CITY OF LONGMONT

STORM DRAINAGE CRITERIA MANUAL

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PREFACE

A nationwide survey (1) was conducted in 1975 by the EPA to determine a broad perspective of the priority needs of stormwater management agencies. The survey respondents, which were key representatives of public works, planning, state regulatory agencies, special districts, and private consultants, were requested to rank the institutional problems faced by their community. The most pressing problem identified was the "lack of areawide policy, criteria, laws and guidelines for developments of private and public stormwater management programs and facilities."

The development of the Urban Storm Drainage Criteria Manual (USDCM) for the Denver region Urban Drainage and Flood Control District (2) (UD&FCD) was a major step in solving the existing and future drainage problems of the area. The USDCM actually predated the EPA survey and was subsequently used by municipalities throughout the United States as a guideline. Many of the local communities outside of the Denver area also adopted the USDCM as their drainage criteria, even though they were not within the special drainage district. The City of Longmont and Boulder County, located north of Denver, adopted and used the criteria for a number of years. However, the USDCM was written with the regional concept in mind and provides criteria and design standards for the many different conditions within the UD&FCD. In an attempt to provide a more specific, up-to-date, and easier to use manual, Boulder County and the City of Longmont contracted with the firm of WRC Engineering, Inc. in 1983 to prepare a complete drainage manual.

The goals set forth for the preparation of the manual were:

1. To unify standards and improve the quality of drainage evaluation and design by providing specific and detailed criteria for the local communities.

2. To reduce the effort required to prepare and review drainage designs by simplifying the methodologies and procedures and by providing numerous worked examples.

3. To provide the necessary information to prepare and review a drainage design within a single document that is complete, organized, and easily referenced.

4. To provide a drainage evaluation and design criteria that will prevent future drainage problems and enhance the urban environment within the goals and objectives of the community.

The first step in the preparation of the manual was to review all the local requirements (i.e., subdivision, planning and zoning regulations, ordinances, codes, criteria, and special agreements or procedures). In addition to the USDCM, information and concepts were also obtained from criteria for the Cities of Louisville, Lafayette, Boulder, Lakewood, Littleton, Aurora, Denver, Fort Collins, Loveland, and Larimer County.

The general contents of the manual were then established and organized into the following 13 sections: General Provisions, Drainage Planning Submittal Requirements, Drainage Policy, Drainage Law, Rainfall, Storm Runoff, Open Channels, Storm Sewer System, Streets, Culverts and Bridges, Hydraulic Structures, Detention, and Erosion and Sedimentation Control. Each section was uniquely enumerated, including all paragraphs, sub-paragraphs, tables, figures, equations, and examples. Each section was prepared in draft format and submitted to the review committee at regular progress meetings. The review committee consisted of the Boulder County Flood Control Engineer, the City Engineer for Longmont, a representative of the Colorado Water Conservation Board, and a private consultant. The sections were then reviewed by the committee and the comments were incorporated into the final draft. In this manner, the manual received a thorough review prior to the final draft stage. The manual was then distributed to various consultants and other governmental agencies for review and comment before final printing. In spite of this extensive review, there will be a need to update the criteria for experience gained during the implementation of the criteria.

The philosophy behind the selection of material to be included in the manual and the amount of discussion, detail, and information to present was based on the following:

1. The design engineer and reviewer are assumed to possess a basic knowledge in the area of open channel hydraulics, storm sewer hydraulics, and urban hydrological techniques.

2. The experience of the review committee with regards to particular drainage problems or solutions suggested that more detailed or more strict criteria was required in certain areas.

3. Additional information on the reasons or philosophy for the criteria was required in order to gain acceptance of the criteria as well as providing a basis for reviewing unique situations that will be encountered.

4. The committee agereed on the need for strict criteria in certain areas but allowed for design flexibility in other areas, within acceptable limitations.

5. The committee identified the need for a self contained document to minimize the design engineers and review engineers time and to minimize conflicting constraints that would develop when the data to be used is not clearly specified.

