22.14 Maintenance and Post Construction Responsibility

All drainage control, flood control and erosion control facilities both public and private shall be regularly maintained. Accumulations of silt, trash, litter or stagnant water which create a health or safety hazard or which endanger the design function of the facility are not permitted. Excessive growth or accumulation of woody vegetation in channels and on dams and levees shall not be permitted. Active erosion due to wind or water associated with drainage control, flood control and erosion control facilities shall not be permitted.

All newly constructed drainage facilities within a public right-of-way must be blocked off at both ends to prevent unauthorized vehicular access with City Standard Tube Gate or removable bollards.
22.15 Common Equations

The most commonly used equations in drainage submittals are: weir, orifice and Manning’s. They are presented below.

1. Weirs

A weir is a barrier in an open channel, over which water flows. A weir with a sharp upstream corner or edge such that the water springs clear of the crest is a "sharp crested weir". All other weirs are classified as "weirs not sharp crested". Weirs are to be evaluated using the following equation:

\[ Q = CLH^{1/2} \]

where:

- **Q** = Discharge in cfs
- **C** = Discharge coefficient use 2.7. If a discharge coefficient other than 2.7 is to be used, provide justification in the drainage submittal.
- **L** = Effective length of crest in feet
- **H** = Depth of flow above elevation of crest in feet (approach velocity shall be disregarded in most applications)

Weirs are generally used as measuring and hydraulic control devices. Emergency spillways in which critical depth occurs and overflow-type roadway crossings of channels are the most common applications of weirs. Channel drop structures and certain storm drain inlets may also be analyzed as weirs. Special care must be exercised when selecting weir coefficients in the following cases:

a. Submerged weirs
b. Broad crested weirs
c. Weirs with obstructions (i.e., guardrails, piers, etc.)

2. Orifices

An orifice is a submerged opening with a closed perimeter through which water flows. Orifices are analyzed using the following equation:

\[ Q = CA (2gh)^{1/2} \]

where:

- **Q** = Discharge in cfs
- **C** = Discharge coefficient use 0.6. If a discharge coefficient other than 0.6 is to be used, provide justification in the drainage submittal.
- **A** = Area of opening in square feet
- **g** = 32.2 ft/sec²
h = Depth of water measured from the center of the opening

Approach velocity shall be disregarded in most applications.

Orifices are generally used as measuring and hydraulic control devices. Orifice hydraulics control the function of many “submerged inlet - free outlet” culverts, primary spillways in detention facilities, manholes in conduit flow, and in storm drain catch basins.

3. Manning’s Equation and Coefficient

Manning’s equation is used to calculate flow, due to gravity, in open channels and conduits. In a conduit, the HGL must be below the soffit. As the Manning’s Roughness Coefficient value increases the velocity decreases and the HGL increases. The equation is presented below:

\[ Q = \left(1.486AR^{2/3}S^{0.5}\right)/n \]

Where:
Q - Flow Rate in Cubic Feet per Second
A - Flow Area
R - Hydraulic Radius; \( R = A/P \) where \( A \) is the flow area and \( P \) is the wetted (flow) perimeter
S - Slope
n - Manning’s Roughness Coefficient

Values of Manning’s “n” to be used in drainage submittals:

<table>
<thead>
<tr>
<th>Material</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Pipe-smooth bore</td>
<td>0.010</td>
</tr>
<tr>
<td>Reinforced Concrete Pipe</td>
<td>0.013</td>
</tr>
<tr>
<td>Poured Concrete</td>
<td>0.013</td>
</tr>
<tr>
<td>No-joint cast in place concrete pipe</td>
<td>0.014</td>
</tr>
<tr>
<td>Reinforced Concrete Box</td>
<td>0.015</td>
</tr>
<tr>
<td>Reinforced Concrete Arch</td>
<td>0.015</td>
</tr>
<tr>
<td>Streets</td>
<td>0.017</td>
</tr>
<tr>
<td>Flush Grouted Rip-Rap</td>
<td>0.020</td>
</tr>
<tr>
<td>Corrugated Metal Pipe</td>
<td>0.025</td>
</tr>
<tr>
<td>Grass Lined Channels (sodded &amp; irrigated)</td>
<td>0.025</td>
</tr>
<tr>
<td>Earth Lined Channels (smooth)</td>
<td>0.030</td>
</tr>
<tr>
<td>Material</td>
<td>Value</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>Arroyo Channels</td>
<td>0.030</td>
</tr>
<tr>
<td>Wire Tied Rip-Rap</td>
<td>0.040</td>
</tr>
<tr>
<td>Medium Weight Dumped Riprap</td>
<td>0.045</td>
</tr>
<tr>
<td>Grouted Rip-Rap (exposed rock)</td>
<td>0.045</td>
</tr>
<tr>
<td>Arroyo Overbank</td>
<td>0.045</td>
</tr>
<tr>
<td>Jetty Type Rip-Rap (D_{50 &gt; 24&quot;)}</td>
<td>0.050</td>
</tr>
</tbody>
</table>
22.16 History

