SECTION 800 STORM DRAINAGE FACILITIES

SECTION **PAGE**

810.00 STORM DRAINAGE DESIGN AND TECHNICAL CRITERIA

811.00 Scope

Section 800 sets forth the design and technical criteria and specifications for the analysis and design of drainage systems. All subdivision plats, site improvement plans, planned building groups and other proposed construction submitted to the City for acceptance will be accompanied by a storm drainage analysis, unless waived by the Director(s). Appropriate drainage system design must be submitted to and accepted by the Director(s) for each phase of construction. Such analysis and design will conform to the criteria set forth herein. Acceptance of the analysis and design is subject to the following conditions:

A. Construction of the system must commence within 1 year of the date of acceptance.
B. No construction has been completed on any adjacent property that may have affected the drainage pattern within the basin.

In either case, the Director(s) may require a new submittal.

A large portion of the criteria and design aids included in these STANDARDS AND SPECIFICATIONS originated from the Urban Drainage and Flood Control District (UDFCD) "Urban Storm Drainage Criteria Manual", current volume and the City of Brighton's Municipal Separate Storm Sewer System Phase 2 Permit (MS4 Permit). For any information not detailed in these specifications, refer to these documents.

812.00 General Provisions

812.01 General Design Criteria

Except where specified here, the procedure, criteria, and standards set forth in the latest revision of the "Urban Storm Drainage Criteria Manual" will be instituted for the analysis of any drainage system. Sound knowledge of current engineering practices and drainage methodology, as well as common sense, will be involved with the analysis of any drainage system.

All development must be in conformance with the current Master Drainage Plan. For areas not included in the Master Drainage Plan, onsite historic flood peaks shall be calculated using the present land use of the site. For offsite areas draining onto the site, flood peaks shall be calculated using fully developed land use determined using the land use plan or, if land use is not defined, using historic percent impervious and runoff coefficients.

Conveyance must be provided downstream of the site to the major drainage way with sufficient capacity to pass the one hundred (100) year event. Easements for these conveyance systems must be provided and shown on the drainage plan as well as conveyed to the city at time of platting.

All major storm floodplain boundaries will be shown on all preliminary and final drainage plans. All pond facilities will be of the detention type. The Director of Utilities will approve methods of detention. Retention facilities shall not be allowed per C.R.S. §37-82-602 (8)(b)(I). Instead infiltration basins that comply with the section 816.01 will be reviewed and approved by the Director(s).

Construction that will impair surface or subsurface drainage will not be accepted. The City reserves the right to issue and enforce more stringent criteria should adverse conditions exist. Designs varying from the criteria will require written approval of the exemption by the Director(s) prior to final acceptance of the plans.

812.02 Design Principals

Natural topographic features will be the basis of location for easements and future runoff calculations. In developed and undeveloped areas, average land slopes may be utilized in runoff computations. Wherever existing drainage patterns and slopes are defined, these will be used. The drainage facilities so designed must be able to handle the design flows with no erosion damage to the system.

Streets will not be used as primary floodways for major storm runoff. The amount of runoff in the streets will not exceed the limits established in Section 815.02 of these STANDARDS AND SPECIFICATIONS.

Any alteration to natural drainage patterns will not be approved unless a thorough investigation and analysis shows no hazard or liability. The Director(s) will have final authority over any system design.

The planning and design of the drainage system will not be such as to simply transfer the problem from one location to another or create a more hazardous condition downstream. Provisions will be made in every subdivision in the form of an easement or Right of Way for the 100-year storm to pass through that subdivision safely.

Enhancement of stormwater runoff quality is required for all developments within the City of Brighton through the use of structural or nonstructural Best Management Practices (BMPs). Refer to the Urban Storm Drainage Criteria Manual (Current Volume) for guidance on selection, use and design of BMPs.

All drainage improvements will be as natural in appearance as possible to be aesthetically pleasing. Maintenance access will be provided for all drainage and flood control facilities as well as inspection to provide proper function. Irrigation ditches will not be used as the outfall of any drainage basin. Expressed written approval must be obtained from the managing organization for irrigation ditches being considered for crossing or easements.

813.00 Design Methods

813.01 Initial and Major Design Storms

Every urban area has two separate and distinct drainage systems whether or not they are actually planned for and designed. One is the initial system corresponding to the initial (or ordinary) storm recurring at regular intervals. The other is the major system corresponding to the major (or extraordinary storm), which has a 1% propability of occouring in any given year. Since the effects and routing of storm waters for the major storm may not be the same as for the initial

storm, all storm drainage plans submitted for acceptance will detail two separate systems; one indicating the effects of the initial storm and the other showing the effects of the major storm.

A. *Initial storm provisions:* The objectives of such drainage system planning are to minimize inconvenience, to protect against recurring minor damage, to reduce rising maintenance costs, and to create an orderly drainage system. The initial storm drainage system may include such facilities as curb and gutter, storm sewer, swales, and other open drainage ways and detention facilities.

B. *Major storm provisions:* The major storm will be considered the 100-year storm. The objectives of the major storm planning are to eliminate substantial property damage or loss of life and will be as directed and accepted by the Director(s). Major drainage systems may include storm sewers, open drainage ways and detention facilities. The correlation between the initial and major storm system will be analyzed to insure a well-coordinated drainage system.

813.02 Storm Return Periods

The initial and major storm design return periods will not be less than those found in the Table 800-1:

TABLE 800-1
DESIGN STORM RETURN PERIODS

Land Use or Zoning	Design Storm Return Period	
	Initial Storm	Major Storm
Residential	5-year	100-year
Business	5-year	100-year
Public Building Areas	5-year	100-year
Parks, Greenbelts, etc.	2-year	100-year
Open Channels and Drainage ways	10 year	100-year
Detention Facilities	Water Quality and 10 year	100-year

813.03 Runoff Computations, Colorado Urban Hydrograph Procedure (CUHP)

The CUHP method is to be used on developments greater than 90 acres. The procedures for the CUHP, as explained in the Urban Storm Drainage Criteria Manual, shall be followed in the preparation of drainage reports and storm drainage facility designs in the City. The CUHP program requires the input of a design storm, either as a detailed hyetograph or as a 1-hour rainfall depth. The program for the latter using the 2-hour storm distribution recommended in the Urban Storm Drainage Criteria Manual generates a detailed hyetograph distribution. The 1-hour rainfall depths for the City of Brighton are presented in Table 800-2.

