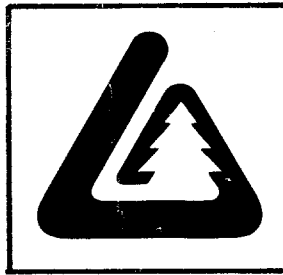


# READING THIS PAGE MAY SAVE YOU TIME

## AVOID THESE COMMON MISTAKES

Good quality submittals are the best means of reducing overall review time. In an effort to improve submittal quality we have compiled the most common mistakes found in Drainage Reports.

- Many incomplete reports and plans are submitted. Preliminary drainage reports are frequently submitted when a final drainage report is required. The checklist in the City of Lakewood *Storm Drainage Criteria Manual* should be referred to during the report preparation to ensure completeness.
- Final drainage reports should include construction level plans and details for all drainage improvements including storm sewer and detention pond outlet structures.
- Hydraulic grade line (HGL) should be plotted on storm sewer profiles. Calculations should be provided in the report.
- Water quality should be addressed using the Urban Drainage and Flood Control District *Urban Storm Drainage Criteria Manual Volume 3*. This is available at [www.udfcd.org/usdcm/vol3.htm](http://www.udfcd.org/usdcm/vol3.htm).
- Water quality capture volume (WQCV) should be provided in detention ponds. The total required volume is the 100-year volume plus the WQCV.



# **STORM DRAINAGE CRITERIA MANUAL**

**City of Lakewood  
Colorado**

**August 9, 1982**

**(Addendum to Engineering Regulations, Construction Specifications  
and Design Standards, City of Lakewood, Colorado)**

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## I. INTRODUCTION

- A. Purpose: This document is formulated to introduce similarity and consistency for storm drainage studies for developments within the City of Lakewood, Colorado; clearly define acceptable drainage analysis and design criteria; and reduce the effort and time required for the drainage approval process.
- B. Amendments: The criteria established herein are subject to amendment and revision. Amendments will be applicable to all drainage studies submitted after the effective date of amendment. However, final drainage reports which are submitted for approval within sixty days after the effective date of amendment and which have prior approval of a preliminary drainage report are exempt from the amendments.
- C. Authority: This Storm Drainage Criteria Manual is a part of the Engineering Regulations, Construction Specifications and Design Standards of the City of Lakewood.
- D. Review Process: Adequate time must be allocated in development planning to permit a complete review. The intent of this manual is to more clearly define the City's criteria and reduce the time and effort required to develop an acceptable drainage study. To improve the review process, all reports will receive an initial review to determine if all essential information is present as shown in Appendix A. Engineering review of the drainage plan will not be started until all essential information is present. A flow chart of the review process is shown in Figure 1.
- E. References: The basic reference for this document is the "Urban Storm Drainage Criteria Manual" (USDCM) by the Urban Drainage and Flood Control District. Where specifically referenced, the guidelines and criteria of the Urban Storm Drainage Criteria Manual shall become a part of this manual.

Concepts developed in the "Storm Drainage Design and Technical Criteria" for the City of Louisville by Water Resources Consultants have been adapted for use in Lakewood in the preparation of this manual.