Throughout the manual, emphasis was placed on simplifying procedures to minimize the time of preparing and reviewing drainage analysis. In the Rainfall section, isohyetal maps for the one-hour and six-hour duration and various frequencies were prepared from published NOAA (3) and UD&FCD data. The county was divided into four rainfall zones and design storms and rainfall intensity data were developed for each zone. The zones were defined as areas with relatively uniform rainfall isohyets or areas rapidly varying rainfall isohyets. The zone boundaries were defined based on a constant elevation for simplicity. The information was published as a

Technical Memorandum and only the results presented in the manual. The design engineer only needs to know the zone in which the project lies to determine the rainfall data to be used.

In the Streets section of the manual, allowable capacity charts were prepared for both the initial and major storm (subject to the limitations set forth in the Policy section) for each street cross-section and traffic classification. First the allowable depth was determined (both initial and major storm), and then the capacity of the street calculated for various slopes. The calculations and procedures were also documented in a published Technical Memorandum. The design engineer only needs to know the traffic classification (i.e., arterial, collector, etc.) and the street slope to determine the allowable capacity for the initial and major storm.

Another procedure that was simplified was the determination of the allowable capacity for storm inlets. Using the allowable depth and capacity for each street section (discussed above), the maximum theoretical capacity for each inlet and for a given street slope was calculated. The theoretical values were then adjusted for allowable interception and capacity charts were prepared. The calculations and procedures were published in a Technical Memorandum but only the capacity charts were printed in the manual. The design engineer need only to know the traffic classification of the street, the slope, and the type of inlet to determine the maximum allowable inlet capacity.

In most instances, the detention requirements for a new subdivision can be determined by two simple calculations for the volume and discharge requirements. The equation technique greatly simplifies the efforts for detention calculations and is based upon extensive research by the UD&FCD and detailed hydrological calculations provided by the consultant for drainage basins in the Boulder County area. In certain instances a more extensive calculation procedure is required if the developer elects to combine onsite detention requirements with offsite runoff or provide a series of ponds instead of one large pond.

To further reduce the time and effort in preparing and reviewing a drainage design, the manual contains 26 example calculations and eleven standard forms to aid the design engineer. One or more examples are provided in each of the technical portions of the manual. Worked examples are provided for time-of-concentration, effective rainfall, channel and reservoir routing, uniform and critical flow, direct step backwater, granular filter design, riprap requirements at pipe outlets, street and inlet capacity, culvert capacity rating and sizing, riprap check structures, low-water crossings, and determination of detention requirements. Many of the examples utilize the results of other examples thereby providing an additional continuity to the manual.

During the course of the work, unique approaches to the technical criteria evolved. One area was in the determination of allowable capacity for the streets. The experience of Boulder and Longmont was that during some storm events, the streets were flooded past the sidewalks onto the grass area, depositing silt and debris. Many complaints were received from the residents. The street designs were checked and found to be in accordance with the previous drainage criteria, which allowed a greater gutter flow depth during major floods. Whereas the design was technically acceptable, the review committee felt that allowing the flood to encroach on private property (i.e., flooding exceeds the street ROW) may be undesirable. The policy for using streets to transport storm runoff was then revised to only allow flooding within the public ROW and the street capacity determined accordingly.

In summary, the major emphasis for the Boulder/Longmont criteria was directed towards organizing the manual to gain more wide-spread use and acceptance, simplifying procedures to minimize efforts of the design and review engineer, incorporating stringent and specific local requirements, and providing example calculations and design details to standardize drainage analysis. The manual contains state-of-the-art technology and data, and is consistent with local standards and procedures.

REFERENCES

1. Poertner, H. G., "Survey of Participants in Seminars on Urban Stormwater Management, in Atlanta and Denver", Sponsored by the U.S. Environmental Protection Agency.

2. Urban Storm Drainage Criteria Manual, Vol. 1 and 2, Denver Regional Council of Governments, Denver, Colorado, March 1969 (with current revisions).

3. Miller, J. F., Frederick, R. H., and Tracey, R. J., Precipitation-Frequency Atlas of the Western United States Volume III - Colorado, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Silver Springs, Md, 1973.

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The following individuals on the staff of WRC Engineering, Inc. have contributed to the preparation and completion of this MANUAL.

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Mrs. Cherie R. Kraft - Word Processing Specialist

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AMENDMENTS AND REVISIONS

This MANUAL has been prepared on the basis of current state-of-the-art technology and procedures. Due to the dynamic nature of urban storm drainage, amendments and revisions will be required from time to time as experience is gained in the use of this MANUAL.

