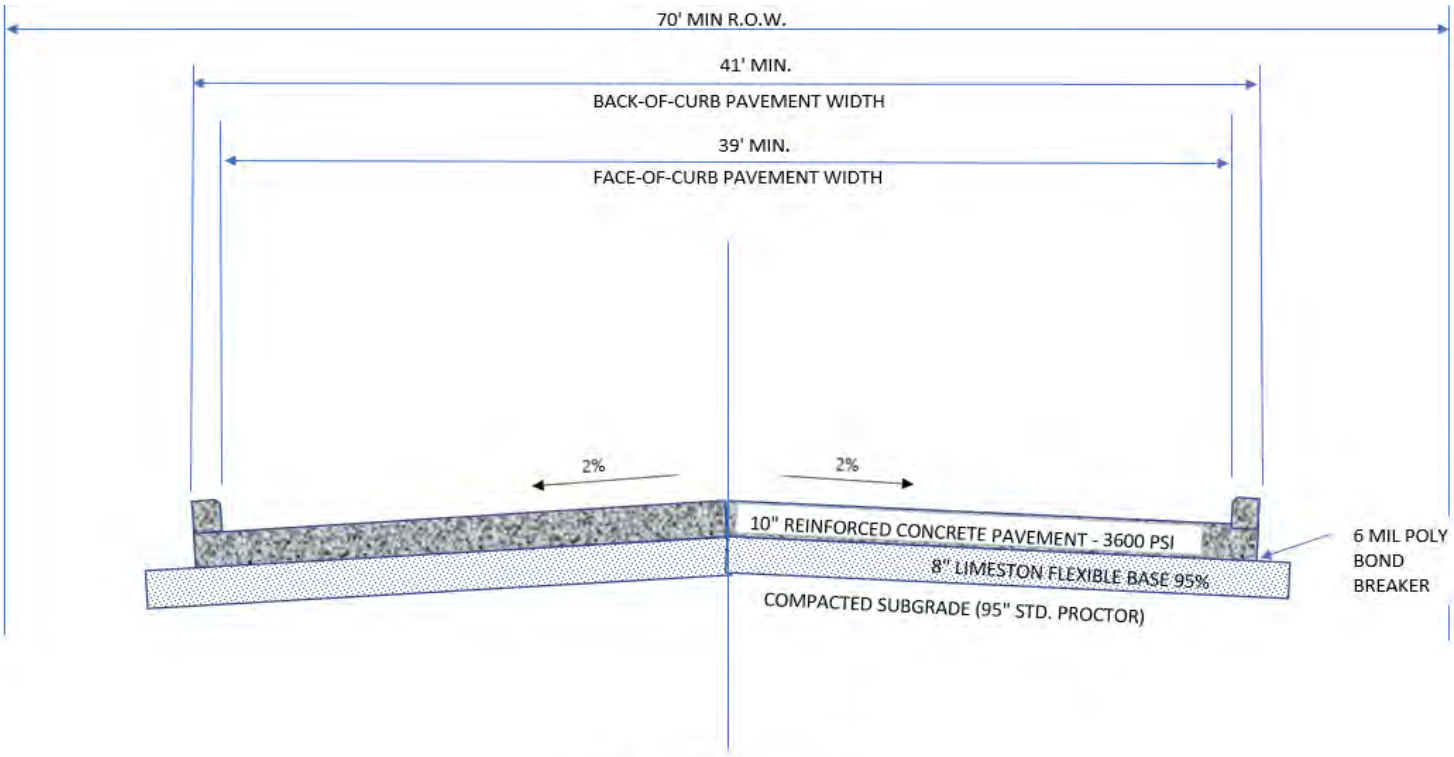
TYPICAL SECTION
MAJOR COLLECTOR STREET

CITY OF LIBERTY

MAJOR COLLECTOR STREET

PUBLIC WORKS

SCALE: N.T.S.



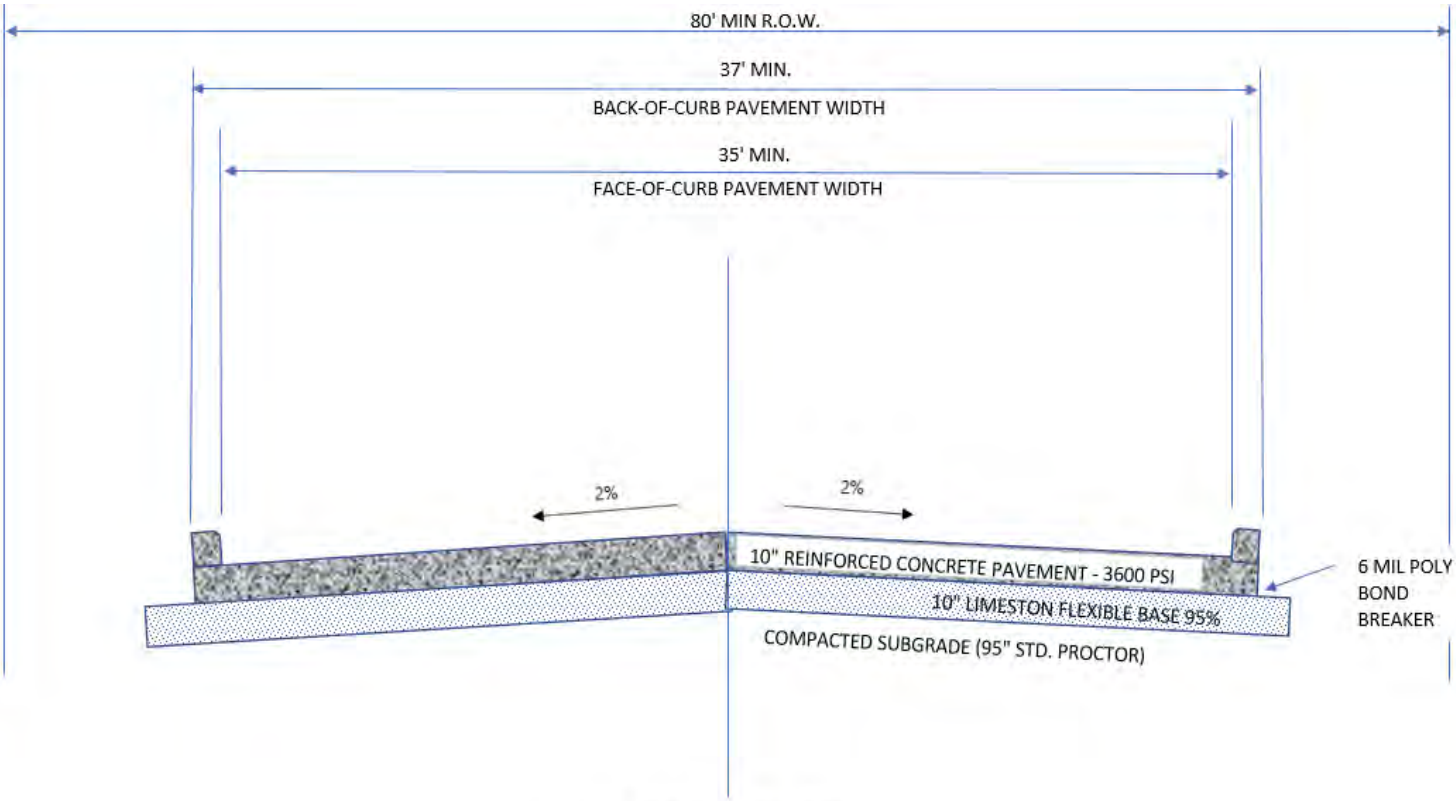
TYPICAL SECTION
INDUSTRIAL STREET

CITY OF LIBERTY

INDUSTRIAL STREET

PUBLIC WORKS

SCALE: N.T.S.



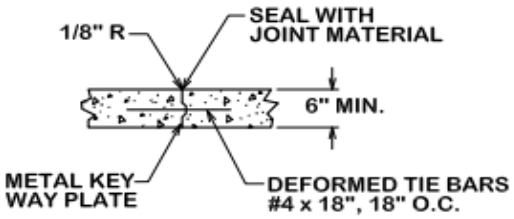
TYPICAL SECTION
MAJOR ARTERIAL STREET

CITY OF LIBERTY

MAJOR ARTERIAL STREET

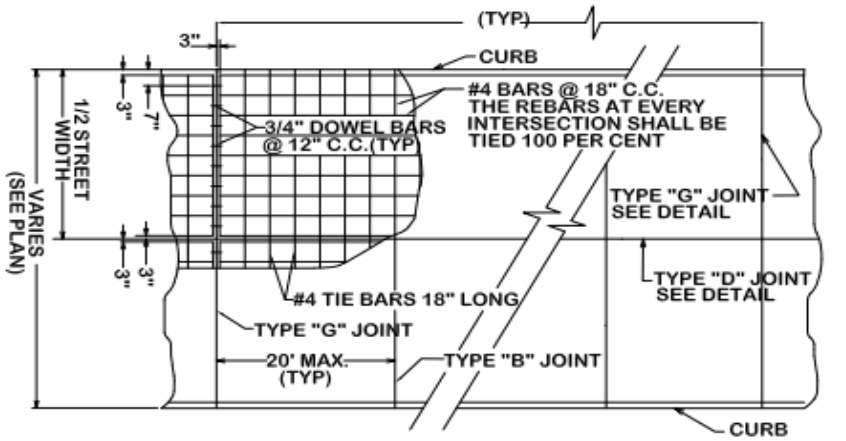
PUBLIC WORKS

SCALE: N.T.S.

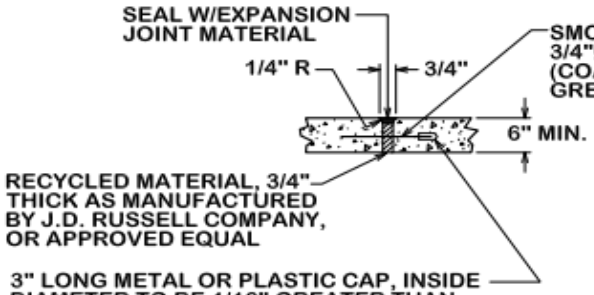


TYPE "D" LONGITUDINAL JOINT

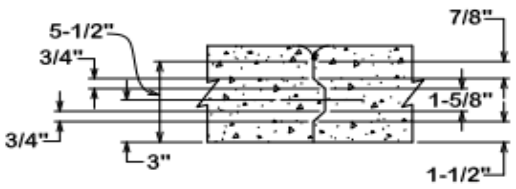
LONGITUDINAL JOINTS SHALL BE REQUIRED ONLY ON THE CENTERLINE OF THE PAVEMENT & IN INTERSECTIONS AS DETAILED



TYPICAL JOINT & REINFORCEMENT LAYOUT FOR CONCRETE PAVEMENT

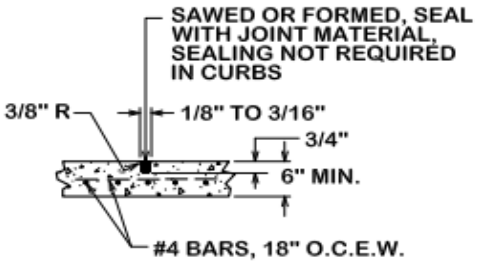


TYPE "G" EXPANSION & CONSTRUCTION JOINT

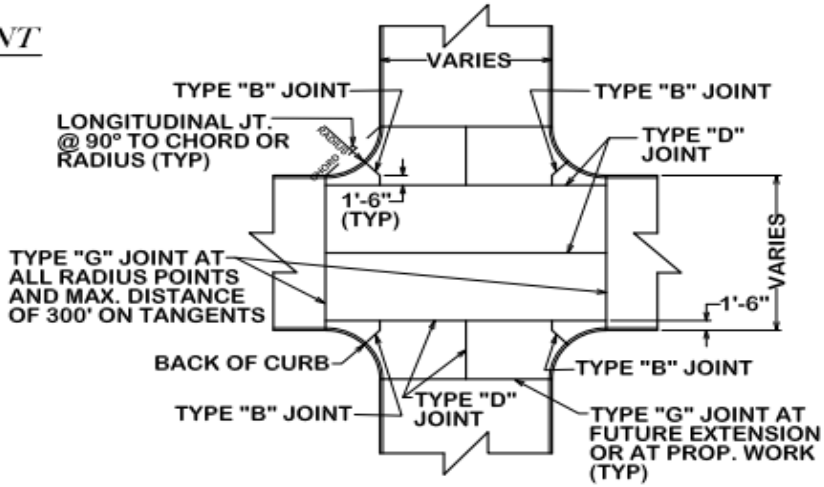


METAL KEY WAY PLATE

NOTE: EXPANSION JOINTS AS SHOWN AND AT EACH RADIUS POINT. CURB EXPANSION JOINTS SHALL BE AT 60' CENTERS. CURB CONTROL JOINTS SHALL BE AT 10'CENTERS.



TYPE "B" CONTRACTION JOINT



TYPICAL JOINT LAYOUT AT CONCRETE INTERSECTION

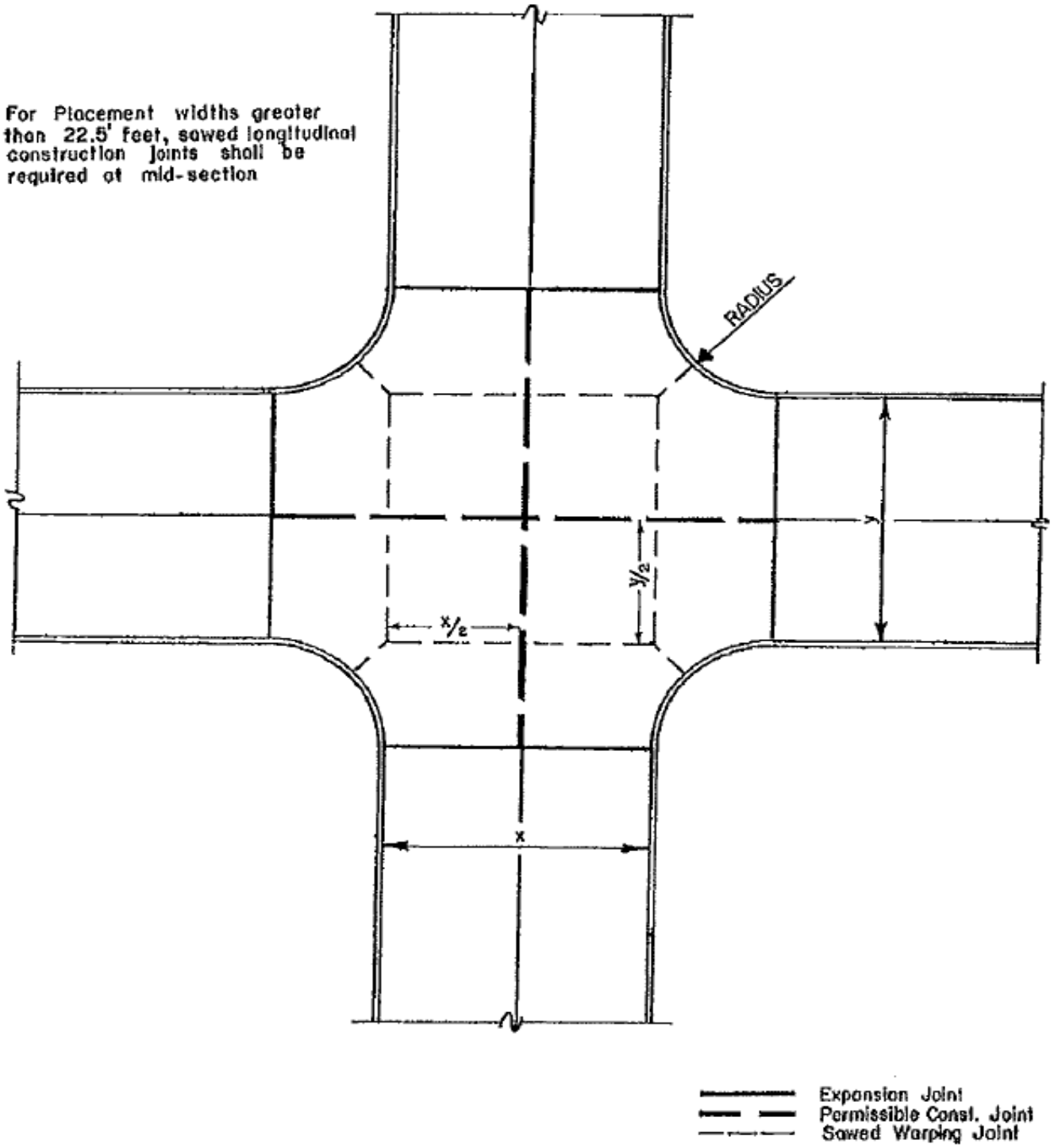
** WIRE MAT IS PROHIBITED

CITY OF LIBERTY

CONCRETE PAVEMENT JOINT AND STEEL REINFORCEMENT LAYOUT

PUBLIC WORKS

SCALE: N.T.S.

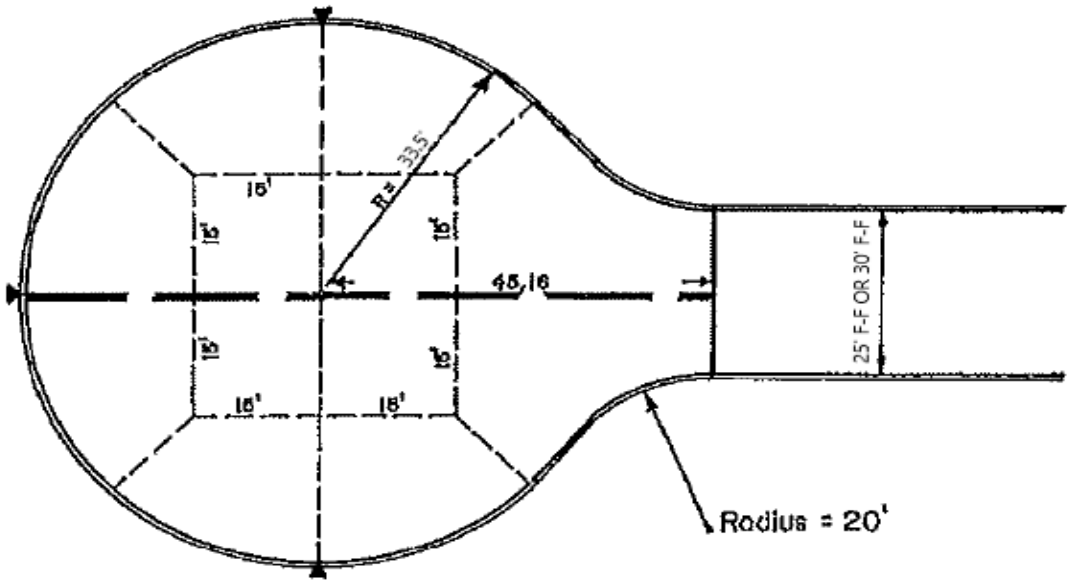


CITY OF LIBERTY

PUBLIC WORKS

STANDARD JOINT DETAIL

SCALE: N.T.S.



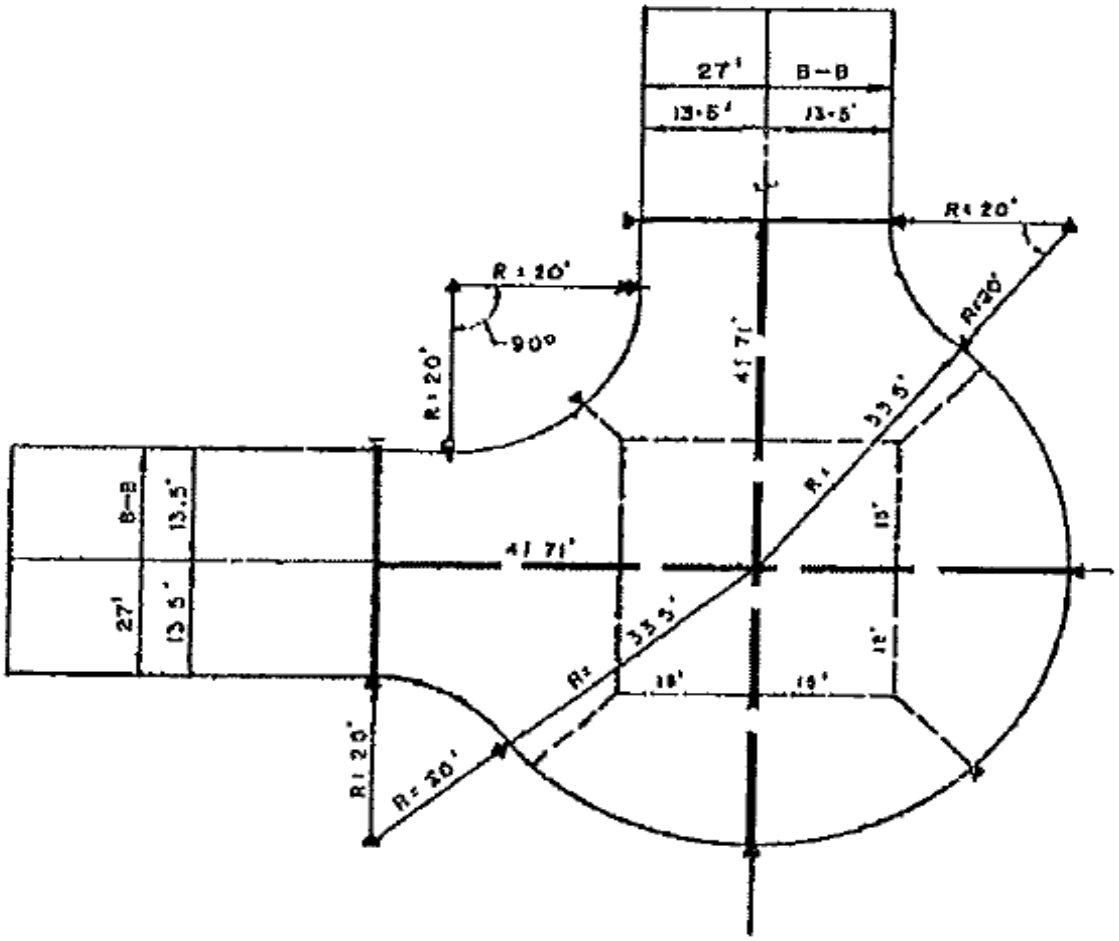
Expansion Joint
Permissible Const. Joint
Sawed Warping Joint

CITY OF LIBERTY

TYPICAL JOINT PATTERN
CUL-DE-SAC
25' F-F OR 30' F-F

PUBLIC WORKS

SCALE: N.T.S.