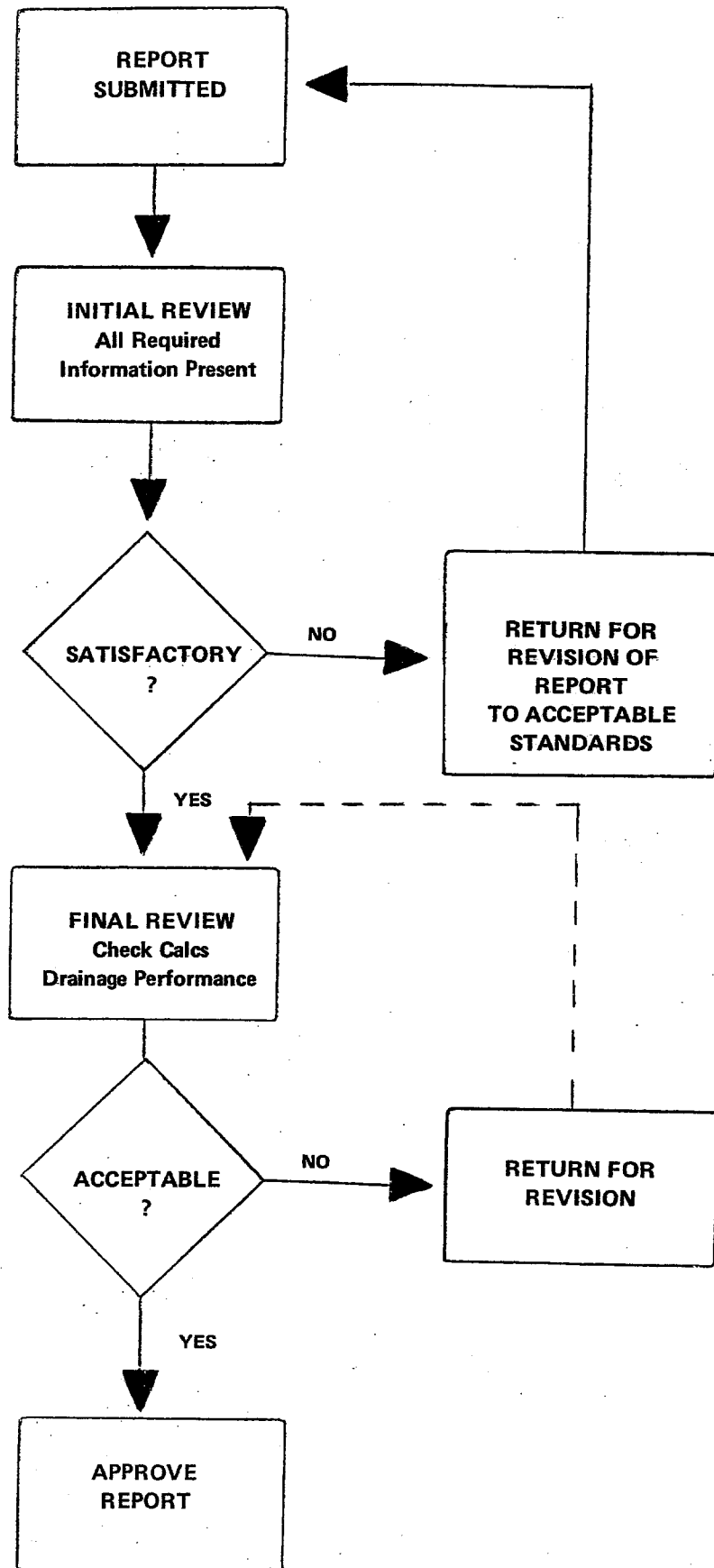


FIGURE 1 – Drainage Report Review Process

## II. STORM DRAINAGE PLANNING & SUBMITTAL REQUIREMENTS

- A. Applicability: Drainage reports are required and must be submitted in accordance with Table I.

TABLE I  
REQUIRED DRAINAGE REPORTS

A preliminary drainage report shall accompany the submittal of a preliminary map. A preliminary drainage report is also required when a rezoning request is conditional upon site plan approval.

A final drainage report shall accompany the submittal of:

1. The final plat in the following zone districts: C-N, 1-R, 2-R, 3-R, and single-family portions of MU's.
2. The site plan in the following zone districts: 4-R, 5-R, 6-R, OF, 1-C, 2-C, 3-C, 4-C, 5-C, IN, and multi-family through industrial portions of MU's.

A flood hazard study shall accompany the submittal of an application for any land use requiring a special use permit pursuant to Article 14 of the Zoning Ordinance.

These requirements are consistent with the provisions of Articles 14 and 15 of the Zoning Ordinance. These requirements are applicable to both new and infill development as illustrated by the following matrix.

<u>Type of Development</u>	<u>Prelim. Map</u>	<u>Final Plat</u>	<u>Site Plan</u>	<u>Bldg. Permit</u>
New (C-N thru 3-R, and single-family portions of MU's)	P	F	N/A	F*
Infill (C-N thru 3-R, and single-family portions of MU's)	-	-	N/A	F*
New (4-R thru IN, and multi-family thru industrial portions of MU's)	P	-	F	--
Infill (4-R thru IN, and multi-family thru industrial portions of MU's)	-	-	F	--

P = Preliminary Drainage Report

F = Final Drainage Report

\* required for sites large than 2 acres in accordance with detention requirements of Ordinance 0-81-165 (Appendix E)



- B. Preliminary Report: A preliminary drainage report shall accompany the submittal of a preliminary map. The purpose of the preliminary report is to identify and define drainage problems associated with the proposed development and to define conceptual solutions. For detailed criteria, see Appendix B. When a rezoning application and approval is conditional upon a site plan approval, a preliminary report will be required.