Table 800-2
CITY OF BRIGHTON
ONE-HOUR RAINFALL DEPTH

Design Storm	Rainfall Depth (in.)
2-Year	0.831
5-Year	1.11
10-Year	1.38
50-Year	2.17
100-Year	2.58

The hydrograph from the CUHP program must be routed through any proposed conveyance facility using UDSWM or a similar method.

813.04 Runoff Computations, Rational Method

The Rational Method is to be used on developments less than 90 acres.The procedures for the Rational Method, as explained in the Urban Storm Drainage Criteria Manual, shall be followed in the preparation of drainage reports in the City.

813.05 Runoff Coefficients

Rational method runoff coefficients: The runoff coefficient (C) to be used in conjunction with the Rational Method will not be less than those listed in the UDFCD Manual.

813.06 Rainfall Intensities

The rainfall intensities to be used in the computation of runoff using the Rational Method shall be calculated using the equation RA-3 in the UDFCD Manual.

814.00 Detention

814.01 General

On-site detention is required for all new development, expansion, and redevelopment. The required minimum detention volume and maximum release rates at these volumes for the 10-year and 100-

year storms shall be determined in accordance with the procedure and data set forth in this criteria. For lands where the City has adopted a Master Plan, detention facilities identified in the Master Plan shall be constructed. For lands where there is no Master Plan, on-site detention is required for all development as discussed in this section. For these lands, detention facilities should be designed using hydrograph and routing methods where possible.

Off-site drainage shall be routed around the detention pond or the drainage area should be included in the pond volume and release rates.

More stringent detention volumes and release rates may be required by the Director(s) to avoid negatively impacting the downstream properties.

Water Quality as called out in the Urban Storm Drainage Criteria Manual shall be provided for all new development, expansion, and redevelopment. The water quality capture volume shall be stored and released slowly over time. Water quality may be provided for in the same facility as flood control. When designing such a facility use the EURV Extended Detention Basin method, refer to Urban Storm Drainage Criteria Manual for further specifications.

Parking lots that serve as detention storage ponds must not have a storage depth of more than 1 foot. Parking lots that serve as detention storage ponds should place notification signs that the area is a pond during a rainfall event. The signs shall be permanent and high quality, meeting the City's specifications for traffic signs. Approval from the Director(s) is required for all parking lot detention.

Underground detentions will only be used when no other method is practical. Approval from the Director of Utilities is required for underground detention.

814.02 Grading Requirements

Slopes shall not be steeper than 4 (horizontal) to 1 (vertical). The geotechnical engineer for the project shall verify slope stability. All earthen slopes shall be covered with topsoil and re-vegetated. For irrigated grassed detention facilities the minimum bottom slope shall be 2% measured perpendicular to the trickle channel. Wet bottom detention facilities shall be reviewed on a case-by-case basis.
Freeboard Requirements

The minimum required freeboard for grassed and parking lot detention facilities is one (1) foot above the computed 100-year water surface.

814.03 Trickle Flow Control

All detention ponds shall include a trickle channel.

Refer to the UDFCD for trickle flow control.

814.04 Outlet Configuration

All detention ponds shall include a micropool, refer to the UDFCD for outlet configuration.

814.05 Inlet Configuration

All detention facilities shall include a forebay, refer to UDFCD for inlet configuration.

814.06 Embankment Protection

Whenever a detention pond uses an embankment to contain water, the embankment shall be protected from catastrophic failure due to overtopping. Overtopping can occur when the pond outlets become obstructed or when a larger than 100-year storm occurs. Failure protection for the embankment may be provided in the form of a buried heavy riprap layer (Type H) on the entire downstream face of the embankment or a separate emergency spillway having a minimum capacity of twice the maximum release rate for the 100-year storm. Structures shall not be permitted in the path of the emergency spillway or overflow. The invert of the emergency spillway should be set equal to or above the 100-year water surface elevation.

814.07 Release Rates

Refer to the Urban Storm Drainage Criteria Manual for water quality release rates.

814.08 Minimum Detention Volume

The minimum required detention volumes should be determined using the following equations (Refer to Urban Storm Drainage Criteria Manual Volume III for water quality release rates):

$V = KA$, (Equation 801)

For the 100-year,
$K_{100} = (1.78I-0.002I^2- 3.56)/1000$ (Equation 802)

For the 10-year,

$K_{10} = (0.95I – 1.90)/1000$ (Equation 803)

Where V = required volume for the 100 or 10-year storm (acre-feet),
I = Developed basin impervious (%)
A = Tributary area (Acres)

814.09 Compensating Detention Procedure

Detention facilities with drainage areas less than 160 acres are to be designed using the compensating detention procedure if any runoff is to flow undetained from the subject property. There may be more than one local detention facility on site. The compensating detention procedure requires that the release rates from the detained and undetained areas be equal to the allowable release rates from the total site. Therefore, the more undetained runoff, the less the allowable detention facility release rate. The limit on the undetained area is 5% or 5 acres, whichever is less.

Minimum Detention Volumes:

The minimum detention volumes shall be calculated using the equations in Section 814.08. The area contributing to the undetained runoff shall be included in the minimum detention volume calculation as if this area was draining to the detention facility.

814.10 Sequential Detention Procedure

Local detention facilities are to be designed using the "sequential detention procedure" if any storm runoff is detained by two or more detention facilities in sequence before leaving the subject property.

Sequential detention facilities are to be designed using Standard Form SF-11. The form is divided into two parts: Singular Detention and Sequential Detention. The singular detention part is for listing and computing the parameters associated with a single detention facility. Each facility is analyzed using the "equation detention method" criteria and the "compensating detention procedure" criteria, if required.
The sequential detention part of the form evaluates the combined effect of the detention facilities. The results of the second part computations will yield the minimum volume required and the maximum release rates allowed for each detention facility. The description of Standard Form SF-11 is as follows:

Col. 1: **Facility Number**: Designated number of the detention facility being analyzed.

Col. 2: **Basin Area**: Area of basin (sub-basin) tributary to the detention facility not including any area tributary to an upstream detention facility.

Col. 3: **(Q-sub I)**: Peak inflow in cfs from the area described in Column 2.

Col. 4: **IMP %**: Percent imperviousness of the area described in Column 2 to be used in Equations 802 and 803.

Col. 5: **K**: K-factor calculated from Equations 802 and 803 and the percent imperviousness (IMP %) in Column 4.