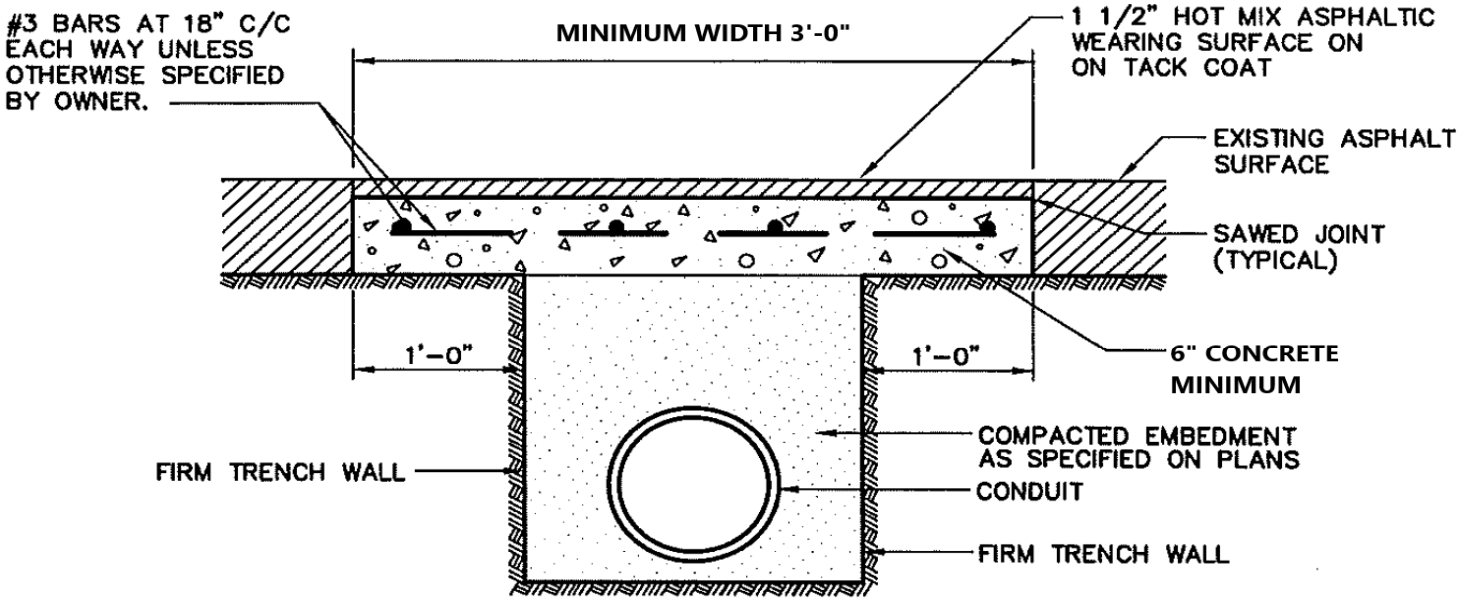
Expansion Joint
Permissible Const. Joint
Sawed Warping Joint

CITY OF LIBERTY

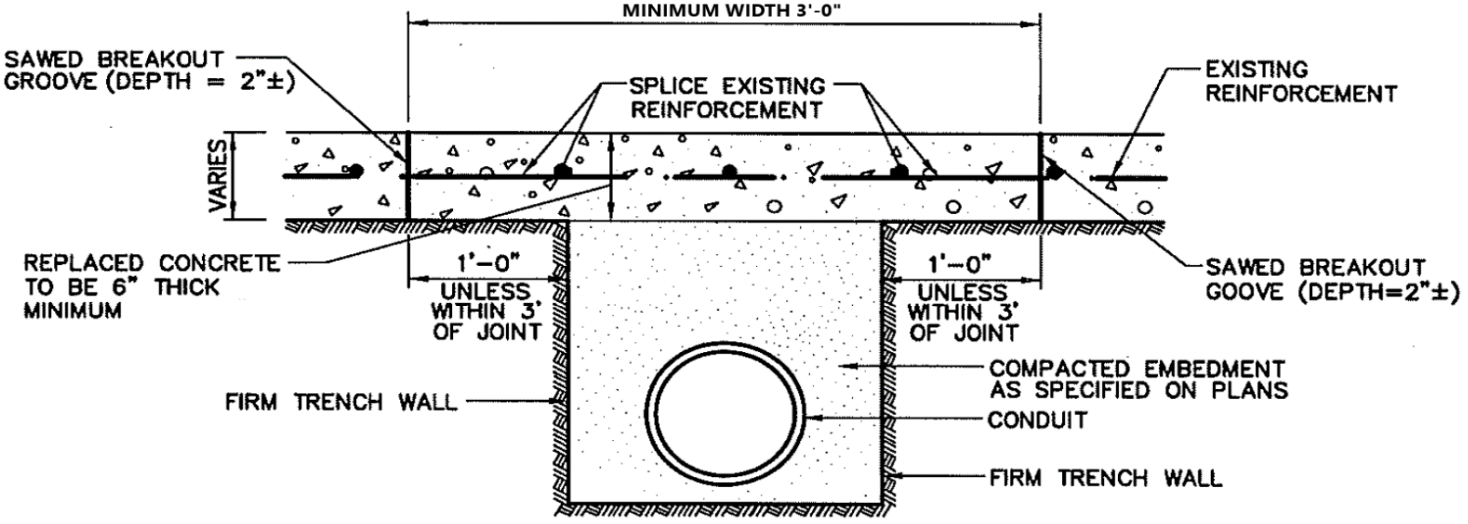
TYPICAL JOINT PATTERN
CORNER CUL-DE-SAC

PUBLIC WORKS

SCALE: N.T.S.



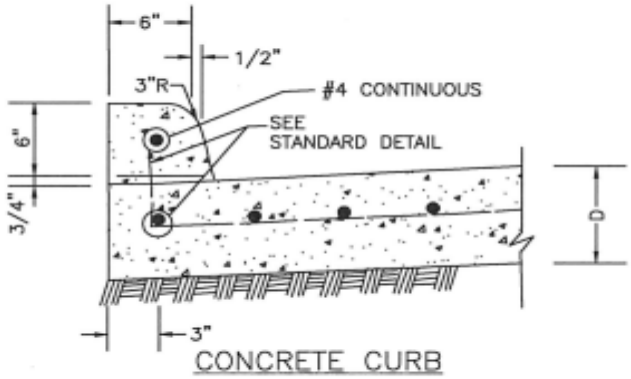
ASPHALT PAVEMENT
N.T.S.



CONCRETE PAVEMENT
N.T.S.

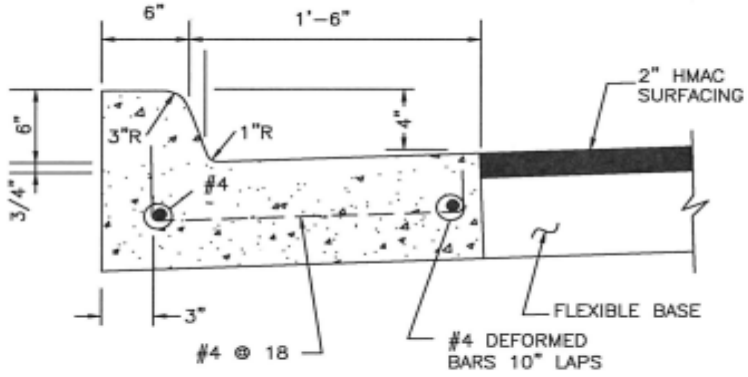
** WIRE MAT IS PROHIBITED

CITY OF LIBERTY	PUBLIC WORKS
CONCRETE STREET REPAIR DETAILS	SCALE: N.T.S.

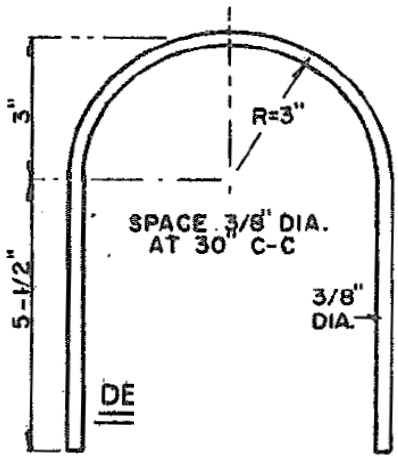


CONCRETE CURB

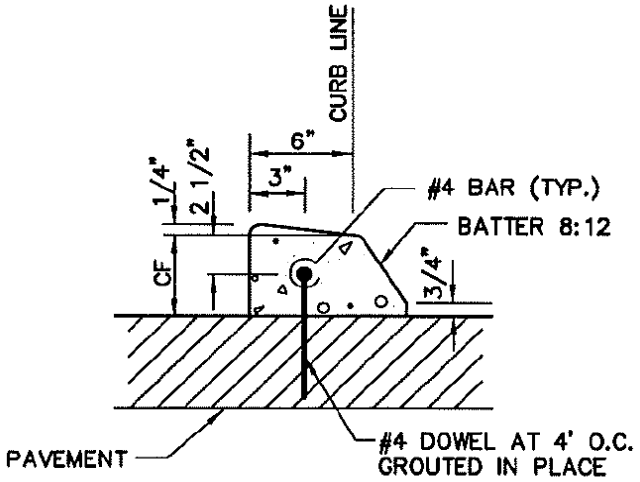
WHEN CONCRETE CURB IS TO BE PLACED EXISTING CONCRETE USE BASE #4 @ 18x10" LONG, DOWELED AND SET IN EPOXY GROUT.
SET #4 DOWELS, 25" LONG AT 12" C–C WHEN PAVEMENT SECTION POURED.



MONOLITHIC CURB AND GUTTER

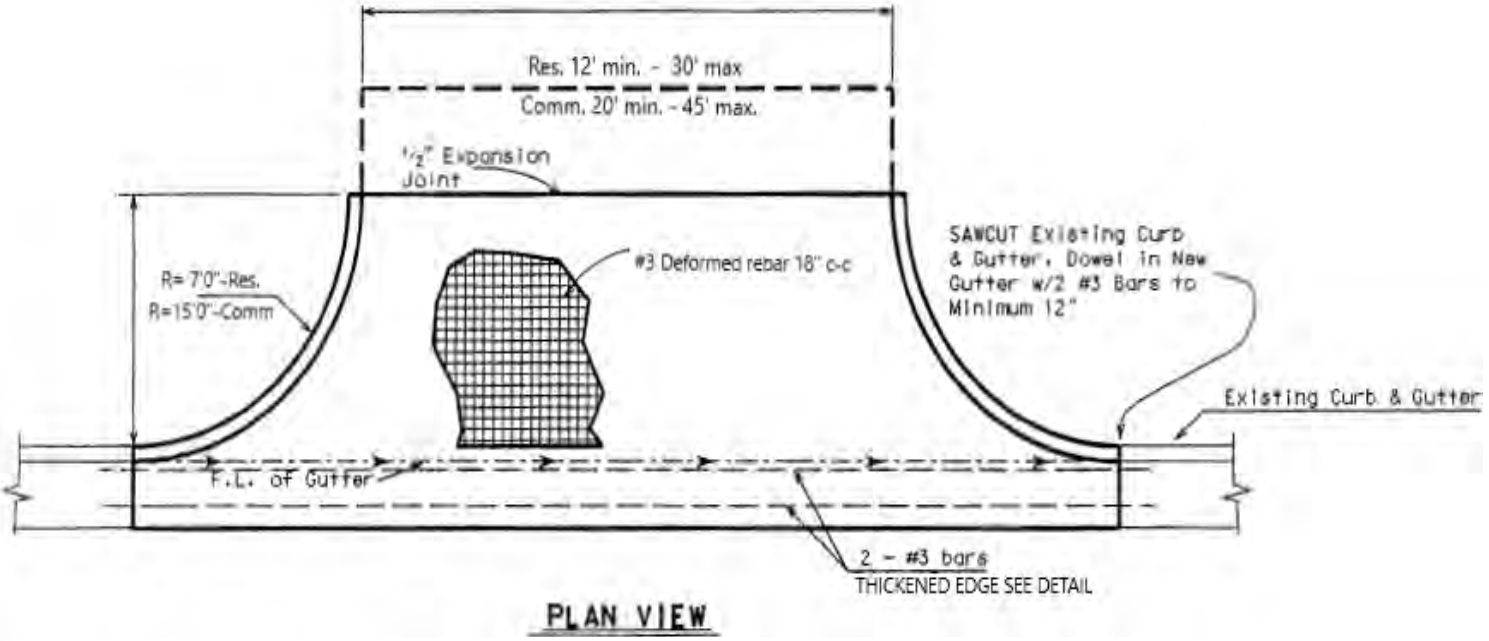


STANDARD DETAIL

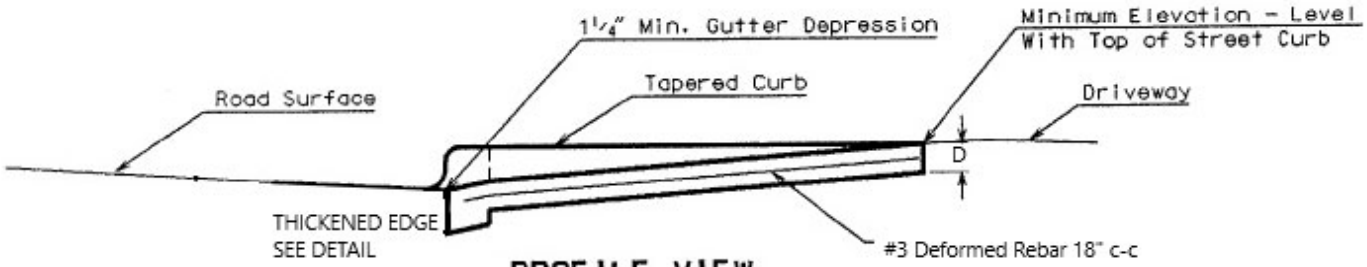


DOWELED CURB
N.T.S.

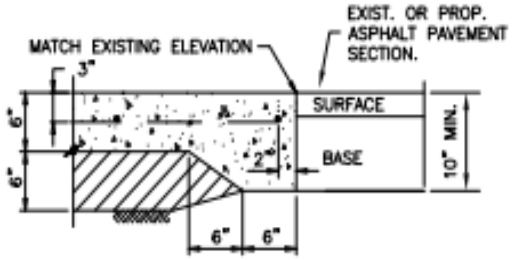
CITY OF LIBERTY	PUBLIC WORKS
CURB AND GUTTER	SCALE: N.T.S.



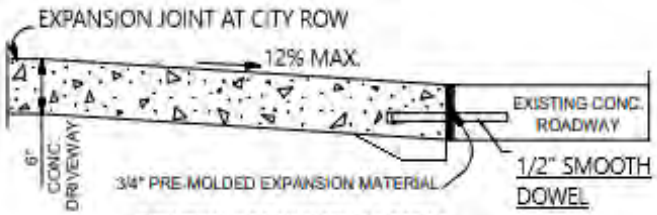
PLAN VIEW



PROFILE VIEW



CONCRETE DRIVEWAY TO ASPHALT PAVMENT CONNECTION DETAIL



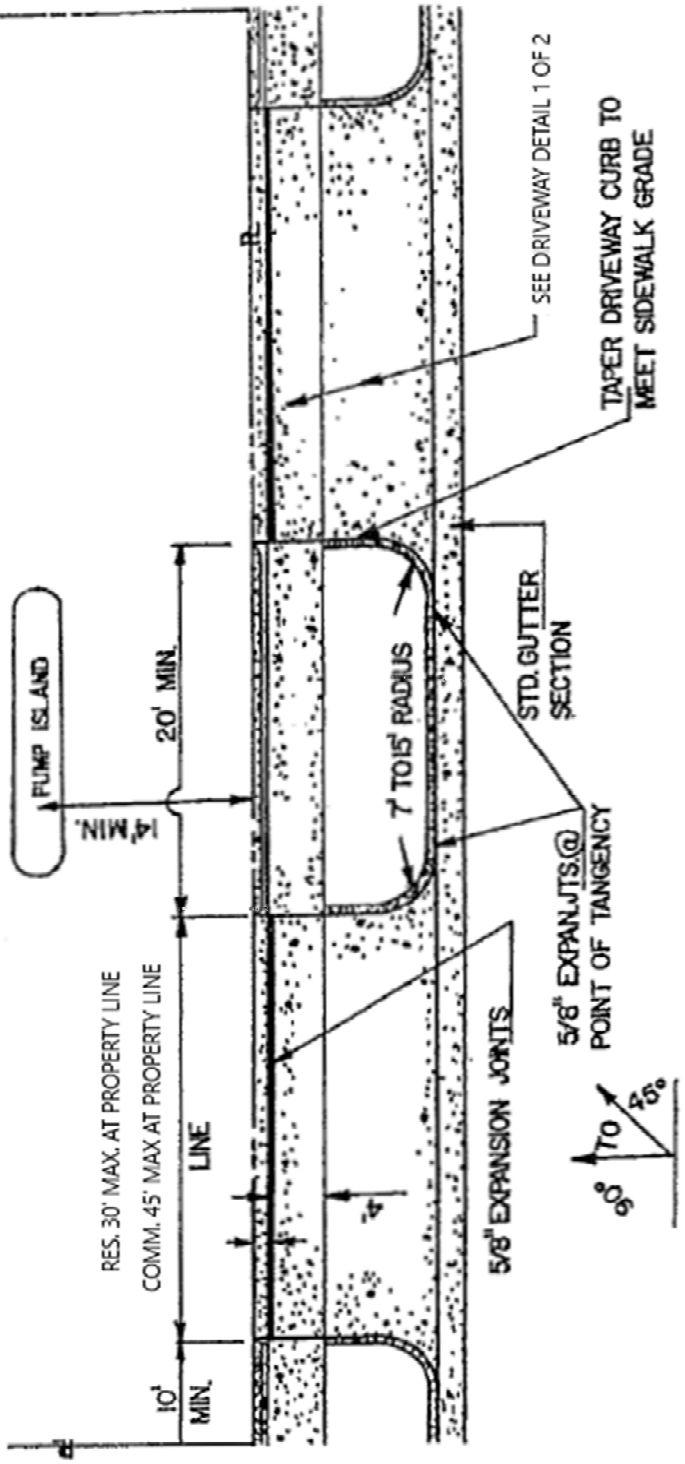
DRIVEWAY CONNECTION DETAIL
THICKENED EDGE DETAIL

CITY OF LIBERTY

DRIVEWAY DETAILS
SHEET 1 OF 2

PUBLIC WORKS

SCALE: N.T.S.



STANDARD DRIVEWAY FOR SINGLE FRONTAGE

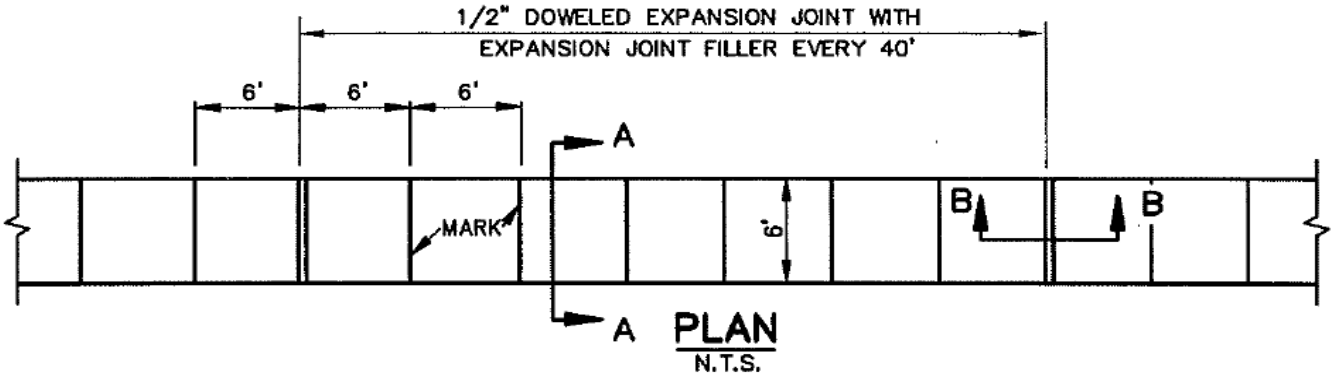
RESIDENTIAL DRIVEWAY THICKNESS - 4" MINIMUM
COMMERCIAL DRIVEWAY THICKNESS - 6" MINIMUM

CITY OF LIBERTY

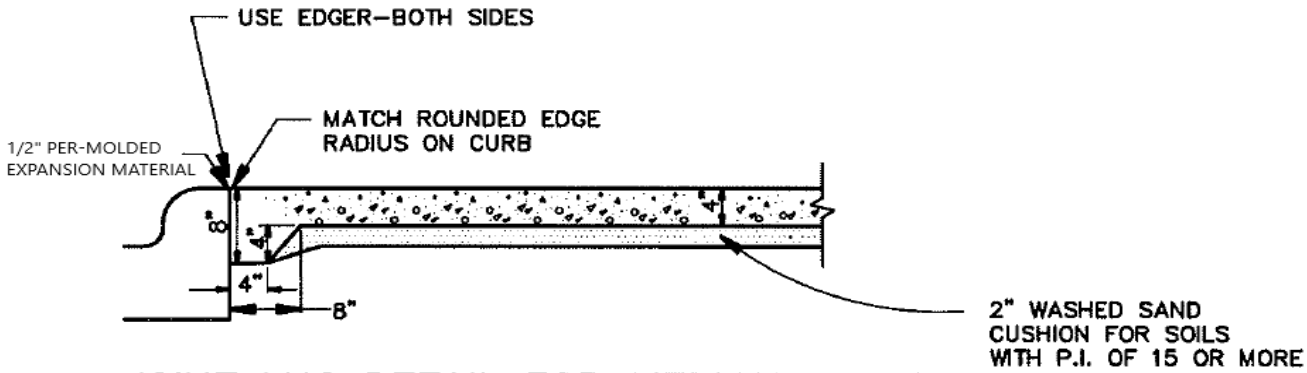
DRIVEWAY DETAILS
SHEET 2 OF 2

PUBLIC WORKS

SCALE: N.T.S.

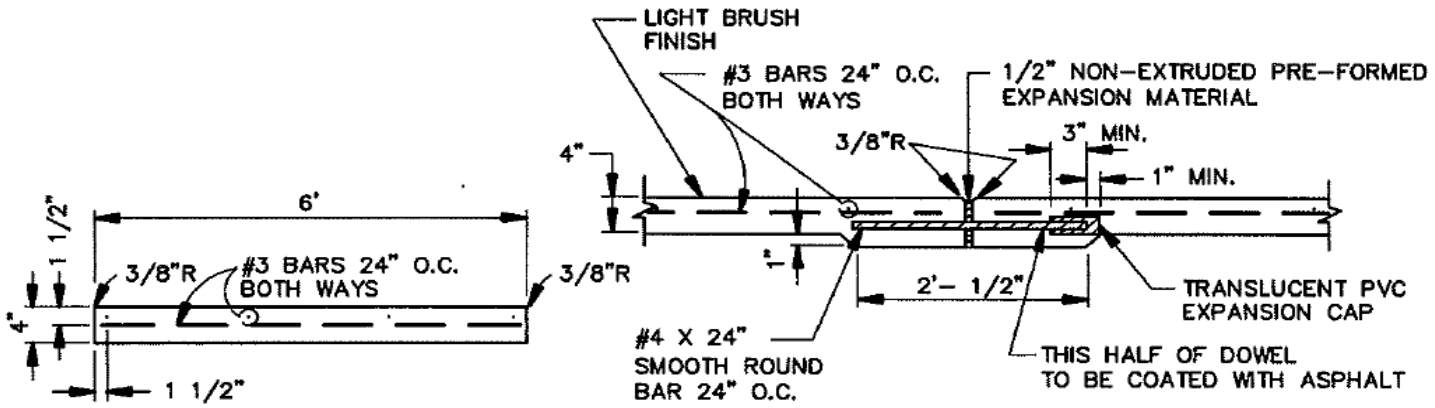


PLAN
N.T.S.



JOINT LUG DETAIL FOR MEDIAN PAVEMENT OR SIDEWALK ADJACENT TO CURB

N.T.S.



SECTION "A–A"
N.T.S.

SECTION "B–B"
N.T.S.

NOTE:

1. CROSS SLOPE OF SIDEWALK SHALL NOT EXCEED 2%.
2. LONGITUDIAL SLOPE SHALL NOT EXCESS 8.33%
3. SIDEWALK WIDTH SHALL BE A MINIMUM OF 5' (1.5' OR MORE OFF THE CURB) AND 6' (LESS THAN 1.5' OFF CURB).
4. SIDEWALK SHALL BE 3000 PSI CONCRETE MINIMUM.
5. ALL HONEYCOMB IN BACK OF EXISTING CURB SHALL BE TROWEL-PLASTERED BEFORE POURING SIDEWALK.

CITY OF LIBERTY	PUBLIC WORKS
SIDEWALK DETAIL	SCALE: N.T.S.

