Section 900 Roadways
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Section 900 Roadways

901 INTRODUCTION

The criteria presented in this section shall be used to determine allowable stormwater encroachment within public streets. The review of all planning submittals as outlined in Section 200 will be based on the criteria herein.

Street, road, and roadway are all general terms that denote a public way for purposes of vehicular travel, including the entire area within the right-of-way. The criteria herein will use these general terms interchangeably.

902 FUNCTION OF STREETS IN THE DRAINAGE SYSTEM

Curb and gutter sections and roadside ditches along urban and rural streets are part of both the Minor and Major Drainage Systems. When the drainage in the street exceeds the allowable limits, a storm drain system or an open channel is required to convey the excess flow. The primary function of streets is traffic movement, and the drainage function may only cause limited interference with the traffic function of streets.

The design criteria for collection and conveyance of runoff on public streets are based on a reasonable frequency and magnitude of traffic interference. Depending on the street classification, some traffic lanes are allowed to be fully inundated during the minor or major storm event. During less intense storms, runoff will inundate traffic lanes to a lesser degree. The primary function of streets as part of the Minor Drainage System is to convey nuisance flows to a storm drain system or open channel without interfering with traffic movement. As part of the Major Drainage System, the function of streets is to provide an emergency path for flood flows with minimal damage to the urban environment.

903 DRAINAGE IMPACTS ON STREETS

Storm runoff can affect traffic function of a street in the following ways:

1. Sheet flow across roadways
2. Concentrated flow in the gutter
3. Ponded water at low points
4. Concentrated flow across traffic lanes
5. Damage to the street section and required maintenance.

The criteria contained in this section of the MANUAL are intended to manage the impacts of stormwater on transportation infrastructure and to maintain a standard and consistent level of safety on county streets and roads during a given storm event.

904 STREET CLASSIFICATION

Each street in Boulder County has an assisgned functional classification based on its role in connecting and providing access between various land uses. These functional classifications are listed in Boulder County's Multimodal Transportation Standards and assigned through the approval of the most recent Boulder County Road Map. The extent to which stormwater is allowed to encroach into the driving lanes of a roadway is based on that roadway's functional class.Limiting flow encroachment on a roadway is the primary criteria by which roadway safety is maintained during a storm event.

Although a majority of county roads will utilize a roadside ditch, some county streets will utilize a curb and gutter section. Using a curb and gutter or roadside ditch to convey flow does not affect the criteria for allowable encroachment because safety concerns remain the same for both types of roadways. The allowable lateral encroachment onto the roadway for each of the county's functional roadway classifications is presented in Table 900-1. These criteria may be listed by the width of roadway that must remain free of water or by the amount of ponding permissible at the crown during each storm event. In no case shall any roadway improvement, reconstruction, or expansion cause more flow encroachment on a parcel or structure outside the county right-of-way than currently exists. These criteria apply to roads with roadside ditches, curb and gutter sections, and culvert crossings. They do not apply to bridge crossings. Criteria for bridge crossings are included separately in Section 1000.

Table 900-1. Allowable Flow Depth and Encroachment for County Roads

Functional Classification	Minor Storm Encroachment	Major Storm Encroachment
Principal Arterial (PA)	10 feet clear each way	10 feet clear in center
Minor Arterial (MA)	Flow may spread to crown	Allowable depth at crown = 3 inches
Collector (C)	Flow may spread to crown	Allowable depth at crown = 3 inches
Residential Collector (RC)	Allowable depth at crown = 3 inches	Allowable depth at crown = 9 inches
Local (L)	Allowable depth at crown = 3 inches	Allowable depth at crown = 9 inches
Local Secondary (LS)	Allowable depth at crown = 3 inches	Allowable depth at crown = 9 inches
Townsite Road	Allowable depth at crown = 3 inches	Allowable depth at crown = 9 inches

905 HYDRAULIC EVALUATION

905.1 Streets With Curb and Gutter

The minor and major storm capacity of each street section may be calculated in one of two ways. The first is by using the UD-Inlet spreadsheet created by the UDFCD to calculate street and inlet capacities. The second is to calculate capacity manually using the Manning's equation shown as Equation 900.1 or the modified Manning's equation shown as Equation 900.2. Equations 900.1 and 900.2 assume a gutter cross slope equal to the roadway cross slope.

