

# **Urban Storm Drainage Criteria Manual: Volume 1 Management, Hydrology, and Hydraulics**

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**Urban Drainage and Flood Control District**

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# Urban Storm Drainage Criteria Manual

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# Preface

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## 1.0 Acknowledgements

### Contributors to Original (1969) Version of the Urban Storm Drainage Criteria Manual (USDCM)

Residents of the Urban Drainage and Flood Control District (UDFCD) and many communities beyond the UDFCD boundary have benefited significantly from the pioneering vision of those who were responsible for the original (1969) version of the USDCM, including D. Earl Jones, Jr., P.E., Dr. Jack Schaeffer, Dr. Gilbert White and Kenneth R. Wright, P.E. (lead author). The vast majority of the policies, principles, and criteria in the 1969 USDCM are found in this updated (2015) version—a true testament to the wisdom of these leaders.

UDFCD wishes to acknowledge and thank all individuals and organizations that contributed to development and publication of the 2015 update of Volumes 1 and 2 of the USDCM. The lists of individuals and organizations that follow are our best effort to acknowledge all of the organizations and individuals that were directly involved in the USDCM’s preparation.

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## 2.0 Purpose

Volumes 1 and 2 of the USDCM provide guidance for engineers, planners, landscape architects, developers, and contractors in selecting, designing, constructing, and maintaining stormwater drainage and flood control facilities. Volumes 1 and 2 focus primarily on stormwater quantity management for drainage and flood control purposes. Volume 3 focuses on smaller, more frequently occurring events that have a greater overall impact on the quality of receiving waters.

## 3.0 Overview

This manual is organized according to the following:

- **Chapter 1: Drainage Policy.** Adequate drainage for urban areas is necessary to preserve and promote the general health, welfare, and economic well-being of the region. The *Policy* chapter lists the 12 principles that guide all the criteria in this manual. Additionally, the chapter includes several policies that support good stormwater and floodplain management as well as the goals and actions of UDFCD.
- **Chapter 2: Drainage Law.** This chapter deals with the general principles of drainage law along with local government drainage actions, financing, floodplain management, and special matters. The information provided in this chapter is specific to the State of Colorado.
- **Chapter 3: Planning.** The urban storm drainage system is a subsystem of the total urban infrastructure system and should be integrated with other subsystems including transportation, parks, open space, and utilities. This chapter identifies and discusses key considerations in the planning process. The chapter also describes types of master plans and outlines the master planning process.
- **Chapter 4: Flood Risk Management.** This chapter addresses programs and policies adopted by UDFCD to manage flood risks and reduce potential losses from flood events. This chapter also provides guidance for specific physical measures that can be implemented to help protect individual structures from flood damage.
- **Chapter 5: Rainfall.** The *Rainfall* chapter provides rainfall depth, duration, intensity, and frequency data and analytical methods used to develop the rainfall information needed to carry out the hydrological analysis described in the *Runoff* chapter of the USDCM. This chapter also provides guidance for development of rainfall distributions for use with the Colorado Urban Hydrograph Procedure (CUHP) and Depth Reduction Factor (DRF) adjustments for use when analyzing watersheds in of 5 square miles or more. There is also a companion workbook, UD-Rain, available at [www.udfcd.org](http://www.udfcd.org) that allows the user to perform calculations in accordance with these criteria.
- **Chapter 6: Runoff.** The *Runoff* chapter presents five methods for hydrologic analysis. Peak rate of runoff, runoff volume, and the time distribution of flow provide the basis for all planning, design, and construction of drainage facilities. There is also a companion workbook, UD-Rational, available on the UDFCD website, that applies the Rational Method to estimate stormwater runoff and peak flows from small urban catchments.
- **Chapter 7: Streets, Inlets, and Storm Drains.** This chapter presents design for both stormwater collection and conveyance utilizing streets and storm drains. Inlet capacity, as presented in this chapter, is based on FHWA Hydraulic Circular No. 22 (HEC-22) methodology which was subsequently refined through a multijurisdictional partnership led by UDFCD, where hundreds of