GENERAL NOTES

CURB RAMPS

1. Install a curb ramp or blended transition at each pedestrian street crossing.
2. All slopes shown are maximum allowable. Cross slopes of 1.5% and lesser running should be used. Adjust curb ramp length or grade of approach sidewalks as directed.
3. Maximum allowable cross slope on sidewalk and curb ramp surfaces is 2%.
4. The minimum sidewalk width is 5'. Where the sidewalk is adjacent to the back of curb, a 6' sidewalk width is desirable. Where a 5' sidewalk cannot be provided due to site constraints, sidewalk width may be reduced to 4' for short distances. 5'x 5' passing areas at intervals not to exceed 200' are required.
5. Turning Spaces shall be 5'x 5' minimum. Cross slope shall be maximum 2%.
6. Clear space at the bottom of curb ramps shall be a minimum of 4'x 4' wholly contained within the crosswalk and wholly outside the parallel vehicular travel path.
7. Provide flared sides where the pedestrian circulation path crosses the curb ramp. Flared sides shall be sloped at 10% maximum, measured parallel to the curb. Returned curbs may be used only where pedestrians would not normally walk across the ramp, either because the adjacent surface is planted, substantially obstructed, or otherwise protected.
8. Additional information on curb ramp location, design, light reflective value and texture may be found in the latest draft of the Proposed Guidelines for Pedestrian Facilities in the Public Right of Way (PROWAG) as published by the U.S. Architectural and Transportation Barriers Compliance Board (Access Board).
9. To serve as a pedestrian refuge area, the median should be a minimum of 6' wide, measured from back of curbs. Medians should be designed to provide accessible passage over or through them.
10. Small channelization islands, which do not provide a minimum 5'x 5' landing at the top of curb ramps, shall be cut through level with the surface of the street.
11. Crosswalk dimensions, crosswalk markings and stop bar locations shall be as shown elsewhere in the plans. At intersections where crosswalk markings are not required, curb ramps shall align with theoretical crosswalks unless otherwise directed.
12. Provide curb ramps to connect the pedestrian access route at each pedestrian street crossing. Handrails are not required on curb ramps.
13. Curb ramps and landings shall be constructed and paid for in accordance with Item 531 "Sidewalks".
14. Place concrete at a minimum depth of 5" for ramps, flares and landings, unless otherwise directed.
15. Furnish and install No. 3 reinforcing steel bars at 18" o.c. both ways, unless otherwise directed.
16. Provide a smooth transition where the curb ramps connect to the street.
17. Curbs shown on sheet 1 within the limits of payment are considered part of the curb ramp for payment, whether it is concrete curb, gutter, or combined curb and gutter.
18. Existing features that comply with applicaible standards may remain in place unless otherwise shown on the plans.

CITY OF LIBERTY	PUBLIC WORKS
WHEELCHAIR RAMP DETAILS SHEET 1 OF 8	SCALE: N.T.S.

DETECTABLE WARNING MATERIAL

19. Curb ramps must contain a detectable warning surface that consists of raised truncated domes complying with PROWAG. The surface must contrast visually with adjoining surfaces, including side flares. Furnish and install an approved cast-in-place dark brown or dark red detectable warning surface material adjacent to uncolored concrete, unless specified elsewhere in the plans.

20. Detectable Warning Materials must meet TxDOT Departmental Materials Specification DMS 4350 and be listed on the Material Producer List. Install products in accordance with manufacturer's specifications.

21. Detectable warning surfaces must be firm, stable and slip resistant.

22. Detectable warning surfaces shall be a minimum of 24 inches in depth in the direction of pedestrian travel, and extend the full width of the curb ramp or landing where the pedestrian access route enters the street.

23. Detectable warning surfaces shall be located so that the edge nearest the curb line is at the back of curb and neither end of that edge is greater than 5 feet from the back of curb. Detectable warning surfaces may be curved along the corner radius.

24. Shaded areas on Sheet 1 of 4 indicate the approximate location for the detectable warning surface for each curb ramp type.

DETECTABLE WARNING PAVERS (IF USED)

25. Furnish detectable warning paver units meeting all requirements of ASTM C-936, C-33. Lay in a two by two unit basket weave pattern or as directed.

26. Lay full-size units first followed by closure units consisting of at least 25 percent (25%) of a full unit. Cut detectable warning paver units using a power saw.

SIDEWALKS

27. Provide clear ground space at operable parts, including pedestrian push buttons. Operable parts shall be placed within unobstructed reach range specified in PROWAG section R406.

28. Place traffic signal or illumination poles, ground boxes, controller boxes, signs, drainage facilities and other items so as not to obstruct the pedestrian access route or clear ground space.

29. Street grades and cross slopes shall be as shown elsewhere in the plans.

30. Changes in level greater than 1/4 inch are not permitted.

31. The least possible grade should be used to maximize accessibility. The running slope of sidewalks and crosswalks within the public right of way may follow the grade of the parallel roadway. Where a continuous grade greater than five percent (5%) must be provided, handrails may be desirable to improve accessibility. Handrails may also be needed to protect pedestrians from potentially hazardous conditions. If provided, handrails shall comply with PROWAG R409.

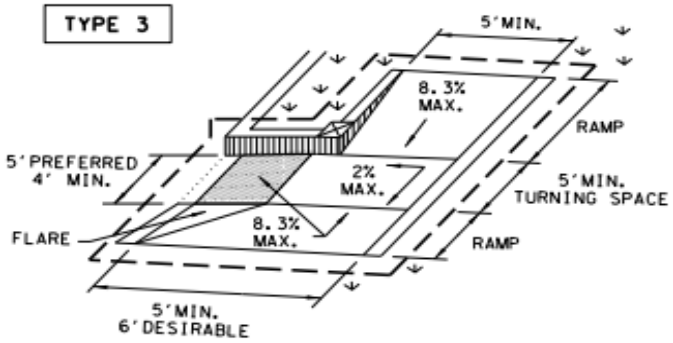
32. Handrail extensions shall not protrude into the usable landing area or into intersecting pedestrian routes.

33. Driveways and turnouts shall be constructed and paid for in accordance with Item "Intersections, Driveways and Turnouts". Sidewalks shall be constructed and paid for in accordance with Item, "Sidewalks".

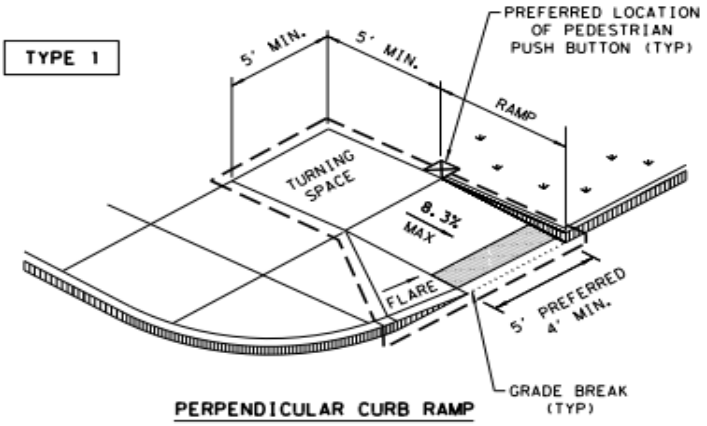
34. Sidewalk details are shown elsewhere in the plans.

CITY OF LIBERTY	PUBLIC WORKS
WHEELCHAIR RAMP DETAILS SHEET 2 OF 8	SCALE: N.T.S.

TYPE 3

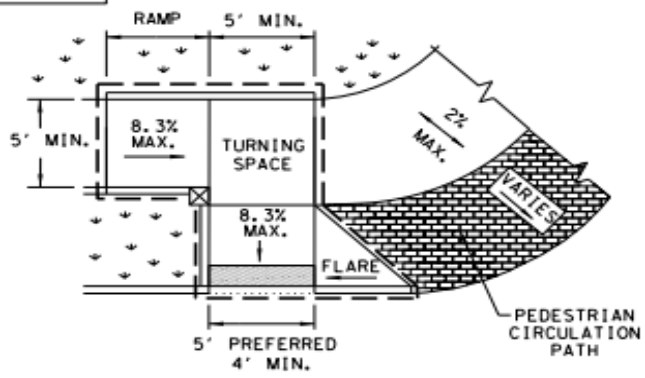


TYPE 1



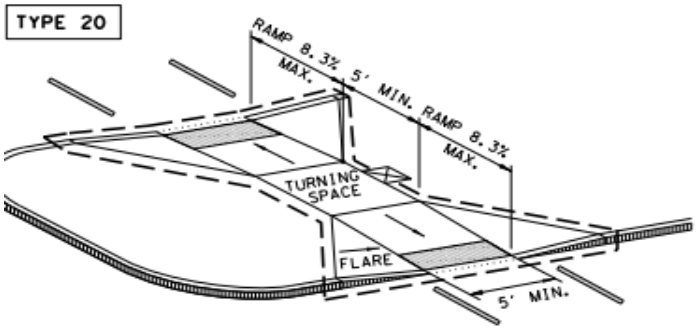
PERPENDICULAR CURB RAMP

TYPE 6



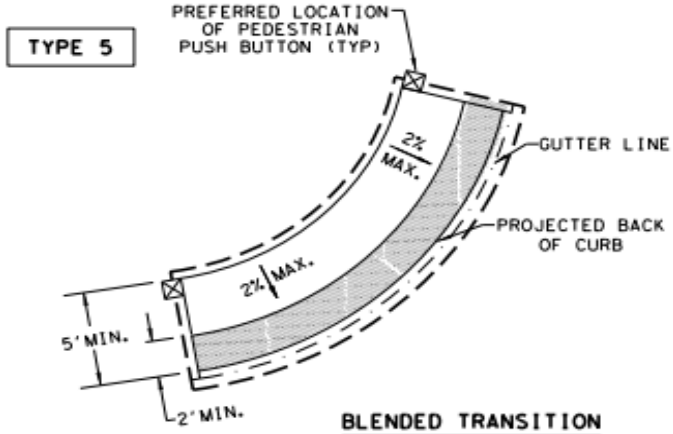
COMBINATION CURB RAMPS

TYPE 20



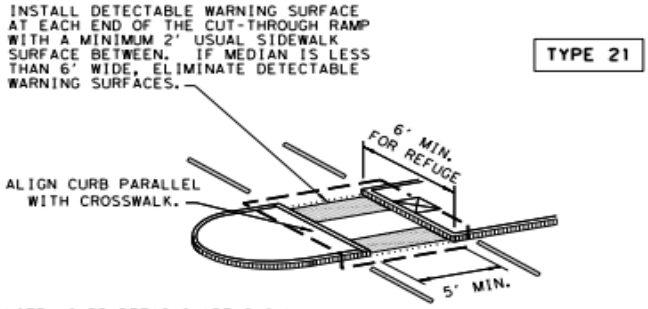
CURB RAMPS AT MEDIAN ISLANDS

TYPE 5



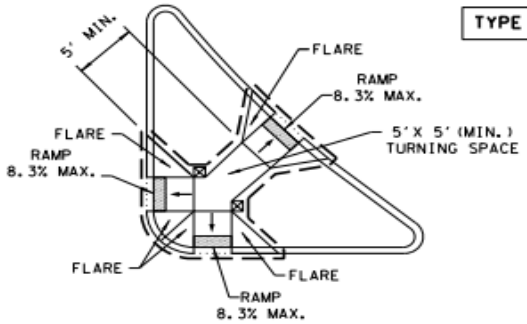
BLENDED TRANSITION
(FLUSH LANDING)

TYPE 21



NOTE: CURB DETAILS ARE SHOWN ELSEWHERE IN THE PLANS.

TYPE 22



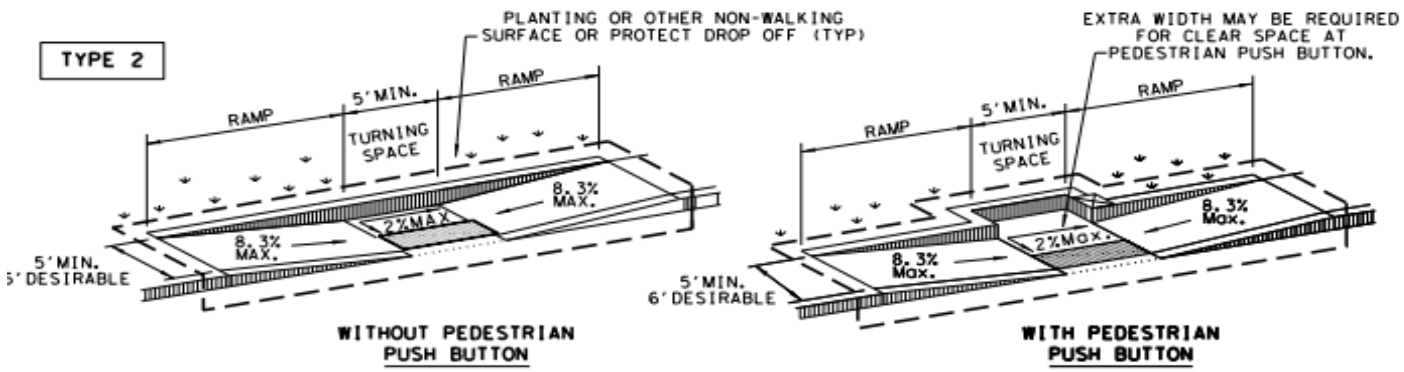
COMBINATION ISLAND RAMPS

CITY OF LIBERTY

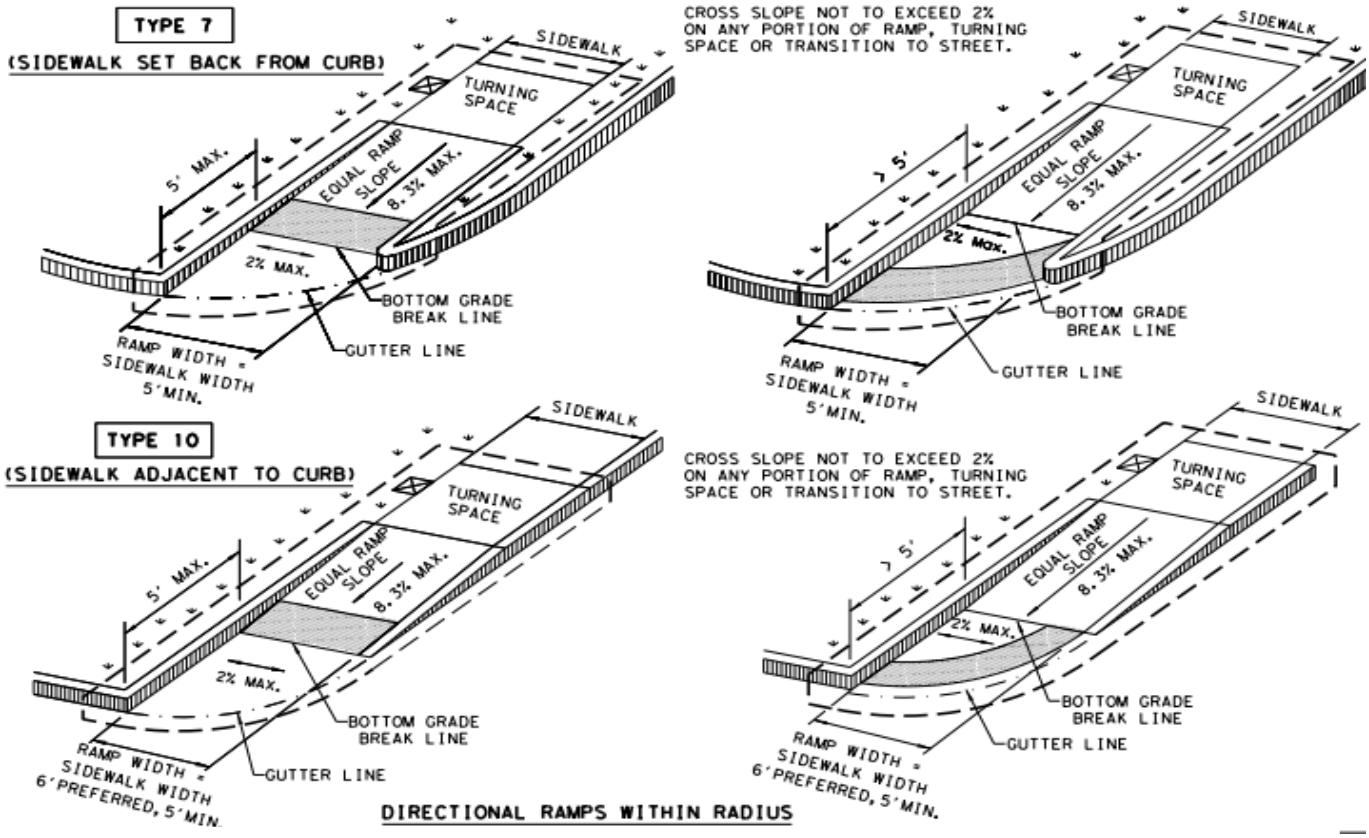
WHEELCHAIR RAMP DETAILS
SHEET 3 OF 8

PUBLIC WORKS

SCALE: N.T.S.



PARALLEL CURB RAMP



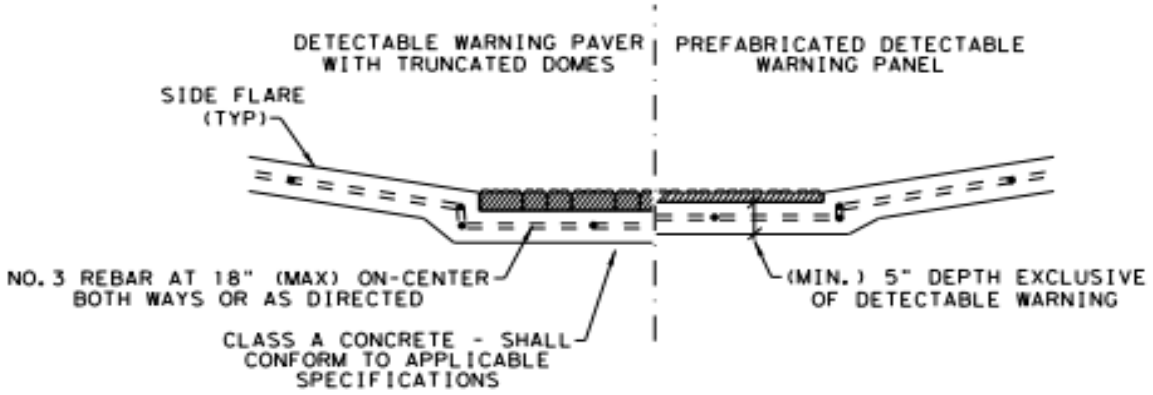
DIRECTIONAL RAMPS WITHIN RADIUS

CITY OF LIBERTY

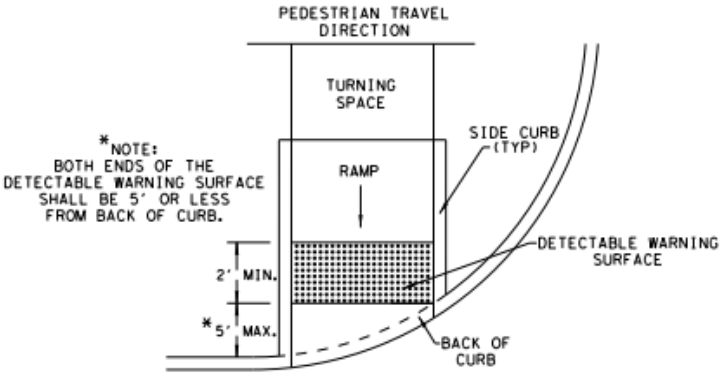
WHEELCHAIR RAMP DETAILS
SHEET 4 OF 8

PUBLIC WORKS

SCALE: N.T.S.



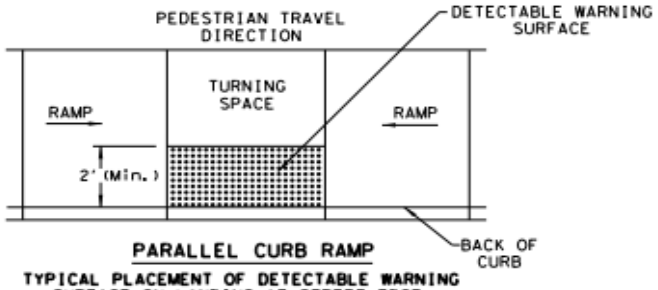
SECTION VIEW DETAIL
CURB RAMP AT DETECTIBLE WARNINGS



DIRECTIONAL CURB RAMP

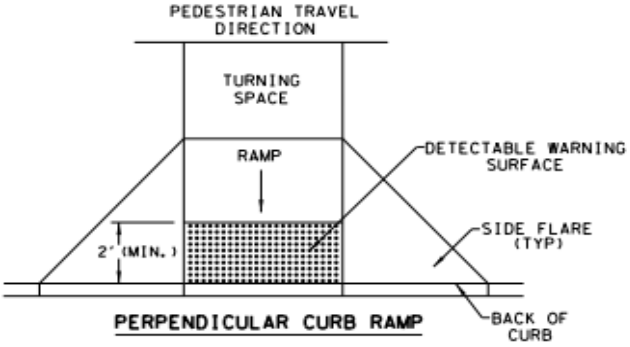
TYPICAL PLACEMENT OF DETECTABLE WARNING SURFACE ON SLOPING RAMP RUN.

DETECTABLE WARNING SURFACE DETAILS



PARALLEL CURB RAMP

TYPICAL PLACEMENT OF DETECTABLE WARNING SURFACE ON LANDING AT STREET EDGE.



PERPENDICULAR CURB RAMP

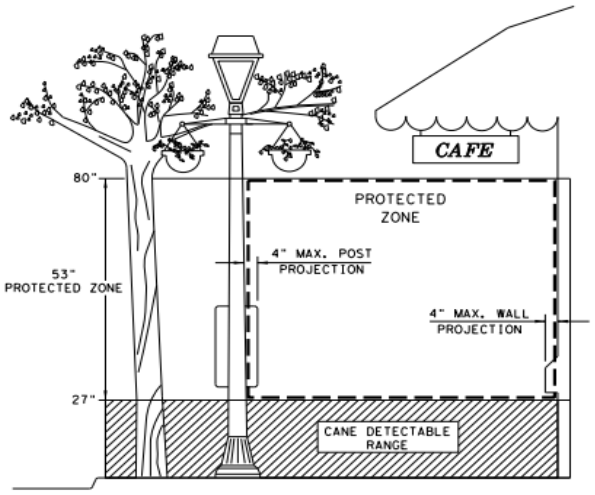
TYPICAL PLACEMENT OF DETECTABLE WARNING SURFACE ON SLOPING RAMP RUN.

CITY OF LIBERTY

WHEELCHAIR RAMP DETAILS
SHEET 5 OF 8

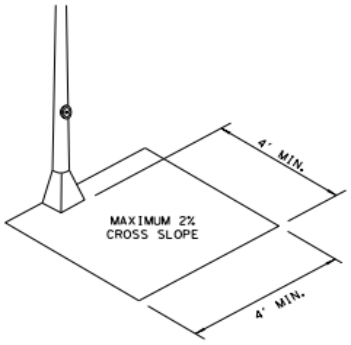
PUBLIC WORKS

SCALE: N.T.S.

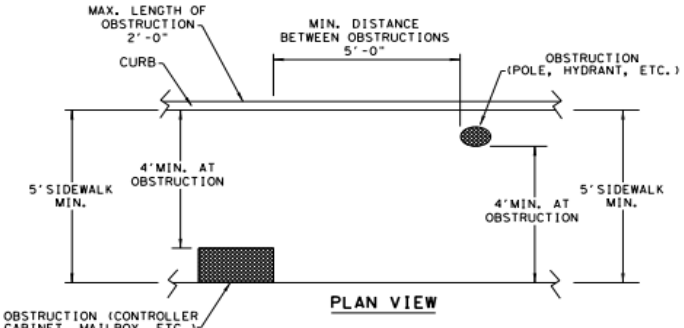


PROTECTED ZONE

NOTE: IN PEDESTRIAN CIRCULATION AREA, MAXIMUM 4" PROJECTION FOR POST OR WALL MOUNTED OBJECTS BETWEEN 27" AND 80" ABOVE THE SURFACE.



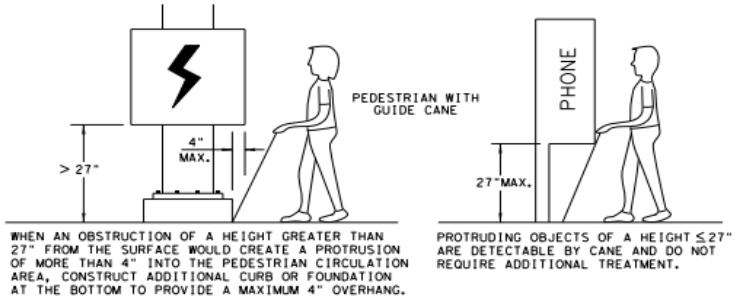
CLEAR SPACE ADJACENT TO PEDESTRIAN PUSH BUTTON



PLAN VIEW

PLACEMENT OF STREET FIXTURES

NOTE: ITEMS NOT INTENDED FOR PUBLIC USE. MINIMUM 4' X 4' CLEAR GROUND SPACE REQUIRED AT PUBLIC USE FIXTURES.



WHEN AN OBSTRUCTION OF A HEIGHT GREATER THAN 27" FROM THE SURFACE WOULD CREATE A PROTRUSION OF MORE THAN 4" INTO THE PEDESTRIAN CIRCULATION AREA, CONSTRUCT ADDITIONAL CURB OR FOUNDATION AT THE BOTTOM TO PROVIDE A MAXIMUM 4" OVERHANG.