$$Q = \frac{0.56}{n} S_x^{5/3} S_L^{1/2} T^{8/3} \tag{900.1}$$

$$Q = \frac{0.56}{nS_x} S_L^{1/2} Y^{8/3} \tag{900.2}$$

where

Q = discharge (ft)

S_x = street cross slope (ft/ft)

Y = depth of water at face of curb (ft)

T = top width of flow spread (ft)

S_L = longitudinal grade of street (ft/ft)

n = Manning's roughness coefficient.

Roadway sections typically do not have gutter cross slopes equal to roadway cross slopes. A composite analysis must be completed for these sections, as presented by Equations 900.3 through 900.8.

$$Q = Q_w + Q_s \tag{900.3}$$

where

Q = total street section capacity (cfs)

Q_w = flow rate in the depressed section of the gutter (cfs)

Q_s = discharge in the section that is above the depressed section (cfs).

The theoretical flow rate, Q, is:

$$Q = \frac{Q_s}{1 - E_o} \tag{900.4}$$

where

$$E_o = \frac{1}{1 + \dfrac{S_w / S_x}{\left[1 + \dfrac{S_w / S_x}{(T/W) - 1}\right]^{8/3} - 1}} \tag{900.5}$$

where

$$S_w = S_x + \frac{a}{W} \tag{900.6}$$

where

$a =$ gutter depression (ft)

$W =$ width of gutter (ft).

Figure 900-1 shows the geometric variables.

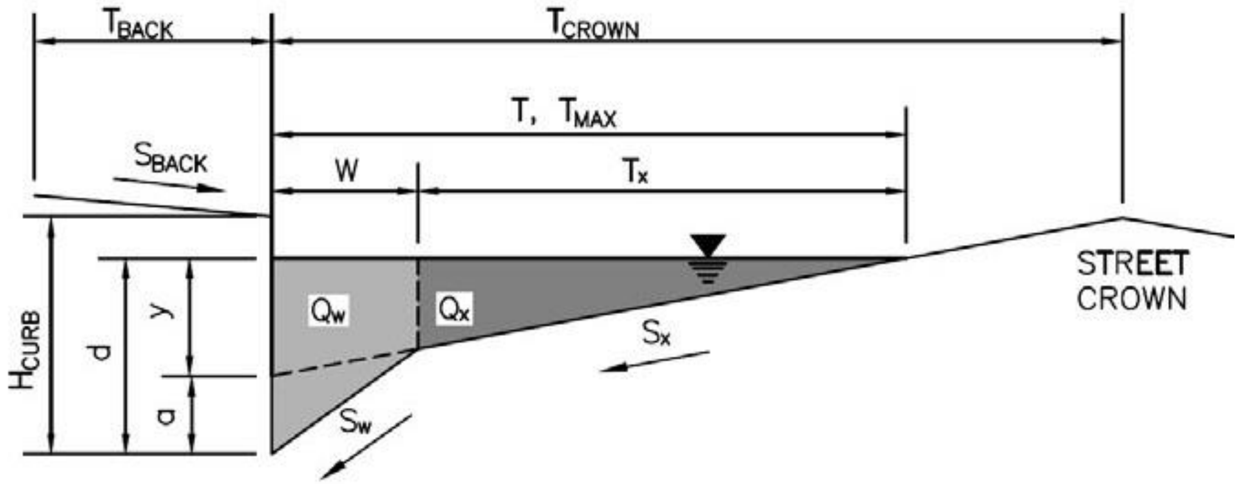

Figure 900-1. Gutter Section Composite Cross Slope (UDFCD, 2016)

From the geometry, it can be shown that:

$$y = a + TS \tag{900.7}$$

and

$$A = \frac{1}{2} S_x T^2 + \frac{1}{2} aW \tag{900.8}$$

where

$y =$ flow depth at the curb (ft)

$A =$ flow area (sf).