Col. 6: **(Q-sub I/A)**: Peak inflow (Q-sub I) in Column 3 divided by the area (A) in Column 2.

Col. 7: **ΣQ**: Peak inflow into detention facility computed by summation of the peak inflow in Column 3 and the maximum release rate from the detention facilities just upstream in Column 10.

Col. 8: **Z**: Equivalent inflow area computed by dividing Column 7 by Column 6 ($\Sigma Q/(Q_I/A)$).

Col. 9: **Minimum S-sub m**: Minimum allowed storage volume for the respective detention facility computed using Equation 801 and the parameters in Column 5 (K-factor) and Column 8 (Z = A).

Col. 10: **Maximum Q-sub m**: Maximum allowed release rate for the respective detention facility computed using the values in Table 800-4 and the Z parameter in Column 8.

STANDARD FORM SF-11
SEQUENTIAL DETENTION CALCULATION

SUBDIVISION _____

CALCULATED BY _____ DATE _____

10-YEAR

FACILITY NUMBER	SINGULAR DETENTION BASIN AREA (A) Ac (2)	Qi CFS (3)	IMP % (4)	K Ft (5)	Qi / A CFS/Ac (6)	SEQUENTIAL DETENTION Σ Q CFS (7)	Z Ac (8)	Sm Ac-Ft (9)	Qm CFS (10)
(1)									

100-YEAR

FACILITY NUMBER	SINGULAR DETENTION BASIN AREA (A) Ac (2)	Qi CFS (3)	IMP % (4)	K Ft (5)	Qi / A CFS/Ac (6)	SEQUENTIAL DETENTION Σ Q CFS (7)	Z Ac (8)	Sm Ac-Ft (9)	Qm CFS (10)
(1)									

$\Sigma Q = Q_i$ + Previous Q_m

$Z = \Sigma Q/(Q_i/A)$

$S_m = KZ$

City of Brighton Section 800
Construction Standards and Specifications
Storm Drainage Facilities

814.11 Exemptions From On-Site Detention

If one or more of the circumstances as listed below are met then the site may request an exemption in writting from on-site detention facility requirments from the Director of Utilities:

- The site drains to a regional detention and water quality facility that is publically owned and mainated; or.
- The parcel shares a common parcel boundry with a regional outfall channel and the ratio of drainageway basin area to site area is 1000:1 or more; or.
- The new development, redevelopment, or expansion results in less than 10,000 square feet.

814.12 Low Impact Development

All new development, redevelopment, or expansions shall incorporate low impact development techniques. A minimum of twenty-five (25) percent of the development, redevelopment or expansion impervious area must be treated by low impact development techniques. All low impact development must be approved by the Director(s).

See the UDFCD Manual for specifications

815.00 Infiltration Basins

Infiltrations basins shall be reviewed and approved by the Director(s) and must comply with C.R.S. §37-82-602 (8)(b)(I).

The capacity of the infiltration basin shall be calculated using the following equation:

24-Hour 100-year precipitation (feet) x Weighted Average Impervious Area x Drainage Basin Area (Acres) x 1.5 + 1 foot of freeboard

816.00 Design Standards

816.01 Open Channels

Except as modified herein, open channels, defined as either natural occurring or manmade, will be designed for the 100-year frequency storm for all tributary areas and will conform to the criteria set forth in the Urban Storm Drainage Criteria Manual. However, the channel design will also be analyzed with respect to initial storm runoff and its effect made known. Whenever practical, the channel should have slow flow characteristics, be wide and shallow, and be natural in its appearance and functioning.

Channels will be designed in such a manner that critical depth and super-critical flows are avoided. Capacities for small channels may be computed from Manning's Formula for uniform flow, except at crossings and transitions where backwater effects will need to be accounted for.

The channel cross section may be almost any type suitable to the location. However, the limitations for design for the major storm and initial storm design flows will include:

A. The channel and overbank areas shall have adequate capacity for the 100-year storm runoff.

B. Side slopes: Side slopes will be as flat as practical. Side slopes of 4:1 will be considered a normal minimum. Under special conditions, slopes of 3:1 may be utilized with written approval of the Director(s). However, a slope of no steeper than 4:1 is the practical limit for mowing equipment.

C. Depth: The maximum design depth of flow for the major storm shall be limited to five (5) feet, not including freeboard. Any design variation exceeding the maximum depth of flow must be submitted in writing for approval by the Director(s). Critical depths and velocities will be investigated for both the major and initial storm runoffs and these values made available to the Director(s).

D. Freeboard: Except where localized overflow in certain areas is desirable for additional ponding benefits or other reasons, the minimum allowable freeboard will be one (1) foot

E. Bottom width: The bottom width should be designed to satisfy the hydraulic capacity of the cross-section recognizing the limitations on velocity, depth and Froude number.

F. Slope of channel: Grass lined channel slopes are dictated by velocity and Froude number requirements, Grass-lined channels normally will have slopes of 0.2% to 0.6%. Where natural topography creates erosive velocities drop structure will be required

G. Curvature: The centerline curvature will not have a radius less than twice the design flow top width, but not less than one hundred (100) feet.

H. Trickle channels: Trickle channels to carry low flows will be required for all new channels. The capacity of a trickle channel will be approximately 2.0% of the major design flow. Where 2.0% of the major design flow exceeds 90 cfs, a low flow channel will be required. Low flow channels shall be in accordance with the UDFCD Urban Storm Drainage Criteria Manual.

I. Design velocity: The maximum velocity for the major storm design runoff will not exceed seven (7) feet per second for grass lined channels, except in sandy soil where the maximum velocity shall not exceed five (5) feet per second.

J. Erosion: All channels will be designed with the proper and adequate erosion control features.

K. Grass lining: The grass lining for channels shall be in accordance with the UDFCD Urban Storm Drainage Criteria Manual.

L. Water surface profile: A water surface profile for the major storm runoff will be computed for all channels and clearly shown on the final drawings submitted for acceptance. Computations of the water surface profile will utilize standard backwater methods such as HEC-2 taking into consideration all losses due to velocity changes, drops, bridge and culvert openings, and other obstructions. A Drainage Report will be submitted along with the final design plan. The energy gradient line must be shown on the final drawings.