PROTRUDING OBJECTS OF A HEIGHT ≤ 27" ARE DETECTABLE BY CANE AND DO NOT REQUIRE ADDITIONAL TREATMENT.

DETECTION BARRIER FOR VERTICAL CLEARANCE < 80"

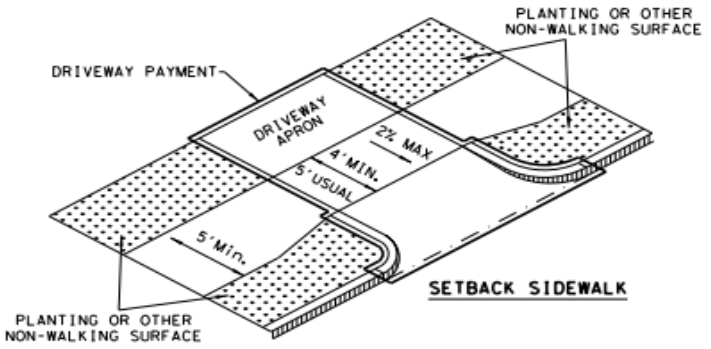
CITY OF LIBERTY

WHEELCHAIR RAMP DETAILS
SHEET 6 OF 8

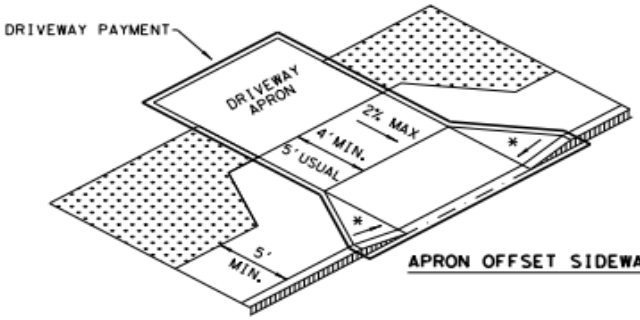
PUBLIC WORKS

SCALE: N.T.S.

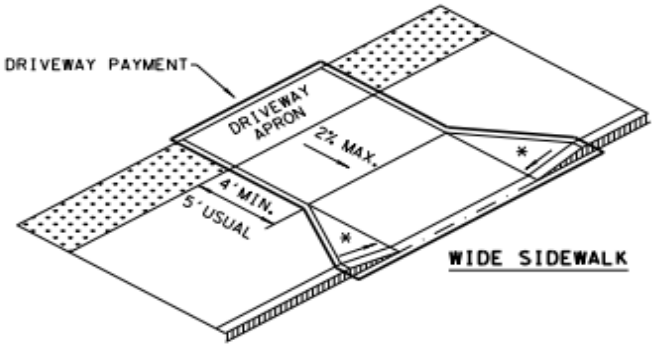
SIDEWALK TREATMENT AT DRIVEWAYS



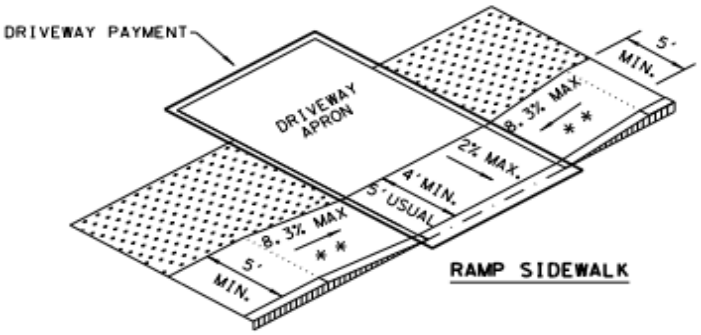
SETBACK SIDEWALK



APRON OFFSET SIDEWALK



WIDE SIDEWALK



RAMP SIDEWALK

NOTES:

* WHERE DRIVEWAYS CROSS THE PEDESTRIAN ROUTE, SIDES SHALL BE FLARED AT 10% MAX SLOPE.

** IF CURB HEIGHT IS GREATER THAN 6 INCHES, USE GRADE LESS THAN OR EQUAL TO 5%. HANDRAIL AND DETECTABLE WARNING ARE NOT REQUIRED.

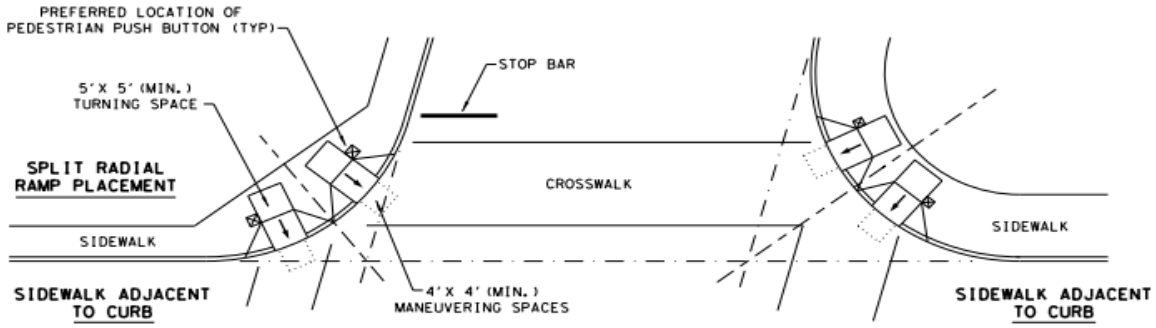
CITY OF LIBERTY

WHEELCHAIR RAMP DETAILS

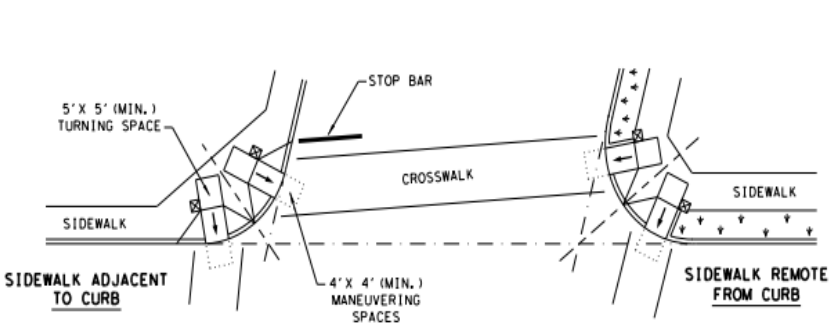
SHEET 7 OF 8

PUBLIC WORKS

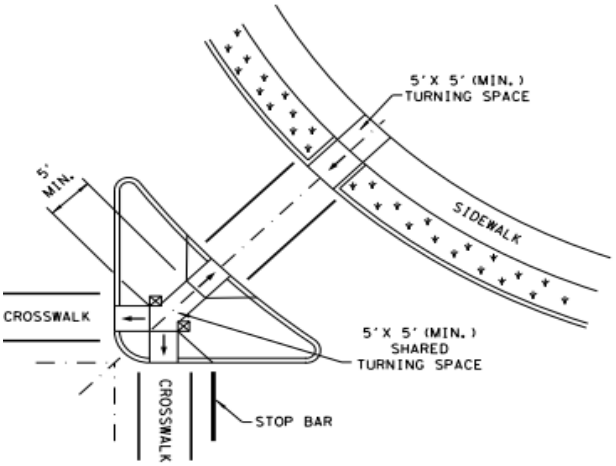
SCALE: N.T.S.



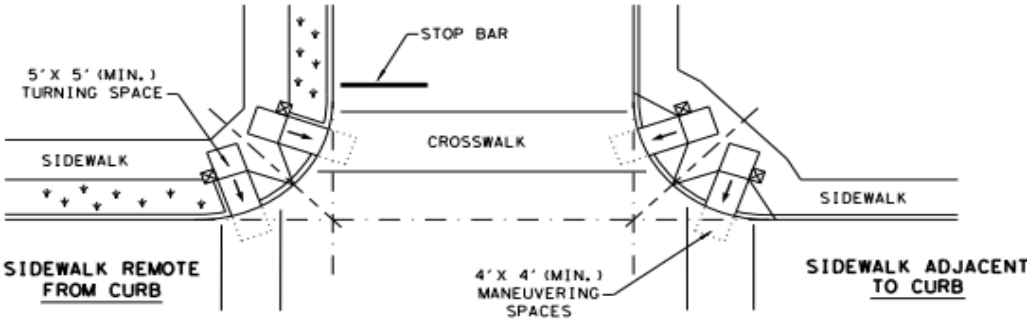
SKEWED INTERSECTION WITH "LARGE" RADIUS



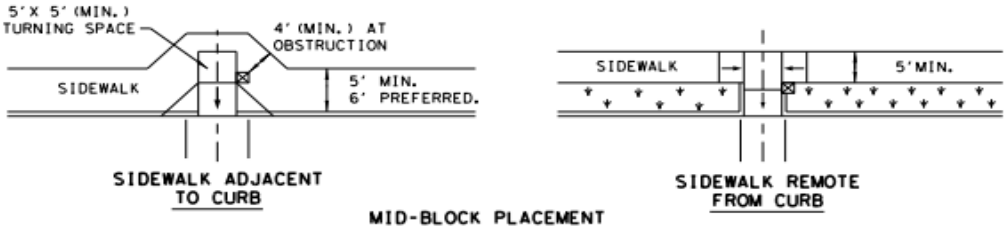
SKEWED INTERSECTION WITH "SMALL" RADIUS



AT INTERSECTION W/FREE RIGHT TURN & ISLAND



NORMAL INTERSECTION WITH "SMALL" RADIUS



MID-BLOCK PLACEMENT PERPENDICULAR RAMPS

CITY OF LIBERTY

****TYPICAL CROSSING LAYOUTS****

WHEELCHAIR RAMP DETAILS

SHEET 8 OF 8

PUBLIC WORKS

SCALE: N.T.S.

Sec. 3.02.003, Parking Lot and Parking Space Dimensions

A. **Generally.** All off-street parking spaces that are not within the City's right-of-way shall be designed in accordance with this Section.

B. **Design and Construction Requirements.**

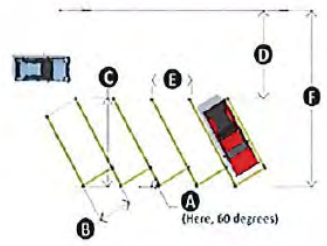
1. *Parking Space / Area Slope.* No parking space or parking area shall be constructed with a slope of more than six percent. The City Council may approve a variance, in accordance with Sec. 8.05.001, *Variances*, to construct a parking area with a slope of more than six percent provided that the slope does not exceed 12 percent. In the instance that the City Council approves a variance for a slope of between six and 12 percent grade, each parking space shall be constructed at right angles to the slope.
2. *Tandem Parking.* Each parking space shall be accessible from a street or alley through aisles and/or driveways, except that tandem parking arrangements are permitted for single-family, two-family, and manufactured home uses or as allowed based on an approved parking study as described in Sec. 3.02.009, *Reduction of Parking and Loading Requirements*.
3. *Dead-End Aisles.* Dead-end aisles are not permitted unless adequate turnarounds are provided in dimensions and configurations that are acceptable to the City Engineer.
4. *Marking.* All parking spaces for nonresidential and mixed uses shall be clearly marked on the pavement with yellow or white traffic paint or raised pavement markers approved by the City Engineer.
5. *Site Access.* All driveways and other site access shall meet the applicable driveway requirements of Sec. 3.02.006, *Site Access*.
6. *Parking Module Dimensions.* Parking modules shall be dimensioned as shown in Table 3.02.003-1, *Parking Module Dimensions*. The dimensions that are set out in the table are illustrated in Figure 3.02.003-1, *Illustrative Parking Module Configurations*.

Table 3.02.003-1
Parking Module Dimensions

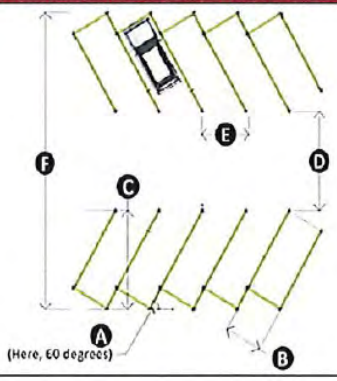
A	B	C	D		E	F	
Angle of Parking (Degrees)	Width of Stall	Depth of Stall 90 Degrees to Aisle	Width of Aisle		Width of Stall Parallel to Aisle	Module Width	
			One Way	Two Way		One Way	Two Way
45	9'	21.1'	12'	20'	12.5'	54.2'	62.2'
45	10'	21.1'	12'	20'	14.1'	54.2'	62.2'
60	9'	22.3'	15'	–	10.4'	59.6'	–
60	10'	22.3'	14'	–	11.6'	58.6'	–
90	9'	20'	–	25'	9'	–	65'
90	10'	20'	–	24'	10'	–	64'
Parallel	9'	9 (width)	12'	24'	22'	30'	42'

Figure 3.02.003-1
Illustrative Parking Module Configurations

Illustrative dimensions for one stall row parking module



Illustrative dimensions for two stall row parking module



CITY OF LIBERTY

PARKINGLOT STANDARDS
SHEET 1 OF 5

PUBLIC WORKS

SCALE: N.T.S.

Sec. 3.02.004, Required Off-Street Parking

A. Generally. The minimum off-street parking regulations shall be provided for the land uses specified in Table 3.02.004-1, *Required Off-Street Parking by Land Use*.

B. Downtown District. All properties within the Downtown (DT) district are exempt from the parking requirements of this Section.

C. Calculation of Spaces. The number of required parking spaces is calculated according to the formulas set out in this Section. The variables used for parking calculations are as follows:

1. *Sum of Specific Uses.* In computing the parking requirements for any development the total parking requirements shall be the sum of the specific parking space requirements, per Table 3.02.004-1, *Required Off-Street Parking by Land Use*, for each use included in the development except as provided in Sec. 3.02.008, *Shared and Offsite Parking*.
2. *Rounding.* If the final calculation of the number of required parking spaces includes a fractional space, the number of required parking spaces is rounded up to the nearest whole number, regardless of the fraction.
3. *Per Square Foot (sf.) of Parking Floor Area (PFA).* The phrase "per sf. of PFA" means that the number of parking spaces is calculated based on the number of "parking-related" square feet of floor area per use. The "PFA" is 85 percent of the gross floor area, plus the area of any parts of the parcel proposed for development that are delineated and used in a manner that is comparable in function and intensity to the use of the inside of the building (e.g., outdoor dining areas).
4. *Per Dwelling Unit (DU).* The phrase "per DU" means that the number of parking spaces is calculated based on the number of dwelling units.
5. *Per Bedroom (BR).* The phrase "per BR" means the number of parking spaces is calculated based on the number of bedrooms.
6. *Per Bed.* The phrase "per bed" means that the number of parking spaces is based on the total number of beds in any given facility. Per bed calculations are normally applied to uses that offer residential care or overnight accommodations with shared rooms.
7. *Per Employee.* The phrase "per employee" means that the number of parking spaces is based on the number of employees during the shift in which the maximum number of employees is present.
8. *Uses Involving Fleets or Vehicle Inventory.* Uses that involve fleets of vehicles (e.g., post offices, police stations, fire stations, etc.) and uses that involve vehicle inventories (e.g., auto sales and service establishments) shall provide adequate on-site parking for the fleet or inventory. Such parking shall not count towards the requirements of Table 3.02.004-1, *Required Off-Street Parking by Land Use.*
9. *Uses Not Listed.* Where a determination of the minimum parking and/or loading requirements cannot be readily ascertained for uses not listed or where uncertainty exists, the minimum off-street parking and/or loading requirements shall be established by the same process as provided for classifying new and unspecified uses. See Sec. 2.02.006, *Uses Not Listed.*

CITY OF LIBERTY

PARKINGLOT STANDARDS
SHEET 2 OF 5

PUBLIC WORKS

SCALE: N.T.S.

Table 3.02.004-1 Required Off-Street Parking by Land Use	
Residential	
Household Living	**Required Off-Street Parking**
Single Family Dwelling (Standard)	2 spaces per dwelling unit (DU)
Duplex (2 du)	2 spaces per DU
Townhouse (3 to 10 du)	1.5 spaces per DU
Apartment (>3 du)[1]	1.5 spaces per DU
Group Home (3 or fewer residents)	1 per employee on largest shift; minimum of 2
Group Home (4 or more residents)	1 per employee on largest shift; minimum of 2
Manufactured Home	2 spaces per DU
Manufactured Home Park	2 spaces per DU
Retirement Housing	1 space per 3 beds
Residential Accessory Uses	**Required Off-Street Parking**
Attached Accessory Dwelling Unit	1 space per BR
Detached Accessory Dwelling Unit	1 space per BR
Home Occupation	No additional parking required
Loft Apartment	1 space per BR
Registered Family Home	1 per employee on largest shift; minimum 3
Short-Term Rental	1 space per BR designated for the use
Agricultural	
Agricultural Uses and Agricultural Support Services	**Required Off-Street Parking**
Animal Husbandry	1 space per 5,000 sf. of the use
Community Garden	1 space per 5,000 sf. of the use
Farm, Ranch or Orchard	No minimum
Farming, Landscaping, and Horticultural Sales	1 space per 5,000 sf. of the use
Greenhouse / Nursery	1 per 350 sq ft GFA plus 1 per 2,500 sq ft outdoor storage
Kennel / Animal Shelter	1 space per 400 sf. PFA
Veterinary Clinic and/or Service, Small Animal	1 space per 350 sf. PFA
Veterinary Clinic, Large Animal	1 space per 350 sf. PFA
Non-residential and Mixed Uses	
Automobile and Related Service Uses	**Required Off-Street Parking**
Vehicle Wash	1 space per 2 bays for self-service vehicle washes (not including the bays); 1 space per unattended automated wash; 5 spaces per attended, automated wash with detail or hand-finishing services
Vehicle Parts and/or Accessories	1 space per 350 sf. PFA
Vehicle Sales	1 space per 1,000 sf. PFA of showroom + 1 space per 20,000 sf. of inventory storage
Vehicle Rental	5 spaces, plus spaces for rental car inventory
Vehicle Repair, Major	1 per 350 sq ft office area plus 1 per 2,500 sq ft outdoor storage and display area plus 2 per service bay
Vehicle Repair, Minor	1 per 350 sq ft office area plus 1 per 2,500 sq ft outdoor storage and display area plus 2 per service bay
Civic, Institutional, and Health Care Uses	**Required Off-Street Parking**
Adult Day Care Center	1 per 10 enrolled persons plus 1 per employee on largest shift
Cemetery / Funeral Services	1 space per 5 seats in the assembly area
Correctional Institution	1 space per 500 sf. PFA
Child-Care, Day Care Center	1 per 10 enrolled persons plus 1 per employee on largest shift
Governmental Service (Library, Administration)	No minimum
Governmental Service (Police, Fire, EMS)	No minimum
Hospital / Rehabilitative Care	1.5 per bed plus 1 per 500 sq ft emergency room and outpatient care area
Library, Museum, or Gallery	1 space per 300 sf. PFA
Medical Lab	1 space per 250 sf. PFA
Medical Office / Clinic	1 space per 350 sf. PFA
Place of Public Assembly, Indoor	1 per 350 sq ft PFA or 1 per 4 seats in assembly area, whichever is greater
School, Public or Private (elementary and middle school)	1 per 10 students plus 1 per employee on largest shift
School, Public or Private (high school and adult education)	1 per 4 students plus 1 per employee on largest shift
School, Vocational or Trade	1 space per 65 sq. ft. of classroom space + 1 space per 300 sq. ft. of office space
Commercial Uses	**Required Off-Street Parking**
Bank, Credit Union, and Financial Services	1 space per 300 sf. PFA
Building Materials and Hardware	1 space per 300 sf. PFA

CITY OF LIBERTY

PARKINGLOT STANDARDS
SHEET 3 OF 5

PUBLIC WORKS

SCALE: N.T.S.

Table 3.02.004-1 Required Off-Street Parking by Land Use	
Dance Hall / Nightclub	1 space per 100 sf. PFA
Gasoline Station	1 space per 4 pump stations or Level 3 charging stations, plus 3 spaces per service bay, plus 1 space per 200 sf. PFA for an attached convenience store
Grocery (Food Sales)	1 space per 350 sf. PFA
Heavy Machinery Sales and Rentals	1 space per 350 sf. PFA
Home Furnishing Store	1 space per 350 sf. PFA
Manufactured Home Sales	1 space per 500 sf. PFA + 1 space per 10,000 sf. outdoor storage area
Motel	1 per guest room plus one per employee on largest shift
Office, General	1 space per 500 sf. PFA
Pawn shop	1 space per 350 sf. PFA
Personal Services	1 space per 350 sf. PFA
Recreational Vehicle Parks and Campgrounds	2 per park site or campsite
Repair Service	1 space per 350 sf. PFA
Restaurant	1 space per 4 seats
Retail Sales	1 space per 350 sf. PFA
Self-storage, mini-warehouse	1 space per 20 storage stalls plus 1 space per 350 sq. ft. of gross floor area of office space
Sexually Oriented Business	1 space per 250 sf. PFA
Studio or Shop (Arts, Crafts, or Recording)	1 space per 350 sf. PFA
Recreation and Entertainment Uses	Required Off-Street Parking
Commercial Amusement, Indoor	1 space per 250 sf. PFA
Commercial Amusement, Outdoor	1 per 350 sq ft PFA plus 1 per 300 sq ft outdoor facilities
Park & Recreation Facility or Center	5 per acre; Minimum 10 spaces
Industrial and Manufacturing Uses	Required Off-Street Parking
Bakery, Wholesale	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Contractor's Shop and/or Service Yard	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Industrial and Manufacturing Product Sales and Supply	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Industrial, Heavy	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Industrial, Light	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Oil and Gas Well	1 space per employee on the largest shift
Publishing Services	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Resource Extraction	1 space per employee on the largest shift
Warehousing and Storage	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Wrecking Services, Salvage and Storage Yards, Junkyards, and Junk Dealers	1 space per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Utility	Required Off-Street Parking
Cargo Terminal	1 per 350 sq ft office area plus 1 per 1,000 sq ft GFA
Landfill	1 space per employee on largest shift
Passenger Terminal	1 space per 400 sf. of PFA
Power Generation, Transmission, and Distribution (includes large solar collectors and windmills)	1 per on-site employee or visitor
Water and Sewage Treatment	1 per on-site employee or visitor
Water Storage	1 per on-site employee or visitor
Table Notes: [1] The off-street parking spaces designated for each apartment shall be located within 100 feet of the dwelling unit served by such spaces.	

CITY OF LIBERTY

PARKINGLOT STANDARDS
SHEET 4 OF 5

PUBLIC WORKS

SCALE: N.T.S.

Sec. 3.02.005, Parking for Persons with Disabilities (ADA)

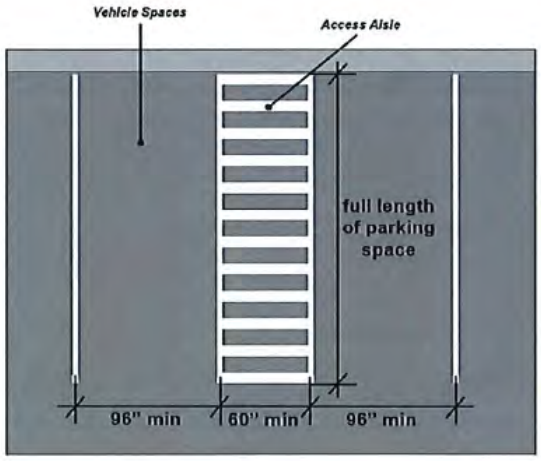
A. **Number of Required Spaces.** Parking for disabled persons shall be provided as set out in Table 3.02.005, *Accessible Parking Requirements*, or as required by the Americans with Disabilities Act (ADA) Standards for Accessible Design and ADA Accessibility Guidelines for Buildings and Facilities published by the United States Access Board. If any of the standards within this Section and the United States Access Board are in conflict then whichever requires more spaces shall be used. Required accessible parking spaces are included in the total number of required parking spaces per Sec. 3.02.004, *Required Off-Street Parking (Calculation of Required Spaces by Land Use)*.