A Manning's *n* value of 0.016 should be used for the gutter and street flow areas. A Manning's *n* value of 0.025 should be used for sidewalk and grass areas in UD-Inlet, if needed. A reduction factor from Figure 900-2, excerpted from the USDCM, shall also be applied, which will reduce effective street capacity. The reduction factor accounts for the increased effect on capacity that items like debris and parked cars can have at steeper roadway slopes. UD-Inlet includes these reduction factors.

While the criteria in Table 900-1 must be used as a limitation on flow in streets, street capacity is typically limited by right-of-way, especially during the major storm event.

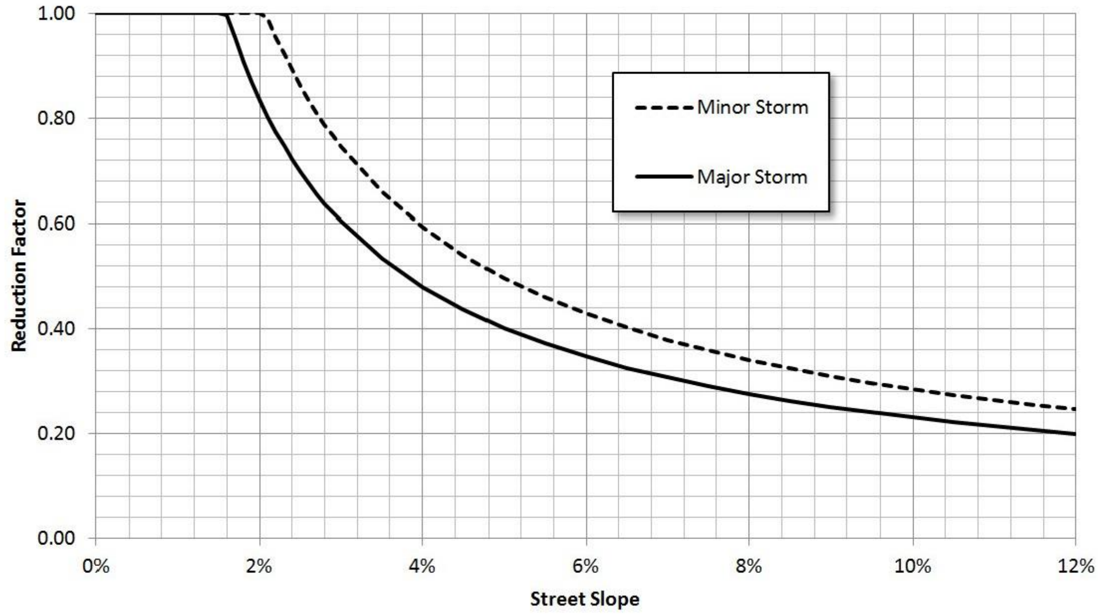

Figure 900-2. Reduction Factor for Gutter Flow (UDFCD, 2016).

905.2 Roads With Roadside Ditches

County roadways are often characterized by roadside ditches rather than a curb and gutter section. The capacity of the roadside ditch is limited by the ditch depth, maximum allowable flow velocity, and maximum allowable Froude number. A new or reconstructed roadside ditch must also not allow more flow to leave the county right-of-way during the major storm event than the currently existing configuration. Figure 900-3 shows a typical county roadside ditch.

Figure 900-3. Example of a Roadside Ditch (Boulder County, 2016).

Roadside ditch layouts will vary with each site's limitations and capacity requirements. Roadside ditch capacity shall be that which is required to limit encroachment as specified in Table 900-1. Safety is a primary concern in the roadside ditch design. Flatter side slopes and shallower depth are safer configurations than steeper side slopes and deeper depth. Side slopes recoverable by an errant vehicle are generally 4:1 or flatter. Slopes of 3:1 are considered a threshold for guardrail on heavily travelled roads. Where paths are adjacent to slopes steeper than 3:1, an optimum separation of 5 feet from the top of slope should be provided.

Right-of-way constraints and roadway slopes do not always allow for ideal ditch sections. A 3:1 maximum ditch side slope is preferred, but this may be steepened if right-of-way constraints require it. A depth of less than 24 inches is preferred, but this may be increased if necessary. Deeper ditches may be required if encroachment criteria cannot be met by using a flat-bottom ditch because of right-of-way constraints. Roadway slopes and ditch velocity restrictions may also require deeper ditches. Maximum allowable flow velocity and Froude number for roadside ditches are given in Section 700, Open Channels.