M. Roughness coefficient (n): The value of the roughness coefficient (n) to be used in Manning's Formula will not be less than those listed in Table 800-5:

- **TABLE 800-5**
  MINIMUM VALUES OF ROUGHNESS COEFFICIENT (n)

Type of Channel and Description Closed Conduits:			Minimum
	Concrete Pipe:		
		Culverts with bends, connections & debris	0.013
		Storm sewer	0.013
		Subdrain with open joints	0.016
	PVC Pipe		0.011
	Concrete Surfaces (bottom & sides):		
		Smooth finish	0.015
		Unfinished	0.017
	Concrete Bottom (with sides of):		
		Mortared stone	0.020
		Dry rubble or riprap	0.030
	Gravel Bottom (with sides of):		
		Formed concrete	0.020
		Dry rubble or riprap	0.04
Excavated or Dredged Channels and Ditches:			
	Earthen, Straight & Uniform, no brush or debris:		
		Grassed, less than 6" high with:	
		Depth of flow < 2.0 feet	0.035
		Depth of flow > 2.0 feet	0.030
		Grassed, approx. 12" high with:	
		Depth of flow < 2.0 feet	0.060
		Depth of flow > 2.0 feet	0.035
		Grassed, approx. 24" high with:	
		Depth of flow < 2.0 feet	0.070
		Depth of flow > 2.0 feet	0.035
		Earth bottom with riprap on sides	0.040
	Rock or Shale Cuts:		
		Smooth and uniform	0.035
		Jagged and irregular	0.040
Curb and Gutter (concrete)			0.016

815.02 Street Flow Capacities

Except as modified herein, the criteria set forth in the Urban Storm Drainage Criteria Manual will be used in analyzing and approving the adequacy of streets as a function of the drainage system. The street classifications for Drainage Purposes are listed in Table 800-6.

Table 800-6
STREET CLASSIFICATION FOR DRAINAGE PURPOSES

Street Classification	Function	Speed/Number of Lanes	Signalization at Intersections	Street Parking
Local	Provide access to residential and industrial areas	Low speed with 2 moving lanes	Stop signs	One or both sides of the street
Collector	Collect and convey traffic between local and arterial streets	Low to moderate speed with 2 or 4 moving lanes	Stop signs or traffic signals	One or both sides of the street
Arterial	Function as primary through traffic conduits in urban areas	Moderate to high speeds with 4 to 6 lanes	Traffic signals (controlled access)	Usually prohibited
Freeway	Provide rapid and efficient transport over long distances	High speed travel with 4 lanes or more	Cloverleaves, access ramps (limited access)	Always prohibited

Both the initial storm runoff and major storm runoff must be considered, and calculations showing such runoff at critical sections will be submitted. The following criteria will apply in the determination of allowable street flow capacities:

A. Street, curb/gutter, walks, crosspans and curb cuts shall conform to all applicable Sections of these STANDARDS AND SPECIFICATIONS.

B. In relation to street capacity for initial storm, pavement encroachment for the initial design storm will not exceed the limitations set forth in Table 800-7:

TABLE 800-7
ALLOWABLE PAVEMENT ENCROACHMENT AND DEPTH OF FLOW FOR INITIAL STORM RUNOFF

Street Classification	Maximum Encroachment*
Local	No curb overtopping; flow may spread to crown of street.
Collector	No curb overtopping; flow spread must leave the equivalent of one 10-foot driving lane clear of water.
Arterials	No curb overtopping; flow spread must leave the equivalent of two 10-foot driving lanes clear of water - one lane in each direction.
Freeways	No encroachment is allowed on any traffic lane.

* Where no curbing exists, encroachment will not extend past property lines.

The storm sewer system will commence at the point where the maximum allowable encroachment occurs.

C. In relation to street capacity for major storm, the allowable depth of flow and inundated area for the major design storm will not exceed the limitations set forth in Table 800-8:

TABLE 800-8
ALLOWABLE DEPTH OF FLOW AND INUNDATED AREA FOR MAJOR STORM RUNOFF

Street Classification	Initial Storm Flow
Local & Collector	Residential dwellings and public, commercial, and industrial buildings should be no less than 12 inches above the 100-year flood at the ground line or lowest water entry of the building. The depth of water of the gutter flow line will not exceed 18 inches and 12 inches for collector streets.
Arterial & Freeway	Residential dwellings and public, commercial, and industrial buildings should be no less than 12 inches above the 100-year flood at the ground line or lowest water entry of the building. The depth of water should not exceed the street crown to allow operation of emergency vehicles. The depth of water over the gutter flow line should not exceed 12 inches.

Cross street flow: Cross street flow will occur by one of the following methods. One method is runoff which has been flowing in a gutter and then flows across the street to the opposite gutter or inlet. The second case is flow from some external source, such as a drainage way or conduit,

which will flow across the crown of the street when the conduit capacity is exceeded. Allowable Cross Street Flow is set forth in Table 800 –9.

TABLE 800-9
ALLOWABLE CROSS STREET FLOW

Street Classification	Initial Storm Flow	Major Storm Flow
Local	6 inches of depth in crosspan.	18 inches of depth above gutter flow line.
Collector	Where cross-pans allowed, depth of flow should not exceed 6 inches.	12 inches of depth above gutter flow line.
Arterial/Freeway	None.	No cross flow. Maximum depth at upstream gutter on road edge of 12 inches.

815.03 Storm Sewers and Storm Inlets

Except as subsequently modified, the design of storm sewers and inlets shall conform to the criteria set forth in the Urban Storm Drainage Criteria Manual. Storm sewers and inlets will be of sufficient capacity to adequately carry the expected runoff from the initial design storm as listed in Table 800-1. The storm sewer system and subsequent storm inlets will commence at all locations where the allowable street capacity is exceeded or wherever ponding of water is likely to occur. Hydraulic analysis must be provided in the Phase III Drainage Report showing no significant surcharge condition exists at inlets or manholes. The Hydraulic Grade Line must be kept 1.5’ below surface grade. The minimum allowable pipe size to be used in storm sewers and laterals will be as listed in Table 800-10:

TABLE 800-10
MINIMUM ALLOWABLE PIPE SIZE

Type of Conduit	Min. Inside Pipe Dia.
Main Trunk Sewer	18"
Short Laterals	15"

Arch pipes will be allowed where design conditions dictate, provided that the minimum cross-sectional areas will not be less than those specified above. All storm sewer conduits will be of sufficient structural strength to withstand an H-20 design load.