Table 3.02.005
Accessible Parking Requirements

Number of Required Parking Spaces	Minimum Number of Accessible Parking Spaces	Minimum Number of Van-Accessible Parking Spaces
1 to 25	1	1
26 to 50	2	1
51 to 75	3	1
76 to 100	4	1
101 to 150	5	1
151 to 200	6	1
201 to 300	7	2
301 to 400	8	2
401 to 500	9	2
501 to 1000	2% of total parking provided in each lot or structure	1 out of 6 accessible spaces, rounded up
1001 and over	20 plus 1 for each 100 over 1000	1 out of 6 accessible spaces, rounded up

B. **Parking Space Size Specifications.** Figure 3.02.005, *ADA Parking Space Dimensions*, details the specific size requirements for both standard automobile and van accessible ADA accessible parking spaces.

Figure 3.02.005
ADA Parking Space Dimensions



CITY OF LIBERTY

PARKINGLOT STANDARDS
SHEET 5 OF 5

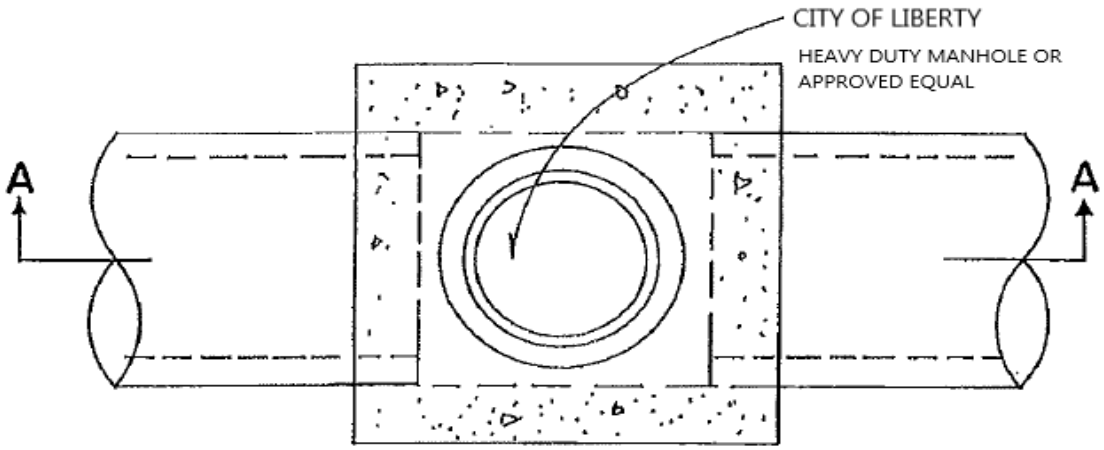
PUBLIC WORKS

SCALE: N.T.S.

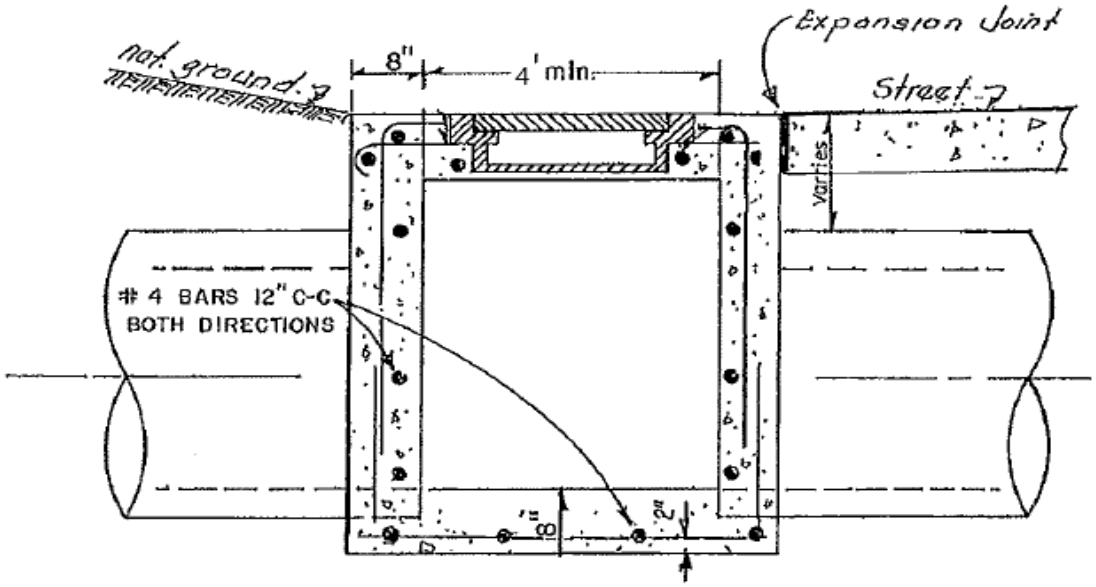
STORMWATER CONSTRUCTION AND DESIGN STANDARDS

CITY OF LIBERTY

SECTION 2



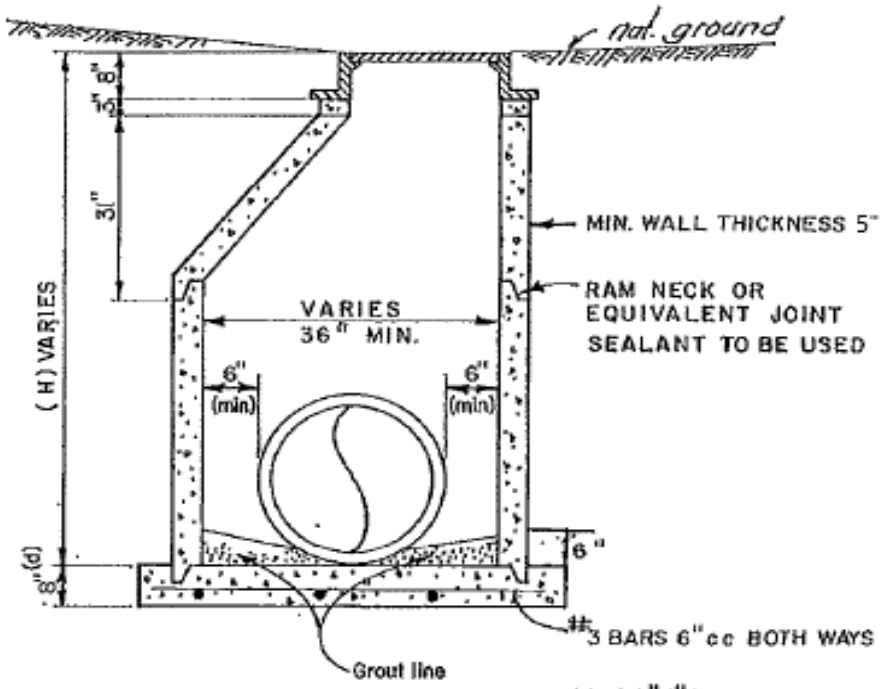
PLAN VIEW
JUNCTION BOX



SECTION A–A

*MANHOLES IN THE STREET REQUIRE TRAFFIC RATED LIDS. LIGHT DUTY LIDS ON OFF TRAVEL LANE STRUCTURES

CITY OF LIBERTY	PUBLIC WORKS
MANHOLE / JUNCTION BOX CAST-IN-PLACE	SCALE: N.T.S.



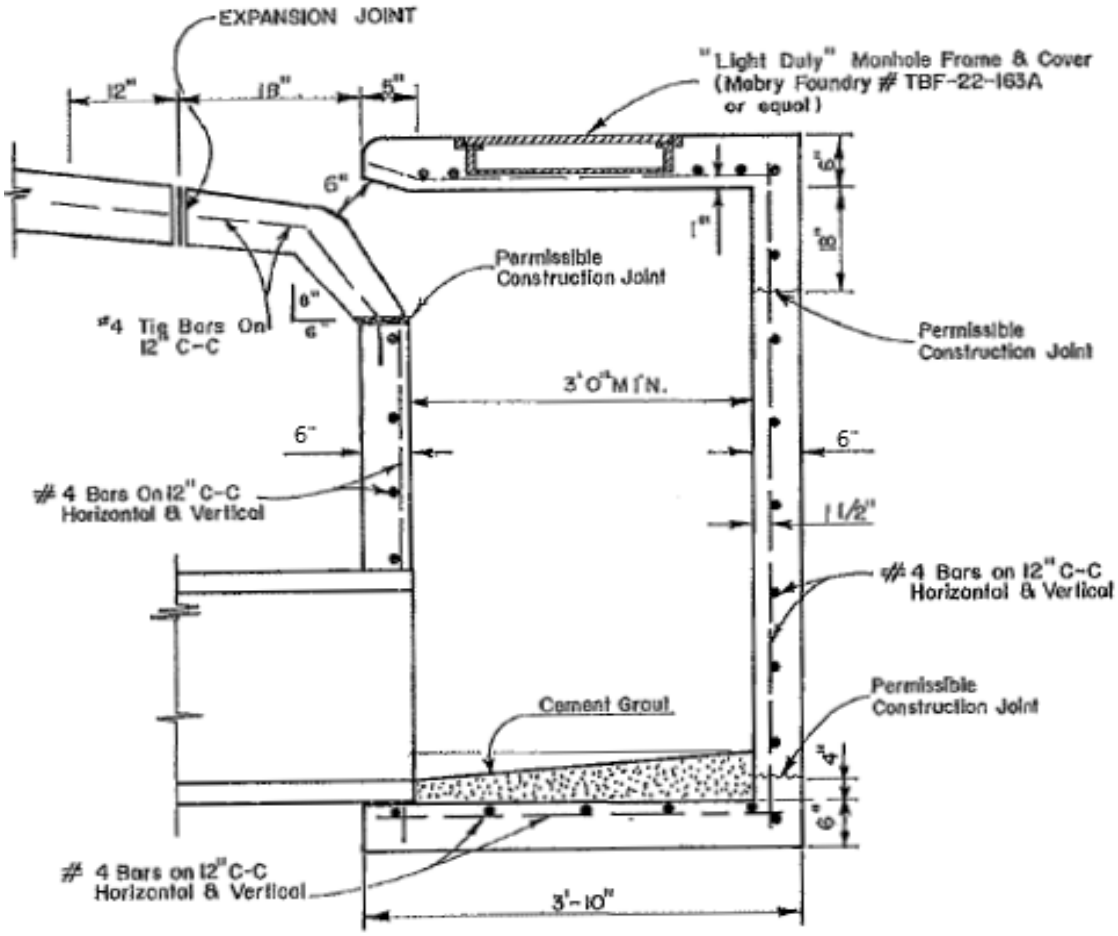
NOTE:
If (h) is greater than 8', then (d) is equal to 12"

Reinforcing To Meet ASTM C-478 Standards

STANDARD REINFORCED PRECAST MANHOLE

*MANHOLES IN THE STREET REQUIRE TRAFFIC RATED LIDS

CITY OF LIBERTY	PUBLIC WORKS
MANHOLE / JUNCTION BOX PRE-CAST	SCALE: N.T.S.

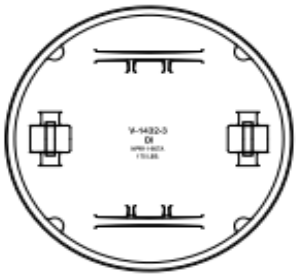


CITY OF LIBERTY

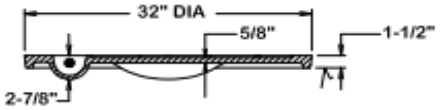
CURB-INLETS
CAST-IN-PLACE

PUBLIC WORKS

SCALE: N.T.S.



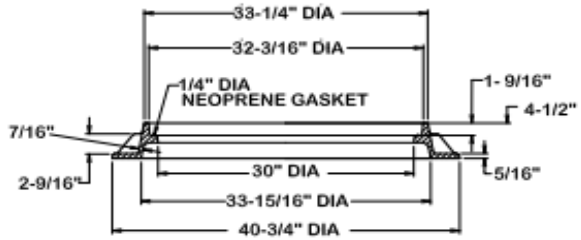
BOTTOM VIEW OF COVER



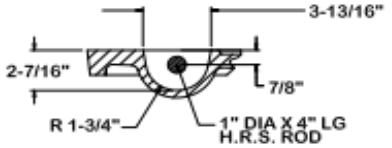
COVER SECTION

NOTE:
STORM SEWER LIDS TO BE USED FOR PUBLIC STORM SEWER SYSTEMS ONLY. NOT TO BE USED ON PRIVATE STORM SEWER SYSTEMS.

√ MACHINED SURFACE



FRAME SECTION



PICKBAR DETAIL

GENERAL NOTES:

1. **BASE THICKNESS AND FOUNDATION SHALL BE AS FOLLOWS:**

INLET DEPTH (FT.) (MEASURED FROM FLOWLINE TO FINAL GRADE)	BASE THICKNESS
0 - 12	8"
12 AND OVER	12"

2. **DEPTHS GREATER THAN 12' WILL REQUIRE 2 MATS OF REINFORCING STEEL IN THE BASE.**
3. **ALL AREAS WHERE EXISTING VEGETATION AND GRASS COVER HAVE BEEN BARED BY CONSTRUCTION SHALL BE ADEQUATELY BLOCK SODDED OR HYDROMULCHED AND WATERED UNTIL GROWTH IS ESTABLISHED. IN DEVELOPED AREAS WHERE GRASS IS PRESENT, BLOCK SOD WILL BE REQUIRED.**
4. **APPROVED EROSION CONTROL MEASURES MUST BE INSTALLED DURING THE ENTIRE TIME THAT EARTH HAS BEEN BARED BY CONSTRUCTION AND SHALL STAY IN PLACE UNTIL ACCEPTABLE VEGETATIVE GROWTH IS ESTABLISHED AFTER CONSTRUCTION IS COMPLETE AND THEN REMOVED BY CONTRACTOR.**

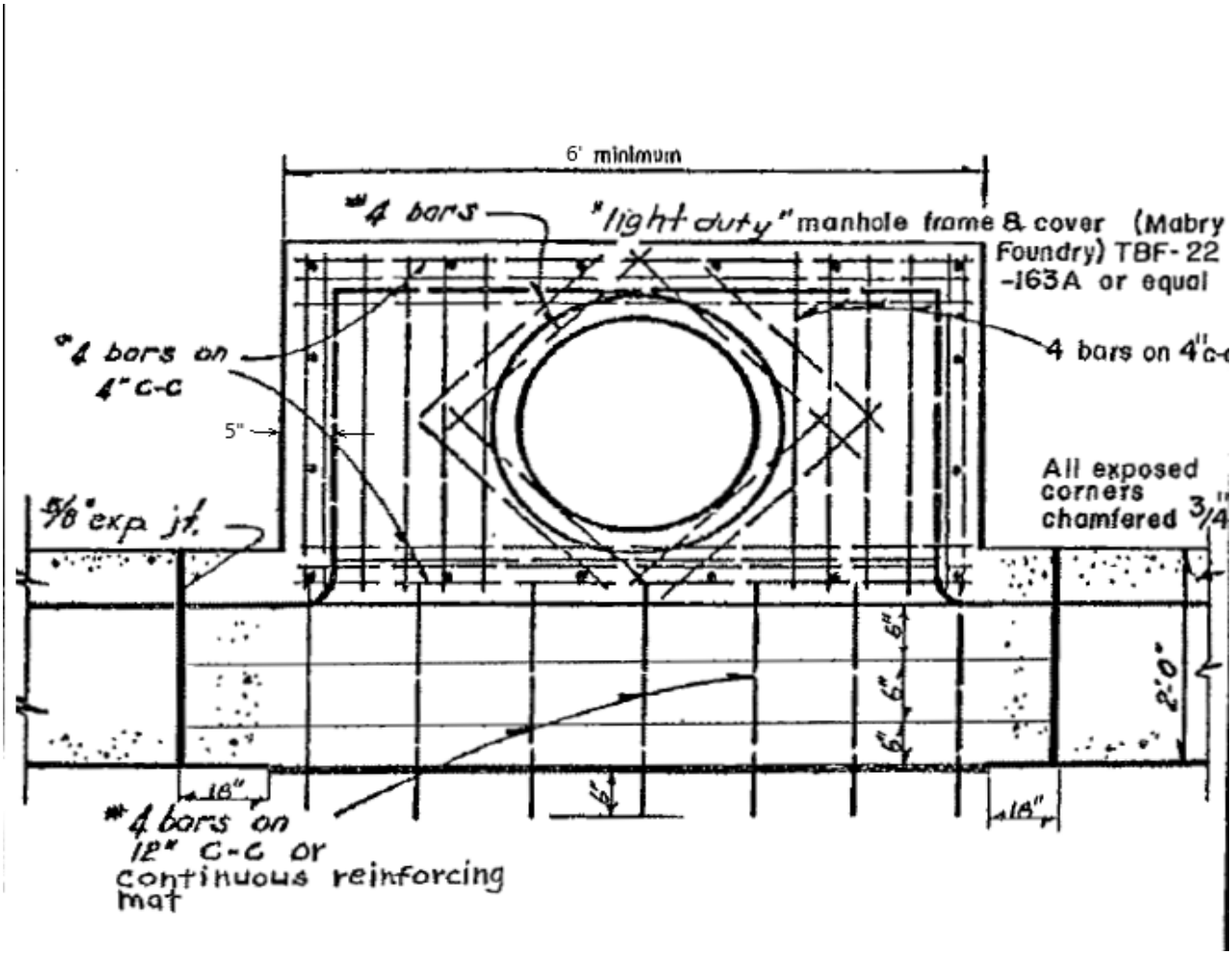
32" DIA. DUCTILE IRON V-1432-3

CITY OF LIBERTY

MANHOLE / INLET
RING AND COVER

PUBLIC WORKS

SCALE: N.T.S.



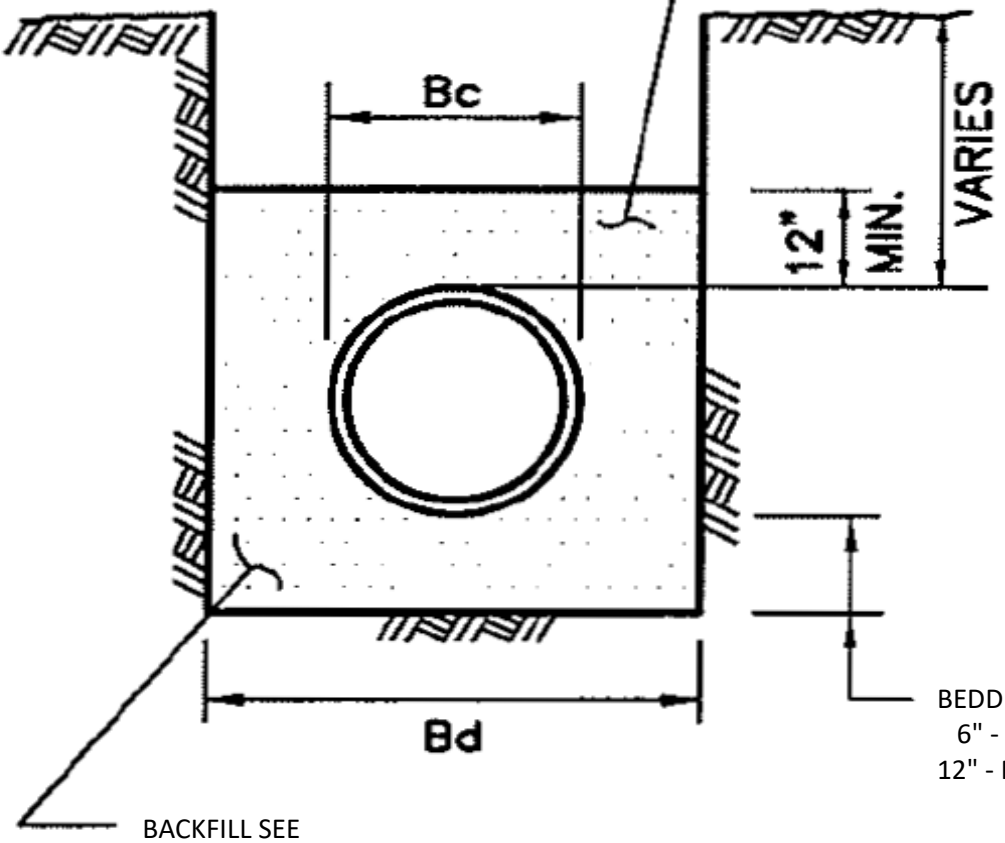
*MANHOLES IN THE STREET REQUIRE TRAFFIC RATED LIDS

CITY OF LIBERTY	PUBLIC WORKS
MANHOLE / CURB-INLET TOP STANDARD DETAIL	SCALE: N.T.S.

NOTE:

Bc = OUTSIDE DIAMETER OF CULVERT

Bd = Bc + 24" FOR CULVERT LESS THAN 42"
Bc + 48" FOR CULVERT MORE THAT 42"



BEDDING THICKNESS:
6" - LESS THAN 42" PIPE
12" - MORE THAN 42" PIPE

BACKFILL SEE
BEDDING AND
BACKFILL DETAILS

NOTE:
THIS DETAIL INCLUDES BOX CULVERTS:
BEDDING THICKNESS:
6" - LESS THAN 5'-0" WIDE BOX
12" - MORE THAN 5'-0" WIDE BOX
Bd =24" FOR BOXES LESS THAN 5'-0" WIDE
48" FOR BOXES MORE THAN 5'-0" WIDE

CITY OF LIBERTY

STORM SEWER / BOX CULVERT
TRENCH DETAIL

PUBLIC WORKS

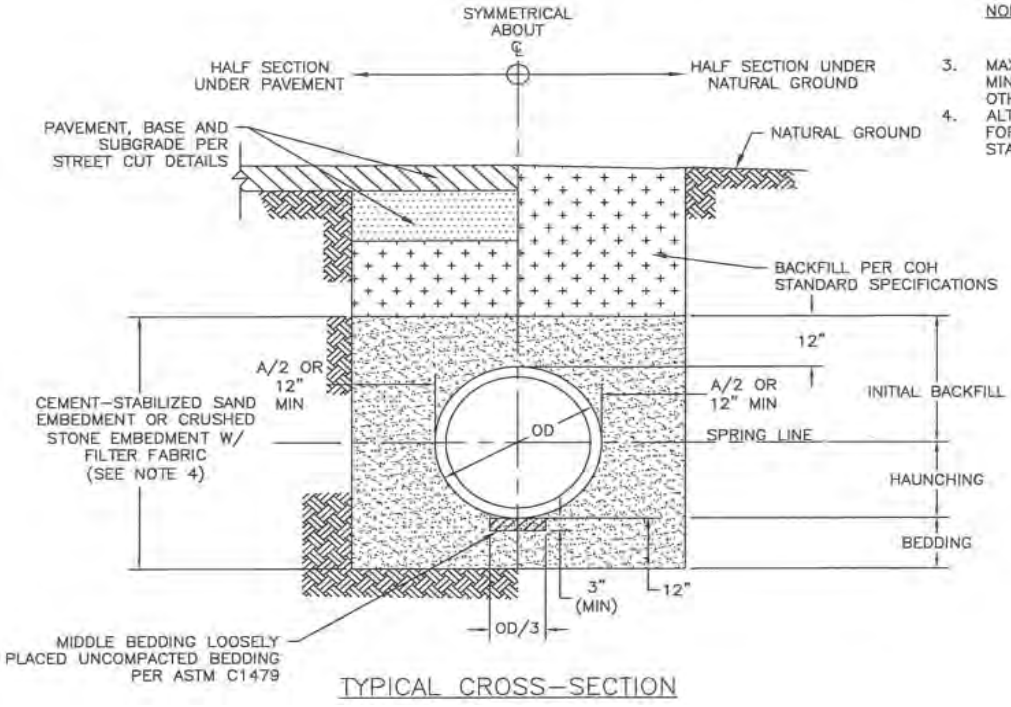
SCALE: N.T.S.

NOTES:

1. THIS DETAIL MAY BE USED ONLY FOR DRY STABLE TRENCH CONDITIONS PER COH STANDARD. SEE COH STANDARD SPECIFICATION FOR REQUIREMENTS IN OTHER CONDITIONS.
2. MIN. TRENCH WIDTH SHALL BE PIPE OD PLUS AN ALLOWANCE "A" FOR THE NOMINAL PIPE SIZE:

NOMINAL PIPE SIZE	"A"
18" TO 30"	24"
OVER 30"	36"

3. MAX. TRENCH WIDTH SHALL BE NOT GREATER THAN MIN. TRENCH WIDTH PLUS 24 INCHES, UNLESS OTHERWISE NOTED.
4. ALTERNATIVE EMBEDMENT BACKFILL MATERIALS FOR FORCE MAINS MAY BE ALLOWED. SEE COH STANDARD SPECIFICATIONS.