Users of this MANUAL are encouraged to submit their comments, criticism, and errors that are found. This information should be addressed to:

Mr. Will Wilkinson, City Engineer
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A list of MANUAL holders will be maintained by City of Longmont. To receive copies of amendments or revisions, please complete the form below and submit to the address shown:

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NAME: ______________________________

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LIST OF EQUATIONS

707	$d_p/h = 1.00\ D_n^{0.22}$	Check Drop Equation	703.4
708	$d_1/h = 0.54\ D_n^{0.425}$	Check Drop Equation	703.4
709	$d_2/h = 1.66\ D_n^{0.27}$	Check Drop Equation	703.4
710	$H_{FB} = 1.0 + V^2/2g$	Freeboard-Grass Channels	704.2
711	$H_{FB} = 2.0 + 0.025\ V\ (d)^{1/3}$	Freeboard-Concrete Channels	704.3
712	$D_{15}(\text{filter}) \leq 5\ d_{85}(\text{base})$	Filter Criteria	705.3
713	$4d_{15}(\text{filter}) \leq D_{15}(\text{filter}) \leq 20d_{15}\ (\text{base})$	Filter Criteria	705.3
714	$D_{50}(\text{filter}) \leq 25\ d_{50}(\text{base})$	Filter Criteria	705.3
715	$VS^{0.17}/(d_{50}^{\ 0.5}(S_s-1)^{0.66}) = 5.8$	Riprap Size Requirements	705.4
716	$(d_{50}/D)(Y_t/D)^{1.2}/(Q/D^{2.5})=0.023$	Circular Conduit Parameter	705.6
717	$(d_{50}/D)(Y_t/H)/(Q/WH^{1.5})= 0.014$	Rectangular Conduit Parameter	705.6
718	$D_a = 1/2\ (D + Y_n)$	Circular Conduit Average Depth	705.6
719	$H_a = 1/2\ (H + Y_n)$	Rectangular Conduit Average Depth	705.6
720	$L = (1/(2\tan \theta))(A_t/Y_t-W)$	Rectangular Expansion Jet	705.6
721	$A_t = Q/V$	Required Area	705.6
801	$H_L = K(V^2/2g)$	Energy Loss Equation	803.2
802	$H_L = K_e\ (V_1^{\ 2}/2g)(1-(A_1/A_2))^2$	Expansion Loss	803.2
803	$H_L = K_c\ (V_2^{\ 2}/2g)(1-(A_2/A_1)^2)^2$	Contraction Loss	803.2
804	$H_L = K_b\ (V^2/2g)$	Bend Loss	803.2
805	$H_L = (V_2^{\ 2}/2g) - K_j\ (V_1^{\ 2}/2g)$	Junction Loss	803.2
901	$Q = 0.56\ (Z/n)S^{1/2}y^{8/3}$	Modified Mannings Formula	905.1
1001	$Q = C_d\ A\sqrt{2gh}$	Orifice Flow	1004.1
1002	$H = h_e + h_f + h_v$	Culvert Head Loss	1004.2
1003	$h_e = K_e\ (V^2/2g)$	Culvert Entrance Loss	1004.2

1004	$h_f = (29n^2L/R^{1.33})(V^2/2g)$	Friction Loss	1004.2
1005	$h_v = V^2/2g$	Velocity Head	1004.2
1006	$H = (K_e + 1 + 29n^2L/R^{1.33})(V^2/2g)$	Culvert Head Loss	1004.2
1007	$L' = L(n'/n)^2$	Length Adjustment	1004.2
1008	$H_w = H + h_o - LS_o$	Culvert Headwater	1005
1201	$V = KA$	Minimum Detention Volume	1203.1
1202	$K_{100} = (1.78I - 0.002I^2 - 3.56)/1000$	100-Yr Detention Coefficient	1203.1
1203	$K_{10} = (0.95I - 1.90)/1000$	10-Yr Detention Coefficient	1203.1
1204	$Q_{100} = 1.00A$	100-Yr Maximum Release Rate	1203.1
1205	$Q_{10} = 0.24A$	10-Yr Maximum Release Rate	1203.1

LIST OF EXAMPLES