The maximum allowable distance between manholes or other suitable appurtenances for cleanouts will not exceed those listed in Table 800-11:

TABLE 800-11
MAXIMUM ALLOWABLE MANHOLE SPACING

Inside Diameter or Minimum Head Room	Maximum Allowable Distance Between Manholes & Cleanouts
18” - 36"	400 feet
42" - 60"	500 feet
60" & Larger	750 feet

The capacities of conduits will be computed using the criteria set forth in the Urban Storm Drainage Manual Friction, lateral, bend, exit and entrance losses shall be included in the design. The storm sewer design shall include tailwater conditions. The value of the roughness coefficient (n) to be used will not be less than those specified in Section 815.01(l) of these STANDARDS AND SPECIFICATIONS. The average flow velocity for the initial storm conduits will not be less than two (2) feet per second.

Allowable storm inlets will be curb opening inlets, type "R" or combination curb/grate inlets, type “13”, similar and equal to the City’s Standard Storm Water Inlets or as approved by the Director(s). Inlets will be utilized at all points where ponding or sump conditions exist. Refer to the Standard Drawings for details.

The theoretical capacity and spacing of storm inlets will be analyzed using the criteria set forth in the Urban Storm Drainage Criteria Manual. Other methods, such as nomographs, may be used to design inlets. The Director(s) must approve other design methods.

The allowable inlet capacity will be determined using the reduction factors. These reduction factors compensate for debris plugging, pavement overlaying, variations in design assumptions or other factors that decrease inlet capacities.

The size of outlet pipes from storm water inlets will be based on the theoretical capacity of the inlet.

Computations for storm sewer design and storm inlet designs shall be submitted on forms similar to those included in these specifications for acceptance. Adequate details of the proposed storm sewer system, including plan and profile, details of inlets, manholes and other appurtenances will be included in the overall drainage plan submitted for acceptance.

The storm sewer outlet shall be protected for the major storm. The protection shall be designed as called out in the Urban Storm Drainage Criteria Manual.

815.04 Culverts

Culvert capacities shall be at least equal to the capacities of culverts designed in accordance with the procedures outlined in the Urban Storm Drainage Criteria Manual. Culverts may be of any shape and construction required by existing topographic features, provided, however, the size, shape, location, and type of construction of culverts will be subject to acceptance by the Director(s). Culverts installed under local and collector streets shall be designed to pass at least the 10-year storm. Culverts installed under arterials shall pass at least the 100-year storm.

Culverts under principal arterials shall have sufficient capacity to pass all of the runoff from the major storm considering a minimum of twenty percent (20%) of the inlet plugged. Higher percentages may be required based on site-specific considerations. In determining the amount of emergency overflow required, capacity credits may be utilized when approved by the Director(s).

Culvert installations will be designed with an emergency overflow. An emergency overflow spillway that can pass the 100-year event at a depth less than one foot shall be provided.

The following design criteria will be utilized for all culvert design:

A. The culvert, including inlet and outlet structures, will properly take care of water, bed load and debris at all stages of flow.

B. Inlets: Culvert inlets will be designed to minimize entrance and friction losses. Inlets will be provided with either flared-end sections or head walls with wing walls. Projecting ends will not be acceptable. For large structures, provisions will be made to resist possible structural failure due to hydrostatic uplift forces.

C. Outlets: Culvert outlets will be designed to avoid sedimentation, undermining of culvert, or erosion of downstream channels. Outlets will be provided with either flare-end sections or headwalls, with wingwalls and riprap. Projecting outlets will not be acceptable. Outlet protection shall be designed according to the Urban Storm Drainage Criteria Manual.

D. Slopes: Culvert slopes will be such that neither silting nor excessive velocities nor scour occur. Generally, the minimum slope of culverts will be limited to one-half percent (0.5%).

E. Excessive ponding above culvert entrances will not be acceptable if such ponding appears likely to cause property or roadway damage, culvert clogging, saturation of fills, detrimental upstream deposits of debris, or inundate existing or future utilities and structures.

F. Tailwater: The height of tailwater at the outlet will be subject to acceptance by the Director(s).

G. Hydraulic Design: Culverts will be analyzed to determine whether discharge is controlled by inlet or outlet conditions for both the initial storm discharge and the major storm discharge. The value of the roughness coefficient (n) used will not be less than those specified in Section 815.01 (l) of these STANDARDS AND SPECIFICATIONS. Computations for selected culvert sizes will be submitted for approval on forms similar to those included in these specifications.

H. Minimum Allowable Size: The required size of the culvert will be based on adequate hydraulic design analysis. In no case will approval be made for round culverts with less than eighteen (18) inches inside.

I. Multiple Culvert Installations: Where physical conditions dictate, multiple culvert installations will be acceptable, subject to approval by the Director(s). Headwalls shall be used with multiple culvert installations. The minimum size of any culvert will not be less than the requirements set forth in Section 815.03 (h) of these STANDARDS AND SPECIFICATIONS.

J. Structural Design: The structural design of culverts shall conform to those methods and criteria recommended by the manufacturer of a specific type of culvert for the specified embankment conditions. Where appropriate, the applicable provisions of Section 815.02 of these STANDARDS AND SPECIFICATIONS will also apply to the design of culverts.

815.05 Pet Waste Stations

In order to protect storwater runoff quality, pet waste stations must be installed at all parks, trails, multi-family, and single family attached developments. The pet waste station must include:

A. Approved Signage,
B. Waste Basket, and
C. Waste Bags

820.00 GENERAL PROVISIONS

821.00 General

All storm drainage construction in the City rights-of-way shall be accomplished in accordance with these STANDARDS AND SPECIFICATIONS, and these standards will cover not only new storm drainage construction but also repairs and maintenance of the existing facilities within the City.

822.00 Accepted Plans

All storm drainage construction shall be done in accordance with engineered construction plans for the work, prepared under the direction of a Registered Professional Engineer licensed to practice in Colorado. Plans will conform to the City's Design Criteria and must be accepted by the Director(s). Storm drainage plans will include an Area Grading Plan and an Erosion Control plan and shall convey adequate detail as determined by the City to ensure proper functioning of the proposed stormwater plan as defined in Section 161.00 of these STANDARDS AND SPECIFICATIONS.

Where work is to be done on an irrigation ditch, the written approval of the ditch owner is required prior to acceptance by the Director(s).

823.00 Permits Required

All permits shall be obtained from the One Stop Customer Service Desk.

824.00 Maintenance of Traffic

Maintenance of traffic shall comply with Section 623.00, Maintenance of Traffic, of these STANDARDS AND SPECIFICATIONS.