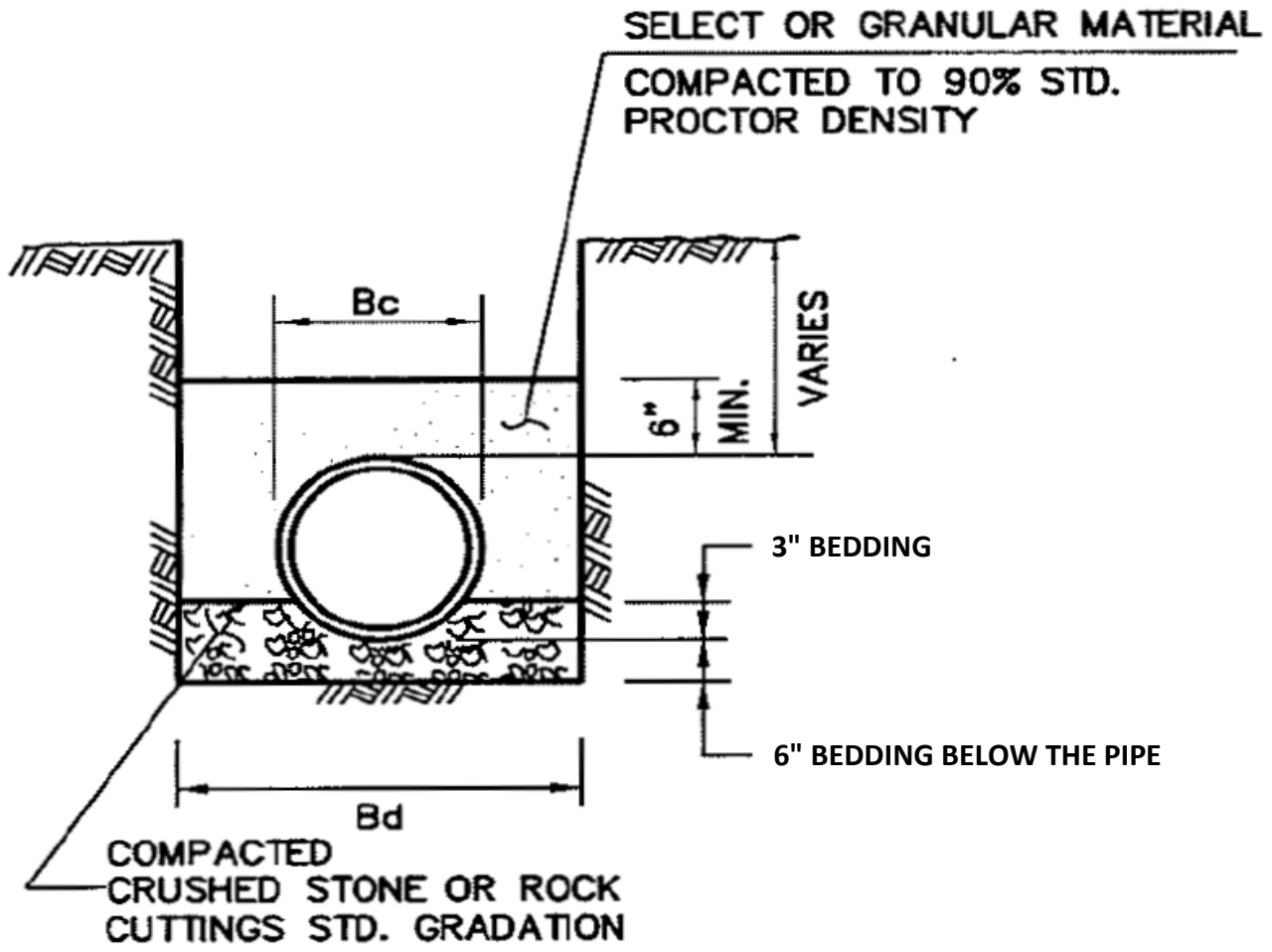
TYPICAL CROSS-SECTION

CITY OF LIBERTY

STORM SEWER BEDDING AND BACKFILL FOR DRY STABLE TRENCH

PUBLIC WORKS

SCALE: N.T.S.



**Bd = TOTAL TRENCH WIDTH
Bc = WIDTH OF CULVERT (INCLUDING BOX)
SEE **STORM SEWER/BOX CULVERT TRENCH DETAIL**

NOTE:

DETAIL PERTAINS TO BOX CULVERTS AS WELL
ROCK SIZE SHOULD BE 3/8" TO 3/4"

CITY OF LIBERTY

STORM SEWER BEDDING AND BACKFILL
FOR WET TRENCH
HIGH GROUND WATER

PUBLIC WORKS

SCALE: N.T.S.

DRAINAGE CRITERIA REQUIREMENTS

CITY OF LIBERTY

SECTION 3

Table of Contents

1 DRAINAGE CRITERIA AND GOALS

1.1 Purpose of the Drainage Criteria Manual

The purpose of this drainage criteria manual is to establish standard principles and practices for the analysis, design, review and construction of primary drainage systems in the City of Liberty.

The City of Liberty requires a properly designed system that will detain and/or carry away runoff from more frequent rainfall events and reducing any adverse effects of storm water.

Providing the City of Liberty with an effective storm water management system would allow sustainable community growth. Setting minimum standards, planning for future detention basins and drainage channels, working with private development interests, coordinating with governmental agencies, and maintaining the efficiency of the existing system is the City's goal. The existing City of Liberty Drainage Facilities can be seen in the Exhibit 1-1

The City of Liberty recognizes the need for planning and development aimed at setting consistent standards responsive to the needs of property developers and design engineers and compliant with federal and state regulations. This Drainage Criteria Manual applies to all areas within the City of Liberty's jurisdictions. However, if the project falls within the jurisdiction of another entity or covers areas in both entities joint coordination and criteria may apply. Coordinate with WCID #5 will be required if this situation applies to a project.

1.2 Development Drainage Policy

The City will review and approve all development projects that discharges storm water directly or indirectly into the City's system and within 500 feet of a WCID #5 ditch. It will not require WCID #5 approval but can coordinate and take their concerns into consideration for approval. WCID #5 and/or TXDOT (Texas Department of Transportation) will be required to approve all development that directly impact their facilities prior to the City of Liberty's approval of all drainage projects of this type.

The City will require that all development plans include some type of detention above or below ground on the development site that collects all storm water runoff on site and discharges the storm water at the same rate or lower than the pre-development rate. The City will not accept any additional storm water from any development due to the City's limited capacity that exist with the system.

1.2.1 Zero Impact (No Adverse Impacts)

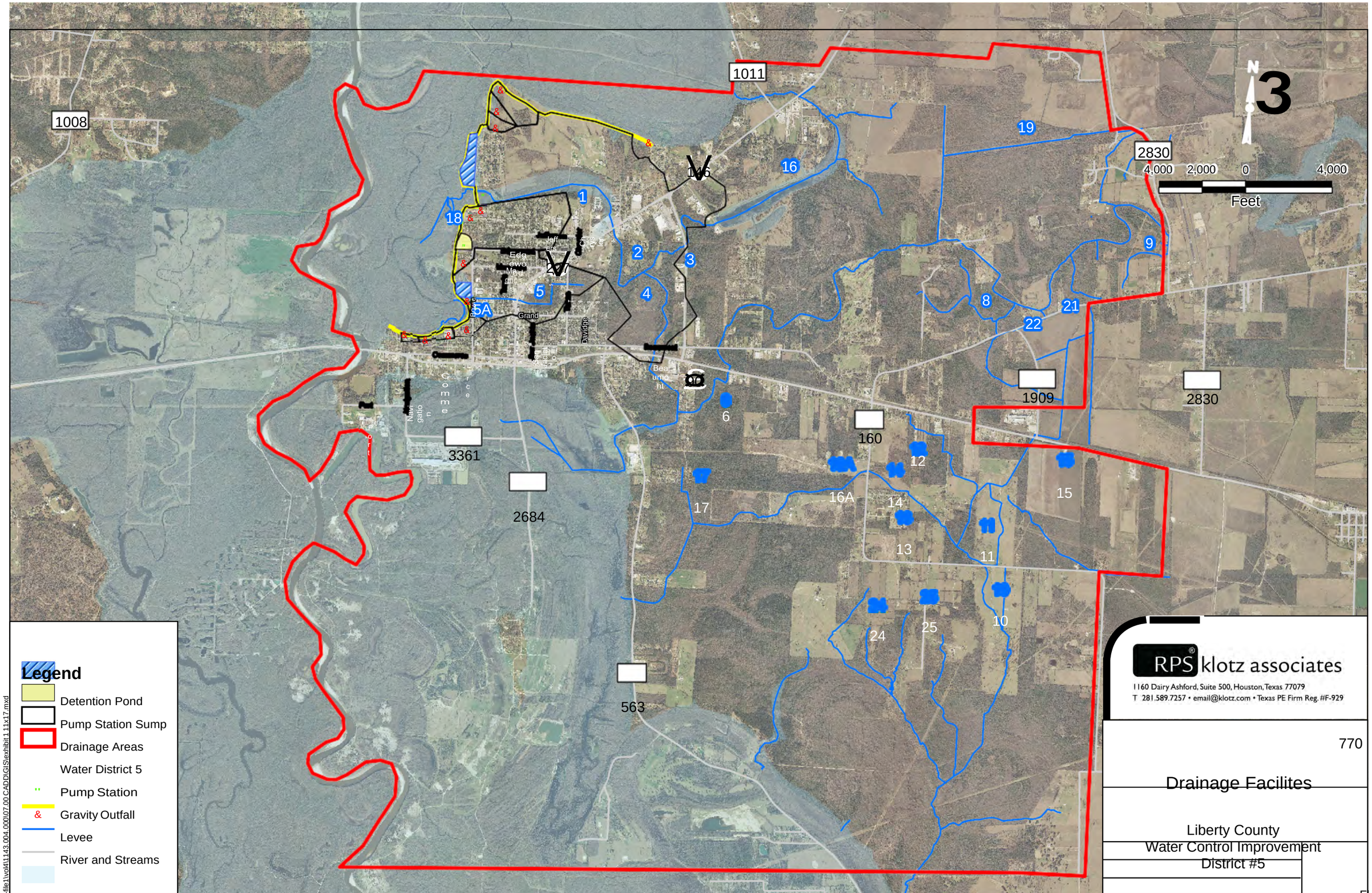
An impact is defined as a change in the volume of runoff, changes in the rate of runoff, and changes in flooding depths in a watershed. Impacts may be adverse or beneficial. Adverse impacts are those which increase the potential for flooding damages. Beneficial impacts, on the other hand, reduce the potential for flood damage. The term zero impact is defined as no adverse effect. The City of Liberty will maintain a strict zero impact policy in all watersheds located within the City Limits and ETJ. This means that neither increases in upstream

1.2.2 Stormwater Detention

Stormwater detention refers to the temporary storage of storm runoff in ponds or other storage facilities. The provision of this temporary storage allows storm runoff to be discharged to a receiving stream at a lower rate, thereby protecting downstream areas from increased flooding associated with increased flow rates and higher flood levels. Public Works recognizes the value of stormwater detention in reducing the potential for flooding and allows the use of detention facilities in addition to adding conveyance capacity for mitigating impacts associated with new development and drainage improvements.

1.2.3 Primary and Secondary Drainage Facilities

For the purposes of this manual, primary drainage facilities include open channels, bridges, culverts, and enclosed drainage systems (i.e., open channel that has been enclosed). Secondary drainage facilities include storm sewer systems, roadside ditches and associated structures, and other facilities such as sheet flow swales, small culverts, and other structures which typically serve relatively small drainage areas, as well as lot grading and drainage requirements.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Jeffers
Edgewood
Main
Grand
Bowie
Davidge
Beaumont
Navigation
Commerce
Legend
Detention Pond
Pump Station Sump
Drainage Areas
Water District 5
Pump Station
Gravity Outfall
Levee
River and Streams
Roads
RPS klotz associates
1160 Dairy Ashford, Suite 500, Houston, Texas 77079
T 281.589.7257 • email@klotz.com • Texas PE Firm Reg. #F-929
770
Drainage Facilites
Liberty County
Water Control Improvement
District #5
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odplain

Aerials 2012 HGAC

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DATE: August 2016

EXHIBIT

1-1

2 REVIEW AND APPROVAL CONCEPT FOR DRAINAGE PLANS

2.1 Submittal Procedure

The types of engineering submittals typically made in connection with new development or drainage studies include the following:

- Construction Documents: These include engineering drawings and specifications for a proposed facility or development which will affect storm water drainage or flood control.
- Permit Applications: Development permits are submitted to the permitting office at Liberty City Hall; 1829 Sam Houston St.

2.2 Submittals For Drainage Plans

The City of Liberty requires that engineering submittals be prepared and stamped by a Professional Engineer for all activities which may affect the rate, direction, or volume of storm water runoff, or the depth and velocity of flow in primary drainage facilities, and other infrastructure within the City of Liberty. Public Works will review the following projects:

1. Construction of new projects, modification and/or improvement of existing facilities, or impacting the existing facilities which are maintained by the City of Liberty, which include:

   a. Open channels

   b. Bridges, culverts, and other hydraulic structures associated with open channels

   c. Detention basins

2. Construction of drainage facilities which are physically located in, on, over, under, or adjacent to a drainage facility maintained by the City of Liberty:

   a. Land development projects

   b. Roads and highways

   c. Bridges and culverts

2.3 General Requirements for Various Submittals

The Civil Plans must have the following information shown on the plan sheets:

2.3.1 New Development

Submittals for all new development shall include the following items:

- a plat of the development illustrating property boundaries, individual lot boundaries, streets, drainage easements, etc.
- a hydrologic impact analysis which identifies the potential effects of the development on downstream peak flow rates.
- if necessary, a hydraulic impact analysis which identifies the potential effects of the development on upstream flood levels. This must show a zero impact.
- a preliminary engineering report which presents the results of impact analyses, describes proposed mitigation measures, provides construction cost estimates, etc.

Preliminary construction plans for proposed streets, storm drainage facilities, utilities, and other features may be submitted along with the preliminary engineering report to the Permitting Office.

2.3.2 Hydrologic Studies

Major watershed hydrologic studies will be summarized in a report which contains sufficient text, exhibits, and computer output to completely describe the methods, data, and assumptions used in the analysis, as well as the results obtained. Information provided in the report should include the following:

- A description of the analysis and the results obtained
- Tabulations of all hydrologic modeling parameters
- Tabulations of all computed peak flow rates
- A watershed map which illustrates the borders of each sub-area included in watershed modeling
- A hydrologic parameter map which illustrates all watercourse lengths, drainage areas, and developed areas
- Output from all hydrologic models used in the analysis
- A computer flash drive containing input files for all hydrologic and hydraulic models in the latest version of WINSTORM

2.3.3 Hydraulic Studies of Primary Drainage Facilities

For hydraulic analyses and designs of primary drainage system components, an engineering report containing the following items should be submitted:

- Sufficient text to summarize the methods, data, and assumptions used in completing the analysis, as well as the results obtained
- Calculations and other information supporting the flow rates used in the analysis in the latest version of WINSTORM
- Tabulations of hydraulic modeling data and results in the latest version of WINSTORM
- Vicinity and site maps which illustrate the location of the project area and the extent of the stream reach being analyzed
- A plotted stream profile(s)
- Plotted cross-sections of the stream with computed flood levels superimposed
- A copy of the effective Flood Insurance Rate Map (FIRM) for the project area and, as needed, a proposed conditions flood plain and floodway map which illustrates proposed changes in flood plain and floodway boundaries
- Copies of all hydraulic calculations in the latest version of WINSTORM
- An analysis of the effects of proposed improvements on downstream peak flow rates and upstream flood levels. This must show a zero impact on the existing drainage system.
- Recommendations for mitigating any adverse impacts associated with proposed improvements to channels or structures
- Output from all hydraulic computer models used in the analysis in the latest version of WINSTORM
- A computer flash drive or other media containing input files for all hydraulic models

For studies involving improvements to open channels and hydraulic structures or designs of new open channels, a right-of-way (ROW) map should also be submitted. Preliminary construction plans may be submitted along with the engineering report. Final plans should be prepared after Public Works has completed its review of the engineering report and issued comments and/or approval.

2.3.4 Detention Studies

The following information must be submitted in support of designs for detention facilities:

- Vicinity, site, and watershed maps which clearly illustrate the location of the facility, its physical extents and configuration, its drainage area, and the relationship of its drainage area to the overall boundaries of the major watershed in which it is located
- A ROW map which illustrates all existing and proposed ROWs in the immediate vicinity of the detention facility
- Discharge calculations which identify peak flow rates for pre-development and post-development conditions for the design storm event
- Hydraulic calculations on which the design of the detention discharge structure is based
- For facilities with a drainage area of less than 200 acres, calculations establishing the required detention storage volume must be submitted using design requirements in Chapter 5.
- For facilities having a drainage area of 200 acres or more, a detention flood routing analysis which assesses the effectiveness of the detention basin in mitigating impacts on downstream peak flow rates must be submitted using design requirements in Chapter 5.
- Calculations involving the required capacity of supplemental and/or emergency discharge structures
- exhibits which illustrate the configuration of the detention facility, inflow structure, and discharge structure
- Benchmark information with topographical elevations.
- A soils report which discusses the suitability of the soil for construction of the proposed facilities

These items should be submitted in supported of a written report which describes the proposed location and configuration of the detention facility, the methods used in the design of the facility, and the conclusions of the detention analysis with regard to the effectiveness of the facility in mitigating increases in downstream peak flow rates. Preliminary construction plans may be submitted along with the engineering report. Final plans should be prepared after Public Works has completed its review of the engineering report and issued comments/approval.

2.3.5 General Engineering Report Requirements

It is recommended that engineering reports be prepared in such a manner as to include all of the necessary information without referencing previous submittals. Each report should utilize text,

tables, and exhibits to thoroughly document the methods, data, and assumptions used in completing analyses of the proposed activity as well as the results obtained. Detailed computations and computer printouts should be attached to the report in the form of appendices. All reports should be bound to insure that the report text, exhibits, and attachments stay together. All reports and accompanying materials should be submitted in a manageable format. Maps should be 24" x 36" or smaller. All maps and other exhibits must be legible and information should be presented a clear and concise manner.

The following exhibits and calculations should be submitted with engineering reports as appropriate:

- **Vicinity Map:** A map showing the project site with respect to recognizable landmarks in the vicinity. This could be a city map with the boundaries of a new development or the limits of a channel improvement project indicated to mark the project location.
- **Site Map:** This is a detailed map of the project site which illustrates the type and extent of activities which are proposed to be completed. For new developments, a plat with all proposed streets, lot boundaries, etc. may be used to satisfy this requirement.
- **Watershed or Drainage Map:** A watershed or drainage map which illustrates all drainage boundaries, flow directions, and computation points.
- **Discharge Calculations:** Calculations specifying computed discharges at key locations, with comparisons of existing and proposed discharges where appropriate. Drainage areas, runoff coefficients, rainfall depths and intensities, infiltration loss parameters, unit hydrograph parameters, and other applicable hydrologic data should be included and clearly documented. For computer applications, printouts should be attached. All storm sewer system analysis must be submitted with the latest version of WINSTORM.
- **Hydraulic Calculations:** Hydraulic calculations specifying the methods used in analyzing channels, storm sewers, and other hydraulic structures and providing a summary of the results obtained. Cross-section data, roughness coefficients, flow rates, and other data should be clearly documented. For computer applications, printouts should be attached. All storm sewer system analysis must be submitted with the latest version of WINSTORM.
- **Benchmark Information:** A description of the benchmark used to establish existing and proposed elevations in the project area, including the exact location, the elevation, and the source of the elevation.
-
- **Right-of-Way Map:** A map which illustrates existing and proposed channel and utility ROWs and easements. Include both underground and overhead utilities and all drainage easements. Sufficient ROW must be permanently set aside to allow for the construction of the most

extensive permanent drainage facilities proposed to pass through the development in the future. These facilities may include open or enclosed channels, storm sewers, ditches, or swales. For channels, the width of the ROW must be adequate to provide for the channel itself plus minimum maintenance berm widths. For enclosed systems, the minimum ROW width is equal to the widest dimension of the underground conduit plus two times the maximum depth from finished ground to the invert of the conduit, or 30 feet, whichever is greatest

- **Soils Report:** A soils report, prepared by a qualified geotechnical engineer, which identifies the existing soil types and assesses the suitability of the soil for the proposed activity. The soils report should address erosion and slope stability in areas subject to the action of storm runoff.
- **Plotted Stream Profile:** A profile of the subject stream which includes computed water surface profiles, existing and proposed flow-line profiles, the locations of existing and proposed bridges, culverts, and utility crossings, the locations of tributary confluences and major storm sewer outfalls in or near the project area, and the locations of hydraulic structures such as dams, weirs, and drop structures.
- **Plotted Cross-Sections:** Typical cross-sections of the subject stream for both existing and proposed conditions.
- **Flood Plain Maps:** A FIRM showing the boundaries of the existing 100-year flood plain and floodway in the project area and a separate map which illustrates proposed changes in flood plain or floodway boundaries.
- **Facility Layout Map:** Plan, elevation, and cross-section views of drainage facilities such as detention basins, roadway culverts, bridges.
- **Erosion Control:** All drainage facilities must be designed and maintained in a manner which minimizes the potential for damage due to erosion. No bare earthen slopes will be allowed. Various slope treatments, including turf establishment, concrete slope paving, and rip-rap, are accepted. Flow velocities should be kept below permissible values for each type of slope treatment. Interceptor structures and backslope swale systems are required to prevent sheet flows from eroding the side slopes of open channels and detention facilities.

2.4 Review and Approval of Submittals to Public Works

Upon receiving an engineering submittal, representatives of the City of Liberty Public Works will check it for completeness and will request additional information as needed. Upon receiving all of the information necessary to thoroughly evaluate the submittal, Public Works will complete the review. Written comments will be forwarded to the submitter, who will make any corrections or adjustments to the analysis and/or re- submit a final package. Upon determining that all necessary corrections and adjustments have been made, the City of Liberty Public Works will prepare a written acceptance of the submittal.

3 HYDROLOGIC & HYDRAULIC CONCEPTS

The purpose of this chapter is to present a brief summary of hydrologic and hydraulic concepts that are required to understand and apply the criteria presented in this manual.

3.1 Definitions of Basic Technical Terms

- **Conveyance:** the ability of a channel or conduit to carry water in the downstream direction
- **Cross-sectional area:** the total area available to carry flow, measured at a vertical plane (cross-section), which cuts across a channel or conduit perpendicular to the direction of flow.
- **Flood plain:** an area inundated by flood waters during or after a storm event of a specific magnitude.
- **Friction loss:** a loss in energy associated with friction between flowing water and the sides of a channel or conduit
- **Hydraulic radius:** a parameter computed as the cross-sectional area divided by the wetted perimeter
- **Hydrology:** the study of the processes through which atmospheric moisture passes between the time that it falls to the surface of the earth as rainfall and the time that it returns to the atmosphere.
- **Hydrograph:** a graph which relates rate of flow and time
- **Infiltration:** the process by which rainfall soaks into the ground
- **Manning's Equation:** a mathematical formula which relates the velocity or rate of flow in a channel or conduit to the physical characteristics of the channel or conduit
- **Minor loss:** a loss in energy associated with changes in flow direction or velocity
- **Probability:** the chance, usually expressed in percent that a storm event of a particular intensity and duration will occur in any given year; equal to the reciprocal of the recurrence interval
- **Rainfall intensity:** the rate at which rainfall occurs, typically expressed in inches per hour
- **Recurrence interval:** the average period of time that will elapse between storms of a particular

intensity and duration (equal to the reciprocal of the probability)

- **Roughness Coefficient:** a number which represents the relative resistance to flow in a channel or conduit
- **Runoff:** precipitation which does not infiltrate into the ground, but instead makes its way to a storm water drainage facility
- **Storm Event:** a single period of heavy rainfall, normally lasting from a few minutes to a few days
- **Time of Concentration:** the time required for water to travel from the most remote point in a watershed to the point at which a peak flow rate or runoff hydrograph is to be computed
- **Unit Hydrograph:** a runoff hydrograph which represents the response of a watershed to 1 inch of runoff
- **Watercourse:** a path which water follows from the boundary of a watershed to the watershed outlet
- **Wetted Perimeter:** the total distance along a channel or conduit cross-section that is in contact with water that is flowing in the channel or conduit

3.2 Basic Hydrologic Concepts

3.2.1 The Hydrologic Cycle

The term hydrologic cycle refers to a series of processes through which moisture falls to earth as precipitation, and returns to the atmosphere. The basic processes involved in the hydrologic cycle include rainfall, infiltration, interflow, storage, evaporation, and transpiration

3.2.2 Design Rainfall Events

Rainfall normally occurs in irregular patterns with respect both to space and time. However, synthetic rainfall events (referred to as “design storm events”) are typically used for hydrologic analyses. These design storm events are developed through statistical analyses of long periods of recorded rainfall data and are defined by the recurrence interval and storm duration.