Stable cut and fill slopes shall be provided no steeper than 2:1 on the plains and 1.5:1 in mountainous areas as an absolute minimum standard. A geotechnical report may be required for slopes steeper than 2:1. Ditch slopes steeper than 3:1 must be protected by a turf reinforcing mat, crimped mulch, or riprap.

The layout of a roadside ditch can be especially challenging when the existing drainage pattern of an entire area is sheet flow toward the new roadway. This can occur in both the mountains and the plains. Once the roadway is constructed, sheet flow on the upstream side of the roadway will become concentrated in roadside ditches whose capacity may be quickly exceeded. There are two options for handling this flow. The first is to enlarge the ditches on the upstream side of the road to convey the design runoff until the ditch reaches a natural cross drainage. The second is to construct cross culverts at locations where there is not a natural cross drainage. For the second option, a ditch will then be required on the downstream side of the road to convey the runoff to the nearest natural drainage. It is not permissible to discharge concentrated runoff to a downstream property that is currently not receiving it without first acquiring easements and agreements from the property owner and providing a means of preventing erosion and routing the flow that is acceptable to the property owner.

Private driveway culverts located in roadside ditches must be sized to meet the criteria for the minor and major storm events in accordance with this MANUAL. The culverts must not create a headwater condition that violates the encroachment criteria in this section. These requirements apply to both new and replacement culverts, although existing culverts may be replaced in kind without a hydrologic and hydraulic analysis, provided the new culvert is at least 18 inches in diameter and that there is no evidence or report of erosion, roadway overtopping, or other damage to the area surrounding the culvert to be replaced. If evidence of any of these is found, the replacement culvert may be sized to match the larger of the nearest upstream and downstream culverts in the same ditch provided it is larger than the culvert being replaced and has not resulted in erosion, damage, or overtopping.

Section 1000 includes an example for sizing a private driveway culvert located in a roadside ditch. When culvert sizing results in an unreasonably large culvert that will not be readily accommodated by the existing roadside ditch, a Design Exception may be requested.

906 ROADWAYS ADJACENT TO CHANNELS

The design of roadways adjacent to open channels should consider the impacts both the roadway and the channel will have on each other. The goal of Boulder County is to construct new and replacement roadways above the 100-year floodplain to prevent damage to long stretches of roadway during large storm events. Depending on the characteristics of area surrounding the roadway, however, meeting this goal may not always be feasible or prudent.

When a replacement roadway is constructed in an area with a constricted floodplain, such as a canyon, raising the road grade will typically result in a more constricted channel width. This in turn may increase 100-year flow velocity and depth, possibly resulting in more damage to downstream facilities during a large event. If the 100-year floodplain is removed from the roadway, water may encroach onto private property on the other side of the channel where it otherwise would not. Causing any increase in water surface elevation on private property is not permitted without obtaining an easement from the property owner, one that the owner may refuse to grant. Figure 900-4 shows an example of a roadway adjacent to a channel.

Figure 900-4. Example of a Roadway Adjacent to a Channel (Boulder County, 2016).

If constructing a new or replacement roadway above the 100-year floodplain will result in additional floodwater encroachment onto private property or an increase in the 100-year floodplain, the approval process for a new or replacement roadway adjacent to a channel will require an alternatives analysis that includes an assessment of cost, benefit, and risk for each alternative. The analysis will evaluate the 5-year, 10-year, 25-year, and 100-year events at a minimum, and more return periods may be requested by the county. Alternatives will also consider protection of the roadway surface and subgrade, an analysis of public safety, and the potential for public notification or permanent signage.

907 REFERENCES

Boulder County, 2012. *Boulder County Multimodal Transportation Standards*, prepared by Boulder County, Boulder, Colorado.

Urban Drainage and Flood Control District, 2016. *Urban Storm Drainage Criteria Manual: Volume 1 Management, Hydrology, and Hydraulics*, prepared by the Urban Drainage and Flood Control District, Denver, CO.