830.00 EROSION CONTROL

831.00 General

Erosion and sedimentation are natural processes, the intensity of which are increased by land disturbing activities that reduce or destroy the aesthetic and practical values of neighboring properties, streams and lakes. The purpose of these erosion criteria is to reduce intensified erosion, caused by either wind or water, to an acceptable level without placing undue burdens on the landowner, builder or community. Erosion and sediment control methods shall be in the form of an Erision and Sediment Control Plan (may also be known as Storm Water Management Plan or Storm Water Pollution Prevention Plan).

832.00 Requirements

Erosion and sediment control measures shall be designed in conformance with CDPHE stormwater management plan preparation guidance and Urban Storm Drainage Criteria Manual. All land-disturbing activities within the City of Brighton shall be in compliance with applicable

Colorado Discharge Permit System (CDPS) Storm water and Colorado Air Quality Control Commission regulations.

833.00 Submittal

An erosion and sediment control plan shall be submitted as part of the development review procces. A detailed erosion control civil plan must accompany the Area Grading Plan and approved Drainage Plan as required in Section 161.09 of these STANDARDS AND SPECIFICATIONS. The erosion and sediment control plan must be submitted to, and accepted by the City of Brighton prior to receiving Erosion and Sediment Control permit.

834.00 Erosion and Sediment Control Plan

See CDPHE stormwater management plan preparation guidance.

835.00 Erosion Control Structures

Standard details and specifications are provided in the Standard Drawings. When applicable, details of erosion control measures should be obtained from the Urban Storm Drainage Criteria Manual.

840.00 STORM DRAINAGE CONSTRUCTION

841.00 Site Work and Earthwork

841.01 General

Site work and earthwork shall be performed in accordance with Section 300.00, Site Work and Earthwork, of these STANDARDS AND SPECIFICATIONS.

841.02 Trenching, Backfilling and Compacting

Trenching, backfilling and compacting shall be performed in accordance with Section 350.00, Trenching, Backfilling and Compacting, of these STANDARDS AND SPECIFICATIONS.

841.03 Preservation of Monuments

Refer to Section 141.00, Protection of Public and Utility Interests, of these STANDARDS AND SPECIFICATIONS.

842.00 Materials

842.01 Pipe

All pipe shall comply with all applicable ASTM and ASHTO standards.

Reinforced concrete pipe (RCP): All applicable portions of Section 706, Concrete and Clay Pipe, of the CDOT Standard Specifications for Road and Bridge Construction shall apply. Rubber gasket joints shall be in accordance with all applicable ASTM and AASHTO standards.

Polyvinyl Chloride Pipe (PVC): All applicable portions of Section 712.13, Plastic Pipe, of the CDOT Standard Specifications for Road and Construction shall apply.

Corrugated aluminum pipe (CAP): shall not be used.

Corrugated polyethylene pipe (CPP): shall be manufactured in accordance with the physical requirements of Type III High Density, Category 3, 4 or 5, P23, P33 or P34, Class C per ASTM D-1248 with the applicable requirements defined in ASTM D-1248. Requirements for test methods, dimensions and markings shall comply with AASHTO Designation M-294. Minimum pipe stiffness (per ASTM test Method D-2412, will be as shown in Table 800-13:

TABLE 800-13

All couplings shall be constructed, tested and designed to manufacturer specifications and as appropriate. A manufacturer's certification that the product was manufactured, tested and supplied in accordance with this specification shall be furnished upon request of the Director(s).

Pipe class designation or gauge shall be as shown on the accepted plans or as designated by the Director(s) for each individual project. Pipe material shall be chosen based on strength and soil conditions. At no time shall corrugated polyethylene pipe (CPP) be allowed under roadways.

All pipe shall be inspected by the Director(s) in order to allow for rejection of pipe that fails to conform to the requirements of these STANDARDS AND SPECIFICATIONS. Defects will be marked so as not to disfigure the rejected pipe. Rejected pipe will be removed from the job site within 24 hours.

At all locations where corrugated aluminum pipe is to be installed, a corrosion resistance level test shall be performed and a test report submitted to the Director(s) for acceptance. The test will classify the soil and water to one of the CR levels shown in Table 800-14.

TABLE 800-14
GUIDELINES FOR SELECTION OF CORROSION RESISTANCE (CR) LEVELS

CR Level	Sulfate (SO_4) % max.	Chloride (Cl) % max.	pH	Sulfate (SO_4) ppm* max.	Chloride (Cl) ppm max.	pH
CR 0**	0.05	0.05	6.0 - 8.5	250	250	6.0 - 8.5
CR 1	0.15	0.15	6.0 - 8.5	250	250	6.0 - 8.5
CR 2	0.05	0.05	6.0 - 8.5	500	500	6.0 - 8.5
CR 3	0.15	0.15	6.0 - 8.5	500	500	6.0 - 8.5
CR 4	0.50	1.00	5.0 - 9.0	1000	1000	5.0 - 9.0
CR 5	1.00	1.50	5.0 - 9.0	2000	2000	5.0 - 9.0
CR 6	1.00	1.50	5.0 or 9.0	2000	2000	5.0 or 9.0

* ppm = parts per million
**No special corrosion protection recommended when values are within these limits.

842.02 Pipe Joints

Pipe joints shall be constructed as designated on the accepted construction plans or as otherwise accepted by the Director(s). Rubber gasket joints for concrete pipe will conform to ASTM C-443. Corrugated metal pipe joints will be installed according to pipe manufacturer's recommendations. Cement mortar joints will be constructed with mortar mixture composed of one (1) part Portland cement to three (3) parts sand and enough water to produce a workable mix. Mortar that has started to set will be discarded and a new batch prepared.

842.03 Manholes, Inlets and Sidewalk Chases

Manholes and inlets may be constructed of cast-in-place or precast concrete. Manhole materials shall comply with all applicable portions of Section 732.04, Manhole Materials, of these STANDARDS AND SPECIFICATIONS.

Inlets shall conform to the Standard Drawings and to applicable Colorado Department of Highways "M" Standards. All lids for inlets shall have the words “No Dumping – Drains to River”,“City of Brighton Storm Sewer”, and an imprinted fish emblem.

842.04 Manhole Base Slabs & Base Beams

Refer to Section 732.05, Manhole Base Slabs and Base Beams, of these STANDARDS AND SPECIFICATIONS.