3.2.3 Infiltration and Runoff

A portion of the rainfall that reaches the earth soaks into the ground via infiltration, while the balance of the rainfall is called runoff. Since infiltration increases with the porosity of the soil,

infiltration for clay soils is less than for sandy soils. Infiltration is reduced as the moisture content of the soil is increased and ceases when the soil becomes saturated. As Infiltration decreases, runoff increases and vice versa.

3.2.4 Runoff Hydrographs

Runoff hydrographs are relationships between the rate of runoff and time. Hydrographs are important because they provide information on the peak rate of runoff and variations in runoff rates throughout the duration of a particular storm event. These variations can be significant in defining the response of a watershed to a rainfall event, especially when the watershed is large and runoff continues over many hours or days.

A unit hydrograph is a hydrograph which reflects the response of a watershed to a rainfall event that produces exactly one-inch of runoff. Runoff hydrographs for storm events producing more or less than one-inch of runoff are computed from a unit hydrograph by multiplying each individual flow rate in the unit hydrograph by the actual runoff volume in inches. This computation is based on various hydrologic parameters and is performed automatically by software programs such as HEC-HMS, which was developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers (USACE).

3.3 Basic Hydraulic Concepts

3.3.1 Manning's Equation

Manning's equation is a commonly used formula that relates the hydraulic capacity and the physical condition of an open channel, a storm sewer pipe, or a box culvert. The equation is written as follows:

$$Q = (1.49/n)A(R_h^{2/3})S^{1/2}$$

where: Q = the flow rate (cubic feet per second);
n = a roughness coefficient related to the relative condition of the channel or structure;
A = the cross-sectional area of flow (square feet);
R = the hydraulic radius, which is computed as the flow area divided by the wetted perimeter (feet);
S = the slope of the channel or structure;

The roughness coefficient (n value) is a measure of the roughness of the surfaces with which water

comes into contact. For example, higher *n* values represent rougher surfaces and lower *n* values represent smoother surfaces. Information on selecting *n* values for open channels and storm sewers is included in Exhibit 3.1 illustrates some of the basic concepts associated with Manning's Equation.

Channel Surface	Manning Roughness Coefficient, n
Asbestos cement	0.011
Brass	0.011
Brick	0.015
Cast-iron, new	0.012
Concrete, steel forms	0.011
Concrete, wooden forms	0.015
Concrete, centrifugally spun	0.013
Copper	0.011
Corrugated metal	0.022
Galvanized Iron	0.016
Lead	0.011
Plastic	0.009
Steel - Coal-tar enamel	0.01
Steel - New unlined	0.011
Steel - Riveted	0.019
Wood stave	0.012

EXHIBIT 3.1

3.3.2 Conveyance

Conveyance is a measure of the capacity of a channel, flood plain, or hydraulic structure to carry storm water. As indicated in Equation 3-2, conveyance increases with the cross-sectional area of flow, the depth of flow in the structure, and the smoothness of the surfaces with which water comes into contact. For example, enlarging a drainage channel will increase the conveyance and the rate of storm water flow within the channel. Clearing away trees and brush from a channel will have the same effect. Replacing a corrugated metal pipe (CMP) with a reinforced concrete pipe (RCP) of the same diameter also results in an increased conveyance because of the smoother interior of the RCP.

$$K = \frac{1.49}{n} AR^{2\beta}$$ **Equation 3-2**

where: K = conveyance (cubic feet per second).

3.4 Effects of Urbanization

Urbanization includes activities such as land clearing, new development, roadway construction, improvements to drainage systems, changes in natural land topography, placement of fill in flood plains,

and construction of pavements and other impervious surfaces. These types of activities have significant effects on the response of a watershed to rainfall, which are summarized below.

- **Increased Volume of Runoff:** Urbanization is typically accompanied by an increase in the percentage of the ground surface that is covered by impervious materials, which decreases infiltration and increases the volume of runoff.
- **Increased Rate of Runoff:** In most urbanized areas, drainage systems are designed to collect and convey storm water as efficiently as possible away from areas occupied by homes, businesses, and roadways. This efficiency tends to concentrate storm water runoff more quickly than the natural drainage system in most areas. In addition, re-grading of natural slopes and the removal of flow-retarding vegetation eliminates natural storage that attenuates runoff rates in non- urbanized areas. These factors cause runoff rates from urbanized areas to exceed rates from undeveloped areas, which tends to increase the water surface elevations (WSELs) in channels.
- **Modified Watershed Response:** The increased efficiency of urban drainage systems tends to decrease the time of concentration from developed drainage areas so that the peak runoff rate occurs more quickly than from the same area prior to development. As a result, development of a drainage area may adversely impact WSELs within the receiving channel due to changes in the timing of peak runoff rates. These adverse impacts may occur even if detention is provided and the developed peak runoff rate is less than the undeveloped peak runoff rate.
- **Reduced Flood Plain Conveyance:** Lots and/or building pads located in flood-prone areas are typically elevated with fill material. The placement of this material in flood plains creates obstructions to flow and reduces the available conveyance in the flood plain. The construction of elevated roads across the flood plain has a similar effect. Such reductions in the conveyance capacity of the flood plain tend to increase WSELs in channels.

4 STORMWATER DESIGN REQUIREMENTS

4.1 Design Policy

4.1.1 Introduction

The purpose of the Stormwater Design Requirements for the City of Liberty is to control the potential flooding in the City. All subdivision developments will be subject to a full hydraulic analysis. The submitted engineered drawings would need to show existing and proposed stormwater systems and the data will only be accepted using WINSTORM. New developments within the City will require detention and the discharge must be equal or less than the pre-development flows and sheet flow to the ROW is prohibited.

A. Design Requirements.

1. Drainage criteria administered by the City of Liberty and complemented by Liberty County's Water Control and Improvement District No. 5 (WCID #5) for newly designed areas provides 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 Liberty Permitting Office at Liberty City Hall, 1829 Sam Houston St. Liberty, TX., for review and approval.

B. Ponding in streets and roadside ditches of 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.

C. 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. 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. 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. No sheet flow from the developed property will be allowed to drain onto the adjacent ROW. Any discharge should only be discharged to the ROW at the approved point of connection (which will have enough capacity to handle the discharged) via a subsurface internal drainage system or open channel.

D. 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 Permitting Department. Review of storm drainage is conducted by Liberty Public Works.

E. The criteria in this Chapter apply to all projects located within the City limits and to expanding utility districts and new utility districts located in the City's Extraterritorial Jurisdiction (ETJ). If the criteria conflicts with Liberty County, WCID #5, or other jurisdictions, the more restrictive criteria shall govern.

4.1.2 Definitions, Formulas and Acronyms

- Conduit – Any open or closed device for conveying flowing water.

- Continuity Equation:

$$Q = VA$$

Where: Q = discharge (cfs or cms)
V = velocity (ft/sec or m/sec)
A = cross sectional area of Conduit (square feet or square meters)

- 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.

- 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.

- Design Rainfall Event – Rainfall intensity upon which the drainage facility will be sized.

- Development - any activity that requires a subdivision plat or development plat pursuant to Code of Ordinances. The term includes New Development and Redevelopment.

  1. New Development – Development of open tracts of land in areas where the storm drainage infrastructure has not been constructed and a drainage outlet must be extended to a channel under the jurisdiction of the City of Liberty, TXDOT or WCID #5 with approval.

  2. or a change in existing storm water collection, conveyance or runoff conditions for the developed site.

- Disturbed Area – means the existing surface has been altered by activity including, but not limited to, clearing, grubbing, demolition, grading, excavating and construction related activity (e.g. equipment, staging, stockpiling of fill material and material storage areas), and construction support activity.
- 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.
- Drainage Area Map – Service area map of the watershed or drainage system.
- FEMA – Federal Emergency Management Agency.
- FIS – Flood Insurance Study, 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 serve as the basis for rating flood insurance and for regulating floodplain development and carrying out other floodplain management measures.
- WCID #5 – Water Control and Improvement District No. 5 (Liberty County).
- Hydraulic Grade Line (HGL) - A line representing the pressure head available at any given point within the drainage system.
- Impervious Surface – Any area that has been compacted or covered such that it does not readily absorb water or does not allow water to penetrate or percolate through to undisturbed underlying soil strata. Surface materials considered impervious shall include, but not 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, 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 that don't allow percolation, 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.

- Manning's Equation:

$$V = (K/n) R^{2/3} S_f^{1/2}$$

Where: K = 1.49 for English units,
1.00 for metric units

V = velocity (ft./sec or m/sec)
R = hydraulic radius (ft. or m) (area/wetted perimeter)
S_f = friction slope (head loss/length) (101)
n = 0.012 for corrugated profile-wall polyethylene pipe
0.013 for concrete pipes,
0.015 for concrete boxes,
0.024 for CMP pipes

- Overland Flow – Flow resulting from a rainfall event that is routed along surface streets or surface channels in a defined manner.

- 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. 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.

- Rational Method - A method for calculating the peak runoff for a drainage system using the following equation for runoff:

  Q = I x (CA)
  Where: C = watershed coefficient
  A = area (acres)
  I = rainfall intensity (inches per hour)

- Sheet Flow – A shallow depth of runoff on a sloping and/or relatively flat surface that does not have a precisely defined bounding condition.

- Spread (Ponding Width)– Calculated only for design rainfall. The width of flow in the gutter, measured laterally from the roadway curb, approaching an inlet.

- 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.

- —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.

- 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.

- Construction of drainage facilities designed per this chapter shall meet requirements of the City of Liberty Standard Specifications and Standard Details. Developer shall be used to perform 2-year and inlet design analysis and design of storm drainage systems as follows:

3. City CIP Projects – In conjunction with design analysis, designs shall comply with guidelines provided in this manual, Storm Sewer Design Applications for the City of Liberty, Texas, CIP Projects.

4. Private Projects within City Limits which include City funding participation.

5. 100% Privately-funded Project located in City Limits

6. Projects in New or Expanding Utility Districts located in City's

4.1.3 Determination Of Runoff

7. Design Rainfall Events.

a. Rainfall Duration:

(1) For design purposes, the rainfall duration for drainage areas less than 200 acres will be no less than 3 hours in duration.
(2) For design purposes, the rainfall duration for drainage areas more than 200 acres will be no less than 6 hours in duration.

b. Rainfall Intensity:

(1) Intensity Duration Frequency (IDF) Curves. figure 7.2, City IDF Curves, depicts the intensity-duration curves to be used for storm sewer and roadside ditch design in the City and the ETJ. These curves were derived from the National Weather Service publications.

(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 b, d, and e are coefficients dependent on the rainfall event, as provided in Table 4.1, below and are based on City depth-duration- frequency values.

Table 4.1

Rainfall Intensity Parameters: Liberty County

Rainfall Frequency	b	d	e
2-year	67.00	8.0	0.790
5-year	65.00	7.4	0.739
10-year	78.00	7.4	0.747
25-year	78.00	7.4	0.716
50-year	90.00	7.4	0.726
100-year	89.00	8.0	0.704

Note: The rainfall data presented above is from the newest TXDOT Bridge Division Hydraulic Manual (Page 66) Dated (31 August 2015) – Table 6 (CONSTANTS FOR USE IN FORMULA I=b/(tc+d)e

It is the engineer's responsibility to ensure that current accepted rainfall intensity calculations is being utilized for the analysis.

8. Application of Runoff Calculation Models.

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, proposed modeling will need to be submitted to Liberty Public Works for Approval.

c. Hydrograph Development Static Conditions – For evaluation of detention volume the approved methodology for hydrograph development shall be

based upon the NRCS Dimensionless Unit Hydrograph or Malcolm's Small Watershed Method.

4.1.4 Determining Runoff Coefficients

d. 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:

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/ROW	0.90

(2) Alternatively, the runoff coefficient C in the Rational Method formula can be calculated from the equation:

$$C = 0.6Ia + 0.2$$

Where: C = watershed coefficient

Ia = impervious area/total area

(3) If the alternate form is to be submitted, the calculation of C shall be provided as part of the drainage calculations.

4.1.5 Determination of Time Of Concentration

Time of concentration can be calculated from the following formula:

$$TC = 10A^{0.1761}+15$$

Where: TC = time of concentration (minutes)

A = subarea (acres)

4.1.6 Hydrograph Development

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 FIS rainfall distribution, Green & Ampt loss rates, and the Clark Unit Hydrograph (T_C&R) methodology.

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: T_C 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.

Table 4.2: Green & Ampt Parametersby Soil Type

Soil Classification	Volume Moisture Deficit	Wetting Front Suction (inches)	Hydraulic Conductivity (in/hr)
Soil Texture			
Sand	0.417	1.95	9.276
Loamy Sand	0.402	2.41	2.354
Sandy Loam	0.412	4.33	0.858
Loam	0.436	3.50	0.520
Silt Loam	0.486	6.57	0.268
Sandy Clay Loam	0.330	8.60	0.118
Clay Loam	0.389	8.22	0.079
Silty Clay Loam	0.431	10.75	0.079
Sandy Clay	0.321	9.41	0.047
Silty Clay	0.423	11.50	0.039
Clay	0.385	12.45	0.024
Soil Group			
A (freely draining)	0.417	1.95	9.276
B (intermediate)	0.436	3.50	0.520
C (intermediate)	0.389	8.22	0.079
D (poorly draining)	0.385	12.45	0.024

4.2 Design of Storm Sewers

4.2.1 General Considerations

e. Drainage systems for curb-and-gutter pavement shall consist of underground closed conduits.

f. City CIP Projects or New Development that is anticipated to become City infrastructure and R.O.W.: The City's Comprehensive Drainage Plan (CDP) may indicate that a larger diameter storm sewer is planned in the area proposed for paving improvements. Public Works has information on proposed improvements and should be consulted for impact on New Development. All storm culverts shall be reinforced concrete or approved HDPE. All subdivision designs will be required to submit the hydraulic design in the latest version of the WINSTORM program

Private Drainage Systems: Are owned by the developer and will be subject to a drainage review and approval by the Public Works Department.

4.2.2 Design Frequency

g. New Development: The Design Rainfall Event for sizing storm sewers in newly developed areas will be at minimum a 5-year rainfallevent.

h. 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 5-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 5- year level of service, then no modifications to the existing storm drain are required

(2) If the proposed Redevelopment results in the hydraulic gradient 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 hydraulic grade line is above the gutter

line), the applicant should check with the City to see if a CIP project is proposed that will require a capital contribution.

4.2.3 Velocity Considerations

i. Storm sewers should be constructed to flow in subcritical hydraulic conditions if possible.

j. Minimum velocities should not be less than 3 feet per second with the pipe flowing full, under the design conditions.

k. Maximum velocities at the storm sewer system outfall should not exceed 8 feet per second without use of energy dissipation at the outfall.

l. Maximum velocities within storm sewers should not exceed 12 feet per second.

4.2.4 Pipe Size and Placement

m. Use storm sewer and inlet leads with at least 18-inch inside diameter or equivalent cross section. Single Family Residential projects such as driveways the recommendation is minimum pipe size of 18-inches if cover will allow in the R.O.W. Box culverts shall be at least 3 feet by 2 feet. Closed conduits; circular, elliptical, or box, shall be selected based on hydraulic principles and economy of size and shape.

n. Larger pipes upstream should not flow directly, or indirectly (via inlet, junction box, manhole) into smaller pipes downstream unless construction constraints prohibit the use of a larger pipe downstream, or the improvements are outfalling into an existing system, or the upstream system is intended for use as detention.

o. Match crowns of pipe at any size change unless severe depth constraints prohibit.

p. Locate public storm sewers in public street R.O.W. or in approved easements. Back lot easements are discouraged and will require a variance from the City design standards.

q. Follow the alignment of the R.O.W. or easement when designing cast in place

concrete storm sewers.

r. Conduits shall connect to manholes and inlets preferably on a straight alignment, however angled connections no greater than 10 degrees normal to the wall will be provided.

s. Center culverts inside lot storm sewer easements.

t. Minimum horizontal clearance between any storm pipe and box shall be at least 48-inches from exterior of the storm pipe or box to the exterior of the existing or proposed public or private utility and other appurtenances.

u. Minimum vertical clearance between any storm pipe or box and other crossing public or private utilities shall be at least 18-inches from exterior of the storm pipe or box to the exterior of the existing or proposed public or private utility.

v. Siphons are prohibited in the City's Storm Sewer System unless approved by the Public Works Director.

4.2.5 Starting Water Surface and Hydraulic Gradient

w. The hydraulic gradient shall be calculated assuming the top of the outfall pipe as the starting water surface.

x. At drops in pipe invert, where the top of the upstream pipe be 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.

y. For the Design Rainfall Event, the hydraulic gradient shall at all times be below the gutter line for all newly developed areas.

z. All hydraulic gradient calculations must be presented in the latest version of WINSTORM.

4.2.6 Manhole Locations

aa. 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 400 feet measured along the conduit run.

bb. 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.

cc. Do not place manholes in driveways or in the street in front of or immediately adjacent to a driveway.

4.2.7 Inlets Design

dd. Locate inlets at low points in the gutter see inlet details in Liberty Construction Design Manual.

ee. Valley gutters across intersections are not permitted.

ff. Inlet spacing is a function of gutter slope. The minimum gutter slope shall requirement is 0.3%.

(1) For minimum gutter slopes, the maximum spacing of inlets shall result from a gutter run of 300-feet from high point in pavement or the adjacent inlet on a continuously graded street section, with a maximum of 600-feet of pavement draining towards any one inlet location.
(2) Inlet location should be spaced to ensure that the ponding width does not exceed one lane of the roadway for the design rainfall event.
(3) Residential Development: Maximum spacing of inlets shall result from a culvert run of 50-feet from inlet to inlet..
(4) Commercial Development: Maximum spacing of inlets shall result from a gutter run of 300-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.
5) Spread (Ponding Width): Calculate 5-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:

$$Q = (K_g/n)(S_x^{1.67})(S_o^{0.5})(T^{2.67}), \text{ and}$$

$$T = y/S_x$$

Where: K_g = 0.56 (US Customary Units) or 0.376 (SI 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).

gg. Use only City of Liberty standard inlets (See Liberty Construction Design Manual).

Table 4.2

STANDARD STORM SEWER INLETS

INLET	APPLICATION	NOMINAL CAPACITY	DWG. NOS.
Type A	Parking Lots/Small Areas	5.00 cfs	
Type B-B	Residential/Commercial	5.00 cfs	
Type C	Residential/Commercial	2.50 cfs	
Type C-1	Commercial	5.00 cfs	
Type C-2	Commercial	10.00 cfs	
Type C-2A	Commercial	10.00 cfs	
Type D	Parking Lots	4.00 cfs	
Type D-1	Small Areas	3.00 cfs	
Type E	Roadside ditches	10.00 cfs	
Type H-2	Residential Commercial	4.00 cfs / 8.00 cfs (one / two sides)	

* The nominal capacity values provided in Table 4.2 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.

hh. Do not use beehive grate inlets or other specialty inlets.

ii. Do not use grate top inlets in unlined roadside ditch.

jj. Do not place inlets in the circular portion of cul-de-sac streets unless justification based on special conditions can be provided.

kk. Place inlets at the end of proposed pavement, if drainage will enter or leave pavement.

ll. Do not locate inlets adjacent to esplanade openings.

mm. 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.

nn. Place inlets on side streets intersecting major streets, unless justification based on special conditions can be provided.

oo. For private development with internal site drainage, only one connection is permitted to any one inlet, and that connection (lead) shall be made to the

back of the inlet. Connection shall not be made to the front face and to the short sides of the inlet unless approved by the City. Design the connection not to exceed the pipe capacity minus either the capacity listed in Table 4.2, Standard Storm Sewer Inlets, or calculated inlet inflow.

pp. For all new construction, convey public or private alleyway drainage to an inlet prior to entering the public street drainage system.

qq. 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. to curbside inlets, existing B inlets shall be enlarged to BB inlets. B inlets are not allowed.

rr. For inlet calculations reference the TXDOT Hydraulic Design Manual Chapter 10, Section 5, Storm Drain Inlets at http://onlinemanuals.txdot.gov/txdotmanuals/hyd/index.htm

- Extreme Event Analysis

9. Frequency for consideration of overflow shall consider extreme rainfall events (up to 100 year storm) which exceed the capacity of the underground storm sewer system resulting in ponding and overland flow from the development to the primary outlet.

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 ROW or open areas and through the development to a

primary outlet.

10. 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.

a. Three analysis methods as presented in Technical Paper No. 101, Simplified 100-year Event Analyses of Storm Sewers and Resultant Water Surface Elevations for Improvement Projects in the City of Liberty, Liberty 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 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.

b. Analysis using WINSTORM will be acceptable to the City.

11. Relationship of Structures to Street: All structures shall be above the maximum ponding elevation anticipated resulting from the extreme event analysis

a. Barring conditions listed in 9.05.D.3.a and b, 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.

b. 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.

c. 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.

4.2.8 Roadway Design Considerations

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.

d. The maximum depth of ponding at high points shall be 6-inches above top of curb.

e. The maximum depth of ponding at low points shall be 18-inches above top of curb.

f. All property shall sheet flow from back of the property to the front. Fence lines and other improvements shall not be constructed on or across dedicated drainage easements.

g. 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.

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.

h. 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.

12. Evacuation Routes and Emergency Service Routes. This standard applies to routes designated by PWE 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, Liberty Public Works Department, or his designated representative. This standard may be modified or exempted for locations in the 100-year floodplain.

13.

4.2.9 Design of Open Channels

14. Design Requirements and General Criteria.

a. Open channels shall be designed according to Manning's equation for uniform flow which can be accessed at and shall convey 100 year event.

b. Design standards for channel construction shall follow the requirements specified in City of Liberty Construction Design Manual

c. Design standards for outfalls into channels shall conform to those in City of Liberty Construction Design Manual.

15. 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' below the top of within banks.

4.2.10 Design of Culverts

c. Head losses in culverts shall conform to TxDOT Hydraulics Manual, Chapter 8, and Culverts.

d. Corrugated metal pipe will be prohibited.

e. For the proposing Street Parking Pads over an existing ditch, the submitted plans must include the following:

(1) Include upstream and downstream ditches/area of the proposed culvert as necessary for drainage analysis.
(2) Include overall drainage area and sub-drainage areas, culvert type, size, slope, length and flow velocities (for 5 and 100 year event).
(3) Include a culvert hydraulic calculation and identify headwater elevations for 5-year and 100-year design events.
(4) Include a calculation for the existing and proposed ditch/culvert flows for 5-year and 100-year design

events.

(5) Identify max ponding elevation (MPE with location) and provide a calculation for the existing and proposed ditch/culvert hydraulic grade lines (HGLs) for 5-year, 10-year, 25-year, and 100-year design events. Show no adverse impact to the area.

(6) Include a calculation for the existing and proposed ditch/culvert capacity (volume) for 5-year, 10-year, and 100- year design events. Show no adverse impact to the area.

(7) Drawing(s) must be sealed and signed by a professional Engineer Licensed in the State of Texas.

4.2.11 Design of Roadside Ditches

16. 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. Design Capacity 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 Paragraph 9.05.D.3.

4.2.12 Velocity Considerations

e. For grass-lined sections, the maximum design velocity shall be 3.0 feet per second during the design event.

f. 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.

g. Minimum grades for roadside ditches shall be 0.1-foot per 100 feet.

h. Calculation of velocity will use a Manning's roughness coefficient (n) of 0.045 for earthen sections and 0.025 for ditches with paved inverts.

i. Use erosion control methods acceptable to the City when design velocities are expected to be greater than 3 feet per second.

j. The top of bank shall not encroach beyond the City R.O.W. or within 2 feet of the edge of pavement.