In August of 2015, two technical subcommittees were convened to update this chapter. One subcommittee was convened to evaluate a new hydrologic model, evaluate hydraulic models and revise the closed conduit and open channel sections of this chapter. The current hydrologic model, AHYMO, was not replaced as the subcommittee decided that further study was required.

Members of this subcommittee are listed below:

Curtis Cherne, PE, CFM
Technical Subcommittee Chair
City of Albuquerque

Daniel Aguirre Wilson and Company
Rick Beltramo Galway Construction
Alandren Etlanus Bohannan Huston Incorporated
Andreas Sanchez SSAFCA
Gerhard Schoener SSAFCA
Stephen Scissons Army Corp of Engineers
Brad Bingham AMAFCA
Shahab Biazar City Engineer
Brian Patterson Titan Development
Rita Harmon City of Albuquerque
Charles Easterling Easterling and Associates
Kevin Daggett City of Albuquerque
Dave Thompson Thompson Engineering Associates
Don Briggs Bernalillo County
Hugh Floyd RESPEC
Pat Stovall Smith Engineering
Vince Carrica Tierra West

The second subcommittee convened to evaluate all other sections of the chapter. The chapter was reorganized for easier use and was structured with the approach to help the development community with site development. Some of the larger changes are:

Addition of Floodplain Development
Addition of Valley Drainage Criteria
Emphasis on Downstream Capacity and Offsite Flows
Addition of Low Impact Development
Removal of Probable Maximum Flood/Precipitation and Dam Design
Members of this subcommittee are listed below:

Curtis Cherne, PE, CFM
Technical Subcommittee Chair
City of Albuquerque

Don Briggs           Bernalillo County
Abiel Carrillo      City of Albuquerque
Kevin Daggett       City of Albuquerque
Scott Steffen       Bohannan Huston Incorporated
Ron Bohannan        Tierra West
Ron Hensley         The Group
Diane Hoelzer       Mark Goodwin and Associates
Jeff Mortensen      High Mesa Consulting Group
Graeme Means        High Mesa Consulting Group
Brian Patterson     Titan Development
Kevin Patton        Pulte Homes
David Soule         Rio Grande Engineering
Jeff Wooten          Wooten Engineering
Rita Harmon         City of Albuquerque

The DPM Technical Subcommittee would like to dedicate this revision to Jeff Mortensen P.E., who sadly passed away during the revising of this manual. Jeff was very knowledgeable in all aspects of drainage and he was involved with the creation of Chapter 22 and every revision since its inception.

February 2015, the DPM revision was approved to incorporate requirements from the EPA MS4 Permit for post-construction development and infiltration was acknowledged in the design of ponds.

Section 22.2, Hydrology was first published in March, 1982, as one of the sections in the three-volume Development Process Manual (DPM). The DPM is the result of the effort of a special team of City of Albuquerque staff and Albuquerque Urban Advisory Council members. The Manual was created in response to mutual needs of the private and public sectors in Albuquerque to clarify the development process. The Three volumes of the DPM are: 1 - "Procedures", 2 - "Design Criteria". The Third Volume "Policies and Plans" is obsolete.

A major revision to Section 22.2 was adopted with the approval of a "Notice of Emergency Rule" by the City in January, 1986. This revision deleted a procedure which based rational method "C" coefficients on SCS Hydrologic Soil Group, and adopted Rational Method Coefficients based on textbook and handbook references.