- physical model tests of inlets commonly used in Colorado were performed at the Colorado State University (CSU) hydraulics laboratory. UD-Inlet, available on the UDFCD website, is a companion workbook that allows the user to calculate inlet capacity in accordance with these criteria.
- **Chapter 8: Open Channels.** This chapter presents principles of stream restoration along with special design considerations for constrained urban streams. There is a focus on preservation, enhancement, and restoration of stream corridors. The chapter also includes design of new channels and swales, methods for bank stabilization, and rock sizing.
- **Chapter 9: Hydraulic Structures.** This chapter includes design of various types of grade control structures including check structures, grouted stepped (or sloped) boulder drop structures, sculpted concrete drop structures, and vertical drop structures. Pipe outfalls and rundowns are also included in this chapter.
- **Chapter 10: Stream Access and Recreational Channels.** This chapter provides criteria related to the design of shared-use paths adjacent to streams and criteria for responsible design of recreational channels including boatable channels. The topics in this chapter are largely related to safety; therefore, this chapter also summarizes all criteria related to safety elsewhere in the USDCM and includes guidance for reviewing a project from the standpoint of public safety.
- **Chapter 11: Culverts and Bridges.** This chapter addresses the hydraulic function of culverts and bridges, i.e., conveyance of surface water through embankments such as roadways and railroads. UD-Culvert is a companion workbook available on the UDFCD website that aids in analyzing the flow conditions in circular and box culverts.
- **Chapter 12: Storage.** This chapter provides guidance for the analysis and design of storage facilities that are implemented independently or in combination with stormwater quality facilities. UD-FSD and UD-Detention, both available on the UDFCD website, are companion workbooks to this chapter that allow the user to design or review almost any type and configuration of detention storage facility.
- **Chapter 13: Revegetation.** This chapter provides guidelines and recommendations for revegetation efforts associated with drainage and water quality facilities. The guidance addresses three habitat types: uplands, riparian areas, and wetlands. For each habitat type, guidance is provided with regard to site preparation, plant material selection and installation, maintenance and post-construction monitoring.

A reference section is provided for each chapter, and additional materials and insight on the topics presented in the USDCM may be found by studying the papers and documents listed at the end of each chapter.

The USDCM provides criteria and standards recommended by UDFCD. Designing facilities that go beyond minimum criteria is encouraged. In addition, there may be other requirements by local, state and federal agencies that may have to be met in addition to the minimum criteria provided herein.

## 4.0 List of Abbreviations

### Commonly Used Abbreviations

ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BFE	Base flood elevation
BMP	Best management practice
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CMP	Corrugated metal pipe
CRS	Colorado Revised Statute(s)
CUHP	Colorado Urban Hydrograph Procedure
CWCB	Colorado Water Conservation Board
DCIA	Directly connected impervious area
DRCOG	Denver Regional Council of Governments
EGL	Energy grade line
EPA	U.S. Environmental Protection Agency
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FHAD	Flood Hazard Area Delineation
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FPE	Flood protection elevation
GSB	Grouted stepped or sloping boulder drop structure
HGL	Hydraulic grade line
HUD	U.S. Department of Housing and Urban Development



H:V	Horizontal to vertical ratio of a slope
ICC	Increased cost of compliance
LID	Low impact development
MDCIA	Minimized directly connected impervious area
NAVD	North American Vertical Datum
NFIA	National Flood Insurance Act
NFIP	National Flood Insurance Program
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PMP	Probable maximum precipitation
RCP	Reinforced concrete pipe
SBA	Small Business Administration
SEO	Colorado State Engineer's Office
SFHA	Special Flood Hazard Area
SFIP	Standard Flood Insurance Policy
SWMM	EPA Stormwater Management Model
TABOR	Taxpayer Bill of Rights
UDSWM	Urban Drainage Stormwater Management Model
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WEF	Water Environment Federation
WQCV	Water quality capture volume

**Commonly Used Units**

cfs	cubic feet per second
cfs/ft	cubic feet per second per foot
ft	foot
ft <sup>2</sup>	square feet
ft/ft	foot per foot
ft/sec	feet per second
ft/sec <sup>2</sup>	feet per second squared
hr	hour
in	inch
in/hr	inches per hour
in/hr/ac	inches per hour per acre
lbs	pounds
lbs/cy	pounds per cubic yard
lbs/ft <sup>2</sup>	pounds per square foot
lbs/ft <sup>3</sup>	pounds per cubic foot
lbs PLS/acre	pounds pure live seed per acre
min	minute
psi	pounds per square inch
psf	pounds per square foot