4.2.13 Driveway and Roadway Crossings

k. Culverts will be placed at all driveway and roadway crossings, and other locations where appropriate.

l. 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.

m. Roadside culverts are to be sized based on drainage area. The minimum culvert size shall be 15 inches inside diameter or equivalent 'cross section'. unless the option for multiple smaller size culverts is approved by the Public Works Director. For example, if the ditch is deeper than or equal to 29", the elliptical pipe with inside diameter of 19" x 30" can be used. When requested, calculations shall be provided for review. In the ETJ, Driveways and/or Culverts on City of Liberty Easements and R.O.W. constructed based on the City of Liberty Construction Manual.

n. Design capacity calculations shall include head loss calculations for driveway and roadway culverts that are placed along the roadside ditch.

o. Stormwater discharging from a ditch into a storm sewer system must be received by an appropriate structure (i.e., stubs to manhole or inlet).

4.2.14 Inlet Protection

p. Ditch invert protection shall be used when velocities exceed 3 feet per second.

q. Ditch invert protection will be used at the upstream and downstream ends of all culverts.

4.2.15 Depth and Size Limitations

r. Maximum depth shall not exceed 4 feet from adjacent edge of pavement without approval from the Public Works Director.

s. Roadside ditch bottoms shall be at least 2 feet wide, unless design analysis will support a narrower width.

t. Ditches in adjoining and parallel easements shall have top of bank not less than 2 feet from the outside easementline.

Design of Outfalls: Outfalls from storm sewers or detention/retention facilities that discharge directly into a channel or other City of Liberty facility shall be designed and constructed in accordance with City of Liberty Construction Manual.

5 STORMWATER DETENTION DESIGN

The intention of Stormwater detention is to mitigate the effect of New Development, or Redevelopment, or Site Modifications on an existing drainage system. Stormwater detention volume requirements are based on

increased impervious surface of the acreage of the disturbed area that results in impervious surface defined in this Chapter. and on existing impervious areas that are redeveloped. Stormwater detention volumes are calculated at the minimum rates set forth in this chapter 5.1.1.

5.1 Application of Detention

u. The use of on-site detention is required for all Developments within the City and for new or expanding development within the City's ETJ. Detention may be required in the City where impervious surfaces are constructed as defined in chapter 4.1.2.

v. Stormwater detention requirements are invoked for redevelopments that include disturbed area resulting in impervious surface. change the quantity of impervious surface on the site or change the on-site (private) drainage system.

w. If water from New Development, or Redevelopment, or Site Modification drains directly into a channel, or a roadside ditch maintained by WCID #5, TxDOT, or other entity, then the requirements of WCID #5, TxDOT, or other entity will govern. If New Development or Redevelopment drains directly to a roadside ditch, drainage ditch or storm sewer maintained by the City of Liberty, then the criteria in this manual will govern.

x. If the drainage system outfalls directly into a channel maintained by WCID #5, and the requirements of WCID #5 include payment of a permit fee, then the City permit fee will be required by the City.

e. All detention ponds shall be designed to hold the additional runoff from the impervious surface for 100 yr frequency and discharged to the City system at the pre-developed 10 yr flow rate. The 100 yr hydraulic gradient shall

be 3-inches minimum below the top of the detention pond.

5.1.1 Calculation of Detention Volume

y. Detention volume for Development areas is calculated on the basis of increases to the disturbed area that results in impervious surface (including all disturbed area)
associated with the project development. and existing conditions at the site. Impervious surface includes all structures, roofs, swimming pools, foundations (whether pier and beam or slab), driveways, parking areas, patios/decks, walkways, compacted or rolled areas, etc. or similar development materials or land treatments that exist or will exist on the property.

z. Single family residential (SFR) lots of 15,000 square feet in area or less: SFR Lots are exempt from detention if proposed Impervious Surface is less than or equal to 65 %. Detention volume of 0.20 acre feet per acre is required for Impervious Surface over 65%. Existing SFR lots of 15,000 square feet or less may be further subdivided and exempt from detention provided the proposed impervious surface remains less than or equal to 65%. If shared driveway is used, detention volume of 0.20 acre feet per acre is required. In other words, for projects that are platted to contain more than one lot and, the detention requirements shall be calculated as follows:

(1) Detention Requirement = 0.5 acre feet per acre of increased impervious surface (including all disturbed area) impervious surface over 65% of the project area;

(2) All runoff shall be collected within the development site and rerouted to the appropriately sized detention pond. Any sheet flow of runoff from impervious surfaces is prohibited.

aa. Areas less than one acre: Detention volume will be required at 0.20 acre-feet per acre of increased disturbed area that results in impervious surface (including all disturbed area). Additionally, detention
volume will be required to offset redevelopment of existing impervious areas surfaces.

Total Detention Volume required is calculated as follows:

$$V_T = [43{,}560 \times (0.20 \times A_{II})] + (1815 \times A_{EI})$$

V_T = Total Detention Volume for the proposed project (Cubic Feet)
A_{II} = Area of increased impervious surface cover (including all disturbed area resulting in impervious surface) (Acres)
A_{EI} = Area of existing Impervious Surface (Acres)

Subdividing of larger tracts (greater than 1 acre) into smaller tracts of 1.0 acre or less to reduce stormwater detention requirements will not be permitted.

bb. Areas equal or greater than 1 acre and less than or equal to 10 acres: Detention volume will be required at 0.65 acre-feet per acre of increased disturbed area that results in impervious surface (including all disturbed area). Additionally, detention volume will be required to offset redevelopment of existing impervious areas.

Total Detention Volume required is calculated as follows:

$$V_T = [43{,}560 \times (0.65 \times A_{II})] + (1815 \times A_{EI})$$

V_T = Total Detention Volume for the proposed project (Cubic Feet)
A_{II} = Area of increased Disturbed area that results in Impervious impervious Cover surface (including all disturbed area) (Acres)
A_{EI} = Area of existing Impervious Surface (Acres) for which detention is not currently provided.

cc. Areas between 10 acres and 50 acres: Detention volume will be required at 0.50 acre-feet per acre of increased impervious surface. Additionally, detention volume will be required to offset redevelopment of existing impervious areas.

Total Detention Volume required is calculated as follows:

If the area of existing impervious surface is less than or equal to 10 acres:

$$V_T = [43{,}560 \times (0.60 \times A_{II})] + (1815 \times A_{EI})$$

If the area of existing impervious surface is greater than 10 acres:

$$V_T = [43{,}560 \times (0.55 \times A_{II})] + (3630 \times A_{EI})$$

V_T = Total Detention Volume for the proposed project (Cubic Feet) A_{II} = Area of increased Impervious Surface (Acres)

A_{EI} = Area of existing Impervious Surface (Acres) for which detention is not currently provided.

dd. Areas greater than 50 acres: A full detention study will need to be submitted for review per section 2.3.4.

ee. Private parking areas, private streets, and private storm sewers may be used for detention provided the maximum depth of ponding does not exceed 9 inches directly over the inlet, and paved parking areas are provided with signage stating that the area is subject to flooding during rainfall events.

ff. Private transport truck only parking may be used for detention provided the maximum depth of flooding does not exceed 15 inches directly above the inlet and signage is provided stating that the area is subject to flooding during rainfall events.

gg. All mitigation 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.

hh. Low Impact Development (LID) techniques that are considered acceptable for achieving detention are Bioretention, Infiltration Trenches, Porous Pavement, and Vegetative Swales. See IDM Ch 13 for LID design guidelines.

Review and approval of engineering calculations demonstrating the volume of detention achieved for each LID feature will be required.

If LID techniques are considered for achieving detention, review and approval of a maintenance and Life Cycle plan are required. This plan shall be signed and sealed by a professional registered engineer and included as part of the review and approval process.

ii. For any new development or any part of an existing development that is still undeveloped, the most recent retention requirements would apply.

5.1.2 Calculation of Outlet Size

jj. Detention pond discharge pipe into an existing storm sewer line or existing City of Liberty ditch:

(1) If the maximum pool elevation is at or below the design hydraulic grade 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 at or above the hydraulic grade 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.

5.1.3 Reducer or Restrictor Pipe Size

kk. Reducer or Restrictor Pipes shall be sized as follows:

(1) Allowable Discharge Rate – Use the lowest of the discharge rates described below:

(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.

(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:

$Q = CA\sqrt{2g}\sqrt{h}$

$D = Q^{½} / (2.25h^{1/4})$

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)

(3) 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.

ll. 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.

mm. The discharge pipe must have a minimum freeboard of 6-inches when connecting to a City ditch and 12-inches when connecting to a City inlet of manhole.

5.1.4 Ownership and Easement

nn. Private Facilities:

(1) Pump discharges into a roadside ditch requires the submittal of pump specifications on the design drawings.

(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.

(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.

Table 4.3: Minimum Berm Width around a Detention Basin

Detention Basins That Are	The Minimum Berm Width Is
Grass-lined with a depth > 7 feet	30 feet
Grass-lined with a depth ≤ 7 feet	20 feet[1]
Grass-lined where side slopes are 8(horizontal):1(vertical) or flatter	10 feet[2]
Grass-lined with the 20-foot maintenance access on a bench	10 feet
Lined with riprap or articulated concrete blocks or partially concrete-lined	Same as grass-lined channel
Fully concrete-lined	20 feet[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.

6 STORMWATER RETENTION DESIGN

The intention of Stormwater Retention is to mitigate the effect of New Development, or Redevelopment, or Site Modifications on an existing drainage system. The additional stormwater runoff volume is retained at the requirements based on:

increased impervious surface of the acreage of the disturbed area that results in impervious surface defined in this Chapter. and on existing impervious areas that are redeveloped. Stormwater retention volumes are calculated at the minimum rates set forth in this chapter 6.1.1.

6.1 Application of Retention

oo. The use of on-site detention is required for all Developments within the City and for new or expanding development within the City's ETJ. Detention may be required in the City where impervious surfaces are constructed as defined in chapter 4.1.2.

pp. Stormwater detention requirements are invoked for redevelopments that include disturbed area resulting in impervious surface. change the quantity of impervious surface on the site or change the on-site (private) drainage system.

qq. If water from New Development, or Redevelopment, or Site Modification drains directly into a channel, or a roadside ditch maintained by WCID #5, TxDOT, or other entity, then the requirements of WCID #5, TxDOT, or other entity will govern. If New Development or Redevelopment drains directly to a roadside ditch, drainage ditch or storm sewer maintained by the City of Liberty, then the criteria in this manual will govern.

rr. If the drainage system outfalls directly into a channel maintained by WCID #5, and the requirements of WCID #5 include payment of a permit fee, then the City permit fee will be required by the City.

cc. All retention ponds shall be designed to hold the additional runoff from the impervious surface for 100 yr frequency and discharged to the City system at the pre-developed 10 yr flow rate. The 100 yr hydraulic gradient shall be 4-inches minimum below the top of the detention pond.

6.1.1 Calculation of Retention Volume

ss. Retention volume for Development areas is calculated on the basis of increases to the disturbed area that results in impervious surface (including all disturbed area)
associated with the project development. and existing conditions at the site. Impervious surface includes all structures, roofs, swimming pools, foundations (whether pier and beam or slab), driveways, parking areas, patios/decks, walkways, compacted or rolled areas, etc. or similar development materials or land treatments that exist or will exist on the property.

tt. Single family residential (SFR) lots of 15,000 square feet in area or less: SFR Lots are exempt from detention if proposed Impervious Surface is less than or equal to 65 %. Detention volume of 0.20 acre feet per acre is required for Impervious Surface over 65%. Existing SFR lots of 15,000 square feet or less may be further subdivided and exempt from detention provided the proposed impervious surface remains less than or equal to 65%. If shared driveway is used, detention volume of 0.20 acre feet per acre is required. In other words, for projects that are platted to contain more than one lot and, the detention requirements shall be calculated as follows:

(1) Detention Requirement = 0.5 acre feet per acre of increased impervious surface (including all disturbed area) impervious surface over 65% of the project area;

(2) All runoff shall be collected within the development site and rerouted to the appropriately sized detention pond. Any sheet flow of runoff from impervious surfaces is prohibited.

uu. Areas less than one acre: Detention volume will be required at 0.50 acre-feet per acre of increased disturbed area that results in impervious surface (including all disturbed area). Additionally, detention

volume will be required to offset redevelopment of existing impervious areas surfaces.

Total Detention Volume required is calculated as follows:

$$V_T = [43{,}560 \times (0.20 \times A_{II})] + (1815 \times A_{EI})$$

V_T = Total Detention Volume for the proposed project (Cubic Feet)

A_{II} = Area of increased impervious surface cover (including all disturbed area resulting in impervious surface) (Acres)
A_{EI} = Area of existing Impervious Surface (Acres)

Subdividing of larger tracts (greater than 1 acre) into smaller tracts of 1.0 acre or less to reduce stormwater detention requirements will not be permitted.

Areas equal or greater than 1 acre and less than or equal to 10 acres: Detention volume will be required at 0.55 acre-feet per acre of increased disturbed area that results in impervious surface (including all disturbed area). Additionally, detention volume will be required to offset. The total retention mitigation volume required shall consist of detention plus retention volumes. Refer to chapter 5 for retention pond discharge rates and restrictor pipe sizes.

7 FINAL DESIGN PROCEDURES

7.1 Final Design Submittal Requirements

7.1.2 Design Calculations

Copies of any documents which show approval of exceptions to the City design criteria.

Design calculations for time of concentration, storm line sizes and grades, and for detention facilities, if any.

Design calculations for the Hydraulic Grade Line of each line or ditch, and for detention facilities, if any.

7.1.2 Drainage Area Map

Existing contour map.

Drainage area and sub-drainage area boundaries.

Drainage area (acres) and flow quantity (cfs) draining to each inlet and

each pipe segment from manhole to manhole.

Extreme event (100-year) Sheet Flow direction.

Existing condition and developed condition Sheet Flow direction for the surrounding properties.

7.1.3 Plan and Profile Sheets

Plan and profile sheets showing Stormwater design (public facilities only).

Projects located within a floodplain boundary or within a floodplain management area shall:

Show the floodplain boundary or floodplain area, as appropriate, on the one- line drawing or Drainage Area Map.

Comply with all applicable submittal requirements of Chapter 19, Code of Ordinances.

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 gradient for the 100-year extreme event; or an alternative equivalent drawing accepted by the City.

Calculation for proportional amount of pipe capacity allocated to the Development along with the drainage area map used for these calculations.

7.1.4 Final Approval

Signature Stage - Submit the following for approval:

Review prints

Original drawings

Stormwater detention maintenance agreement letters.

Drainage Area Map with the following information:

Existing contour map.

Drainage area and sub-drainage area boundaries.

Drainage area (acres) and flow quantity (cfs) drainage to each inlet and each pipe segment from manhole to manhole.

Extreme event (100-year) Sheet Flow direction.

Existing condition and developed condition Sheet Flow direction for the surrounding properties.

WCID #5 approval letter

Profile drawing as specified in the City of Liberty Construction Manual

Final approval will be given in writing by the City of Liberty Public Works Director

7.1.5 References

Texas Department of Transportation. (2011). Hydraulic Design Manual.

Harris County Flood Control District Policy, Criteria, and Procedure Manual

Windstorm – Storm water design program

ASCE Manual and Reports of Engineering Practice No. 77, Design and Construction of Urban Stormwater Management Systems, Current Edition.

Hydraulic Engineering Circular No. 22, (HEC-22), Current Edition, “Urban Drainage Design Manual”, Federal Highway Administration (FHWA).

National Oceanic and Atmospheric Administration (NOAA) - Atlas - Precipitation - Frequency Atlas of the United States (Texas) – Current Edition

WCID #5 Drainage Criteria Manual – RPS Klotz Associates _ August 2016

TABLE 7.1

PDS-based point precipitation frequency estimates with 90% confidence intervals C							
Duration	Average recurrence interval (years)						
	1	2	5	10	25	50	100
5-min	**6.14**(4.66-8.11)	**7.27**(5.56-9.50)	**9.11**(6.94-12.0)	**10.6**(7.99-14.2)	**12.8**(9.28-17.5)	**14.4**(10.2-20.3)	**16.1**(11.1-
10-min	**4.85**(3.67-6.40)	**5.75**(4.39-7.51)	**7.22**(5.50-9.48)	**8.45**(6.34-11.3)	**10.2**(7.39-14.0)	**11.5**(8.13-16.2)	**12.8**(8.84-
15-min	**4.15**(3.14-5.48)	**4.90**(3.74-6.40)	**6.11**(4.66-8.03)	**7.12**(5.34-9.49)	**8.52**(6.18-11.7)	**9.58**(6.78-13.5)	**10.7**(7.36-
30-min	**3.01**(2.28-3.98)	**3.53**(2.70-4.62)	**4.38**(3.34-5.76)	**5.09**(3.82-6.78)	**6.05**(4.38-8.28)	**6.77**(4.78-9.53)	**7.53**(5.19-
60-min	**1.99**(1.51-2.63)	**2.36**(1.80-3.08)	**2.95**(2.25-3.87)	**3.45**(2.59-4.59)	**4.13**(2.99-5.65)	**4.65**(3.28-6.54)	**5.21**(3.59-
2-hr	**1.20**(0.914-1.57)	**1.48**(1.12-1.88)	**1.90**(1.45-2.47)	**2.28**(1.72-3.01)	**2.83**(2.07-3.86)	**3.29**(2.34-4.61)	**3.79**(2.63-
3-hr	**0.870**(0.666-1.14)	**1.10**(0.831-1.38)	**1.44**(1.10-1.86)	**1.76**(1.33-2.32)	**2.24**(1.65-3.06)	**2.65**(1.90-3.72)	**3.12**(2.17-
6-hr	**0.502**(0.387-0.652)	**0.661**(0.495-0.810)	**0.883**(0.680-1.13)	**1.10**(0.840-1.44)	**1.44**(1.07-1.95)	**1.73**(1.25-2.42)	**2.08**(1.45-
12-hr	**0.288**(0.224-0.371)	**0.387**(0.291-0.468)	**0.523**(0.406-0.664)	**0.658**(0.506-0.856)	**0.867**(0.648-1.17)	**1.05**(0.763-1.46)	**1.27**(0.892
24-hr	**0.165**(0.129-0.212)	**0.226**(0.171-0.270)	**0.309**(0.241-0.389)	**0.391**(0.302-0.505)	**0.517**(0.388-0.691)	**0.629**(0.458-0.865)	**0.761**(0.537
2-day	**0.093**(0.073-0.118)	**0.129**(0.099-0.154)	**0.180**(0.141-0.225)	**0.229**(0.178-0.294)	**0.304**(0.229-0.403)	**0.369**(0.270-0.504)	**0.446**(0.317
3-day	**0.067**(0.053-0.085)	**0.093**(0.072-0.111)	**0.130**(0.103-0.163)	**0.166**(0.130-0.212)	**0.221**(0.167-0.292)	**0.269**(0.197-0.365)	**0.324**(0.231
4-day	**0.054**(0.043-0.068)	**0.074**(0.057-0.088)	**0.103**(0.082-0.128)	**0.132**(0.103-0.168)	**0.175**(0.133-0.231)	**0.213**(0.158-0.290)	**0.258**(0.184
7-day	**0.035**(0.028-0.044)	**0.048**(0.037-0.056)	**0.065**(0.052-0.081)	**0.083**(0.065-0.105)	**0.110**(0.085-0.146)	**0.135**(0.101-0.184)	**0.164**(0.117
10-day	**0.028**(0.022-0.035)	**0.037**(0.029-0.043)	**0.050**(0.040-0.061)	**0.062**(0.049-0.079)	**0.082**(0.064-0.109)	**0.101**(0.076-0.137)	**0.122**(0.087
20-day	**0.018**(0.015-0.022)	**0.023**(0.018-0.027)	**0.030**(0.024-0.037)	**0.037**(0.030-0.046)	**0.047**(0.037-0.062)	**0.056**(0.042-0.075)	**0.066**(0.048
30-day	**0.014**(0.012-0.018)	**0.018**(0.014-0.022)	**0.023**(0.019-0.028)	**0.028**(0.022-0.035)	**0.035**(0.027-0.045)	**0.041**(0.030-0.054)	**0.047**(0.034
45-day	**0.012**(0.010-0.015)	**0.015**(0.012-0.018)	**0.019**(0.015-0.023)	**0.022**(0.018-0.028)	**0.027**(0.021-0.035)	**0.031**(0.023-0.041)	**0.035**(0.025
60-day	**0.011**(0.009-0.014)	**0.013**(0.011-0.016)	**0.016**(0.013-0.020)	**0.019**(0.015-0.024)	**0.023**(0.018-0.029)	**0.026**(0.019-0.034)	**0.029**(0.021

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estim
than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP
Please refer to NOAA Atlas 14 document for more information.

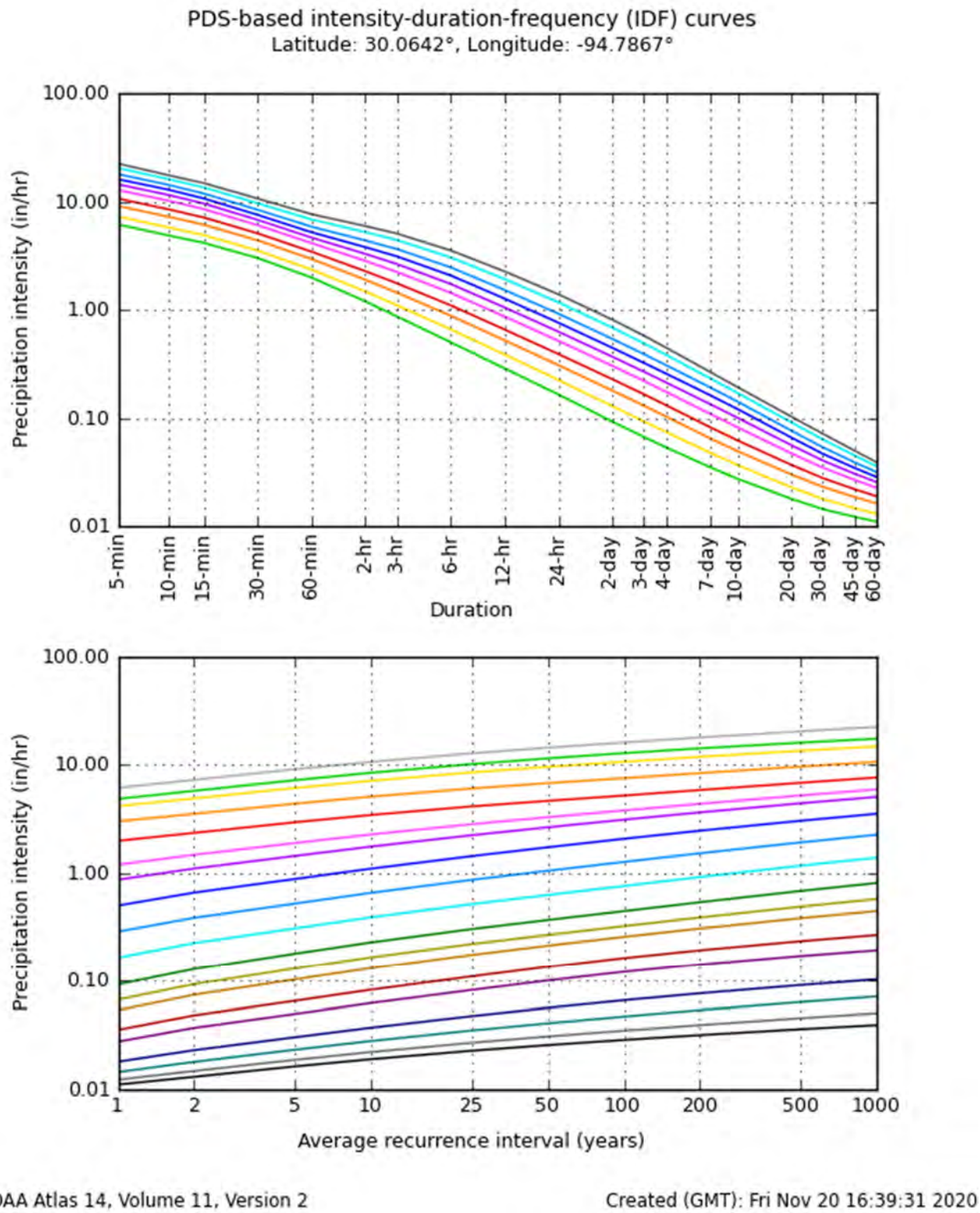

Figure 7.2 : City of Liberty, TX

END OF CRITERIA MANUAL