The "D.P.M. Subcommittee on Drainage" was established by the City of Albuquerque in January, 1987. The Subcommittee held its first meeting in February, 1987. The Subcommittee consisted of members from City staff, Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) staff and local engineering consultants, and was organized to update and revise the DPM design criteria for Section 22.2, Hydrology. The Bernalillo County Public Works Department later joined the Subcommittee. In January, 1990 the subcommittee changed its name
to the DPM "Drainage Design Criteria Committee" to avoid potential confusion with another committee established by the DPM Steering Group.

The Drainage Design Criteria Committee has met on a regular basis to develop a major update of the hydrology section of the DPM. In 1987, a research study to determine local infiltration factors was conducted by Dr. Richard Heggen at the University of New Mexico to supplement the work of the Committee.

A "draft" of the "Revision of Section 22.2, DPM" was distributed for community review in January, 1990. This document recommended use of initial abstraction and uniform infiltration to complete rainfall loss. It also included a procedure for smaller basins based on the Rational Method, and a procedure for large and small watersheds based on the HYMO computer program.

With the adoption of the Bernalillo County Storm Drainage Ordinance (No. 90-6) the County Engineer was responsible for establishing criteria, procedures and standards for the design of flood control, drainage controls, and erosion control improvements. To fulfill this requirement, Bernalillo County adopted "Interim Drainage Design Criteria for Bernalillo County" (April, 1990). This document incorporated Parts A, B, E and F from the January, 1990 draft of Section 22.2, Hydrology.

In January, 1991, a revision of "Section, 22.2," was distributed to eight (8) Federal and State agencies, and to 26 local engineering firms. A public "Notice of Review" was published in the Albuquerque Journal and Tribune on February 4, 1991. Following incorporation of review comments, the August, 1991 version of Section 22.2, Hydrology was released for use by the Drainage Design Criteria Committee. This version included the placement of the rainfall peak in this second hour of the design storm. Modifications to the Probable Maximum Flood procedures incorporated a "local storm" and a "general storm." A "Notice of Second Review" was published in the Albuquerque Journal and Tribune on August 31, 1991. The August, 1991 version has been accepted by the City, County and AMAFCA as an allowable procedure for hydrologic analysis and design of flood control structures.

The January, 1993 version of Section 22.2, Hydrology incorporates comments received since August, 1991. The version includes a procedure to evaluate basin hydrology for steep natural slopes, and some text revisions suggested by the USDA Soil Conservation Service. For most applications, there will be no computational differences between the January, 1993 version and the August, 1991 version. The text has been reformatted into seven (7) separately numbered parts to simplify future revision of the document.

The pages which follow replaced all previous pages in the Hydrology Section of the DPM (Section 22.2, pages 2 through 21). Following a public review and comment period, the revised Section 22.2, Hydrology was approved by the City Engineer and the Mayor. In the City of Albuquerque, the revision became effective on April 7, 1993. Bernalillo County also adopted the revision as the standard for design of flood and drainage control, effective April 7, 1993. The revised Section 22.2, Hydrology is to be regarded as the principal reference for hydrologic design in the City of Albuquerque and Bernalillo County.

The Drainage Design Criteria Committee wish to acknowledge the assistance of the many individuals who reviewed the document. In particular we wish to thank Richard Leonard, Brian Burnett and Dwayne Sheppard for their work on the Committee.
The D.P.M. Drainage Design Criteria Committee:

Richard J. Heggen, PE, PH, PhD
Professor of Civil Engineering
University of New Mexico

Howard C Stone, PE
Water Resources Manager
Bohannan-Huston Inc.

Clifford E. Anderson, PE & PS
Drainage Engineer, AMAFCA

Charles M. Easterling, PE
Pres., Easterling & Assoc.

Robert S. Foglesong, PE & PS
Surface Water Hydrologist
Bernalillo County Public Works

Fred Aguirre, PE
Hydrologist, PWD
City of Albuquerque
22.17 Reference

The reference section remains unchanged, as the latest revision used committee members’ experience. Their years of experience were a valuable resource. Their names are listed in the History section.

Hydraulics

A. Weirs and Orifices


B. Closed Conduits


C. Channels


D. Catch Basins

1. Los Angeles County Flood Control Authority, Design Manual - Hydraulic P.O. Box 2418 Los Angeles, California 90054 Rev. 1972.

E. Street Hydraulics

1. See Reference C-1

2. See Reference C-4

F. Berms and Levees

1. See Reference C-6

2. See Reference C-7

3. See Reference C-8