842.05 Concrete

Concrete shall conform to Section 400.00, Concrete Work, of these STANDARDS AND SPECIFICATIONS, for Portland cement concrete work. Type II cement will be used. Concrete encasement of pipe will conform to the details shown on the accepted plans.

842.06 Cast Iron Fittings

Refer to Section 732.07, Cast Iron Fittings, of these STANDARDS AND SPECIFICATIONS.

842.07 Bedding Material

Bedding for storm sewer mains shall meet the classification of well graded gravel meeting AASHTO classification as an A-1-a soil as shown in Table V of Standards Detail Drawing STM12C. All applicable portions of Section 352.00, Bedding for Pipelines and Service Lines, of these STANDARDS AND SPECIFICATIONS, shall apply.

842.08 Riprap and Filter Cloth

Riprap and filter cloth shall be installed at those locations noted on the accepted plans, or in locations designated by the Director(s). Riprap and bedding shall meet the standards set forth in the Drainage Criteria Manual.

842.08.01 Riprap

Rock used for riprap shall be hard, durable, angular in shape, and be free from cracks, overburden, shale and organic matter. Neither breadth nor thickness of single stone shall be less than one-third (1/3) its length and rounded stone will not be accepted. The rock shall sustain abrasion test (Los Angeles machine - ASTM C0535-69) and shall sustain a loss of not more than ten percent (10%) after twelve (12) cycles of freezing and thawing (AASHTO test 103 for ledge rock procedure A). The rock shall have a minimum specific gravity of 2.50. Classification and gradation for riprap are shown in Table 800-14.

The riprap designation and total thickness of riprap shall be as shown on the accepted plans. The maximum stone size shall not be larger than the thickness of the riprap.

TABLE 800-14
CLASSIFICATION AND GRADATION OF RIPRAP

Riprap Designation	% Smaller Than Given Size By Weight	Intermediate Rock Dimension (Inches)	d(50)* (Inches)
Type VL	70-100	12	
	50-70	9	
	35-50	6	6**
	2-10	2	
Type L	70-100	15	
	50-70	12	
	35-50	9	9**
	2-10	3	
Type M	70-100	21	
	50-70	18	
	35-50	12	12
	2-10	4	
Type H	70-100	30	
	50-70	24	
	35-50	18	18
	2-10	6	
Type VH	70-100	42	
	50-70	33	
	35-50	24	24
	2-10	9	

*d(50) = Mean particle size
** Bury Types VL and L with native topsoil and re-vegitate to protect from vandalism.

842.08.02 Filter Cloth

Filter cloth shall be manufactured especially for the stability of erosion control construction and made from polyethylene, polypropylene or polyester yarns in accordance with the following:

A.	Weight	3.9 oz/yd	ASTM D1910
B.	Thickness	15 mils	ASTM D1777
C.	Grab Strength	130 lbs	ASTM D1682
D.	Elongation Break	60%	ASTM D1682
E.	Mullen Burst Strength	140 psi	ASTM D3786
F.	Puncture Strength	40 lb	ASTM D751
G.	Trapezoid Tear Strength	60 lb	ASTM D751
H.	Equivalent Opening Size	70-100 U.S. Sieve	CW 02215

842.08.03 Filter Material

The filter material that shall be placed on top of the filter cloth (at specified thickness) prior to placement of the riprap shall meet the requirements of "Stabilization Material" as defined in Section 340.01, Definitions, of these STANDARDS AND SPECIFICATIONS.

When requested by the Director(s), the Contractor shall furnish copies of tests from a certified and acceptable testing laboratory for the following:

A. Gradation and soundness of riprap
B. Gradation of filter material
C. Strength and characteristic tests for filter cloth

843.00 Installation

Refer to Section 733.01, General, of these STANDARDS AND SPECIFICATIONS.

843.01 Alignment and Grade

Refer to Section 733.02, Alignment and Grade, of these STANDARDS AND SPECIFICATIONS.

843.02 Protection of Existing Underground Utilities

Refer to Section 733.03, Protection of Existing Underground Utilities, of these STANDARDS AND SPECIFICATIONS.

843.03 Wet Trench

Refer to Section 351.00, Trench Excavation for Pipelines and Service Lines, of these STANDARDS AND SPECIFICATIONS.

843.04 Handling Pipe and Fittings

Refer to Section 733.05, Handling Pipe and Fittings, of these STANDARDS AND SPECIFICATIONS.

843.05 Sewer Pipe Installation

Refer to Section 733.06, Sewer Pipe Installation, of these STANDARDS AND SPECIFICATIONS.

843.06 Connections to Existing Manholes

Refer to Section 733.07, Connections to Existing Manholes, of these STANDARDS AND SPECIFICATIONS.

843.07 Construction of Manholes, Inlets and Sidewalk Chases

Manholes and inlets shall be constructed in accordance with applicable portions of Section 733.08, Construction of Manholes, of these STANDARDS AND SPECIFICATIONS. Refer to the Standard Drawings for manhole details, inlet details, and for sidewalk chase details. Inlets shall be per CDOT Construction Details or accepted by the City of Brighton.

843.08 Construction of Open Channels and Special Structures

All work will conform to details shown on the accepted plans and whatever additional specifications are required. Construction will be accurately done to line and grade according to construction stakes as required by Section 733.02 of these STANDARDS AND SPECIFICATIONS.

When required, sidewalk chases will be constructed as detailed on the Standard Drawings.

843.09 Riprap and Filter Cloth

Excavation for riprap shall conform to all applicable portions of Section 300.00, Site Work and Earthwork, of these STANDARDS AND SPECIFICATIONS.

The Contractor shall complete the excavation in accordance with the accepted plans or as directed by the Director(s), then he shall place the filter cloth over the graded areas loosely enough so that any protrusions from underneath or applied bands to the cloth will not cause stretching of the cloth beyond elastic limits.

The outer edge of the filter cloth shall be folded vertically upward at the trench. All overlapping joints shall be a minimum of two (2) feet wide, with the upstream section overlapping the downstream portion. The overlapping joints shall be secured with staples at each edge of the adjoining sections of cloth, and spaced at two (2) foot intervals. The Contractor, at his expense, in

accordance with the manufacturer's recommendations, shall repair any holes, rips or other damage to the filter cloth.

Stabilization material, as described in Section 340.01, Definitions, of these STANDARDS AND SPECIFICATIONS, shall be placed on top of the filter cloth (where filter cloth is used) to a thickness of six (6) inches. The material shall be placed using equipment, which will not rip, tear or otherwise damage the filter cloth. Any damaged areas shall be promptly repaired at the Contractor's expense. The material shall be screeded to give a finished surface, which is within one- (1) inch of the specified thickness.

Riprap shall be placed to conform to the details shown on the accepted plans. The larger size stones shall be placed first and roughly arranged in close contact. The toe trench and foundation course shall be closed first. The spaces between the larger stones shall then be filled with smaller stone of suitable size, so placed as to leave the surface evenly stepped, conforming to the contour required. The finished surface shall be even and tight and shall not vary from the planned surface by more than one-quarter (1/4) foot per foot of depth. The material may be machine placed with sufficient handwork to accomplish the requirements noted herein.

Where riprap is to be grouted, the stones shall be laid with care to prevent earth and sand from filling the joints. Grout and concrete must be removed form exposed rock for aesthetic purposes. Joints shall be filled with grout and the surfaces swept with a stiff broom. The work shall be protected and kept moist during hot weather for at least three (3) days after grouting, or coated with a clear membrane-curing compound. Grout shall consist of one- (1) part cement and three (3) parts aggregate, by volume. The Portland Cement shall be Type II and aggregate shall be two (2) parts sand and one (1) part gravel passing a three-eighths inch (3/8") square mesh screen. The amount of water in the mix shall be such as to permit gravity flow into the interstices with limited spading and brooming.

Except when approved in writing by the Director(s), the Contractor shall cease all grouting or placement of concrete into which riprap is to be placed when the descending air temperature in the shade and away from artificial heat falls below thirty-five (35) degrees Fahrenheit, and there is frost in the subgrade. When concreting is permitted during cold weather, the temperature of the mix shall not be less than sixty- (60) degrees Fahrenheit at the time of placing. The Contractor shall not place filter cloth, stabilization material, or riprap on frozen ground.

843.10 Inspections

Refer to Section 154.00, Inspections, of these STANDARDS AND SPECIFICATIONS.

850.00 TRENCHING, BACKFILLING AND COMPACTING

Refer to Section 350.00, Trenching Backfilling and Compacting, of these STANDARDS AND SPECIFICATIONS.

860.00 RESTORATION AND CLEANUP

Refer to Section 360.00, Restoration and Cleanup, of these STANDARDS AND SPECIFICATIONS.

870.00 GRADING AND EXCAVATION

Refer to Section 330.00, Site Preparation, of these STANDARDS AND SPECIFICATIONS.

880.00 STORMWATER QUALITY

The control measures for applicable development sites shall meet one of the following base design standards listed below:

(A) WQCV Standard: The control measure(s) is designed to provide treatment and/or infiltration of the WQCV and:

1) 100% of the applicable development site is captured, except the permittee may exclude up to 20 percent, not to exceed 1 acre, of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to street).

2) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).

(B) Pollutant Removal Standard: The control measure(s) is designed to treat at a minimum the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less.

1) 100% of the applicable development site is captured, except the permittee may exclude up to 20 percent not to exceed 1 acre of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to street).

(C) Runoff Reduction Standard: The control measure(s) is designed to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60% of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration. This base design standard can be met through practices such as green infrastructure. “Green infrastructure” generally refers to control measures that use vegetation, soils, and natural processes or mimic natural processes to manage stormwater. Green infrastructure can be used in place of or in addition to low impact development principles.

(D) Applicable Development Site Draining to a Regional WQCV Control Measure: The regional WQCV control measure must be designed to accept the drainage from the

applicable development site. Stormwater from the site must not discharge to a water of the state before being discharged to the regional WQCV control measure. The regional WQCV control measure must meet the requirements of the WQCV in Section 880.00 (A).

(E) Applicable Development Site Draining to a Regional WQCV Facility: The regional WQCV facility is designed to accept drainage from the applicable development site. Stormwater from the site may discharge to a water of the state before being discharged to the regional WQCV facility. Before discharging to a water of the state, 20 percent of the total impervious surface of the applicable development site must first drain to a control measure covering an area equal to 10 percent of the total impervious surface of the applicable development site. In addition, the stream channel between the discharge point of the applicable development site and the regional WQCV facility must be stabilized.

1) The regional WQCV facility must be implemented, functional, and maintained following good engineering, hydrologic and pollution control practices.

2) The regional WQCV facility must be designed and maintained for 100% WQCV for its entire drainage area.

3) The regional WQCV facility must have capacity to accommodate the drainage from the applicable development site.

4) The regional WQCV facility be designed and built to comply with all assumptions for the development activities planned by the permittee within its drainage area, including the imperviousness of its drainage area and the applicable development site.

5) Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the facility. Consideration of drain time shall include maintaining vegetation necessary for operation of the facility (e.g., wetland vegetation).

6) Regional Facilities must be designed and implemented with flood control or water quality as the primary use. Recreational ponds and reservoirs may not be considered Regional Facilities. Water bodies listed by name in surface water quality classifications and standards regulations (5 CCR 1002-32 through 5 CCR 1002-38) may not be considered regional facilities.

(F) Constrained Redevelopment Sites Standard:

1) Applicability: The constrained redevelopment sites standard applies to redevelopment sites meeting the following criteria:

(a) The applicable redevelopment site is for a site that has greater than 75% impervious area, and

(b) The permittee has determined that it is not practicable to meet any of the design standards above. The permittee's determination shall include an evaluation of the

applicable redevelopment sites ability to install a control measure without reducing surface area covered with the structures.

2) Constrained Redevelopment Sites Design Standard: The control measure(s) is designed to meet one of the following:

a) Provide treatment of the WQCV for the area captured. The captured area shall be 50% or more of the impervious area of the applicable redevelopment site. Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented

(b) The control measure(s) is designed to provide for treatment of the 80th percentile storm event. The control measure(s) shall be designed to treat stormwater runoff in a manner expected to reduce the event mean concentration of total suspended solids (TSS) to a median value of 30 mg/L or less. A minimum of 50% of the applicable development area including 50% or more of the impervious area of the applicable development area shall drain to the control measure(s). This standard does not require that 100% of the applicable redevelopment site area be directed to control measure(s) as long as the overall removal goal is met or exceeded (e.g., providing increased removal for a smaller area), or

(c) Infiltrate, evaporate, or evapotranspirate, through practices such as green infrastructure, a quantity of water equal to 30% of what the calculated WQCV would be if all impervious area for the applicable redevelopment site discharged without infiltration.