The City Engineer may modify the requirements of Appendix B for a preliminary drainage report when the development is of a minor nature such as a parking lot expansion, or other minor type improvements.

The City Engineer may accept a preliminary drainage report as acceptable even though minor corrections are still needed. This shall be accomplished by attaching an addendum to the preliminary report stating the deficiencies of the report and stating that all such minor corrections shall be completed as part of the final drainage report. This addendum shall be signed by the developer's engineer.

- C. Final Drainage Report: A final drainage report must be prepared and submitted with the final plat, site plan, or building permit for all applicable developments. The purpose of the final report is to translate the preliminary plan from a conceptual plan to a construction plan. The final drainage report shall contain all calculations and information listed in Appendix B.

The City Engineer may modify the requirements of Appendix B for a final drainage report when the development is of a minor nature such as a parking lot expansion, or other minor type improvements.

- D. Flood Hazard Study: Proposed development or improvements in the flood hazard zone shall meet the requirements of Article 14 of the Zoning Ordinance. The flood hazard study shall be in the form of a final drainage report and shall include all such computations necessary to show that the requirements of Article 14 are met.

- E. Method of Submittal: Two copies of the drainage report will be submitted for review. The city will review and make any comments deemed necessary on the submitted drainage report and return that copy to the submitter. A resubmittal must be accompanied by the previous report reviewed by the city. The resubmitted report must indicate that it has been revised and all revisions suitably indicated.

When the drainage report is deemed acceptable by the city, two additional copies of the drainage report and the mylar "Drainage Plan Sheet" (See G below) must be submitted for approval.

- F. Format: Drainage reports shall be prepared on standard size paper (8½x11) and suitably bound. The "Drainage Plan Sheet" (See G below) may be either folded and bound with the report or folded and placed in a pocket which has been bound within the report, including cover, tabs, etc.

- G. Drainage Plan Sheet: The drainage plan sheet shall consist of a 24" x 36" mylar sepia of the approved Drainage Plan Sheet from the approved final drainage report. The mylar Drainage Plan Sheet shall be submitted to the city for approval when the final drainage report is approved.

Any proposed revisions to the approved Drainage Plan Sheet shall be submitted to the city for approval in the same manner as a final drainage report.

The approved Drainage Plan Sheet shall be a part of the construction documents, plans and specifications for the proposed development. No building permit will be issued unless the approved Drainage Plan Sheet is included among the construction documents.

- H. Easements and Rights-of-Way: In the event that part or all of a proposed development is traversed by any water course channel, stream or creek, gulch, or other natural drainage channel classified as a "major channel," (any channel or drainageway with 100 cfs or greater flows in a major storm or any channel with a designated floodplain on the City's Official Flood Hazard Map) the subdivider shall dedicate adequate easements for storm drainage and maintenance access purposes.

Easements are also to be deeded for the purposes of operation, repair, alteration, and maintenance of the storm water management system in areas composed of single family detached dwellings and two-family dwellings or in other developments when the City has accepted maintenance and operation responsibilities. These easements shall cover the outlet structure, storm water pipes, detention area berms, and other parts of the storm water management system which the City deems shall be granted to the City.

All developments which have publicly owned easements shall provide covenants running with the land stating that no buildings, fills, excavations, structures, fences, or other alterations shall be constructed within a publicly owned easement without the express written consent of the City.

- I. "As Built" Drainage Plan: A professional engineer retained by the developer shall inspect the construction of the improvements for the purpose of determining conformance with the approved Drainage Plan Sheet. This inspection shall include verification that the following conform reasonably to the drainage plan:

- Finished floor elevations
- Sizes, grades, locations, and elevations of drainage structures, channels, pipes, etc.
- Location of basin boundaries
- Detention pond volumes
- Facilities appear to be constructed in a workmanlike manner and functional

Any significant deviations from the approved drainage plan shall be annotated on the "As-built" plans. Significant deviations are those that exceed the following tolerances:

- elevations  $\pm 0.1$  ft
- slopes greater of  $\pm 5\%$  but not less than .0005 ft/ft.
- distances  $\pm 1.0\%$
- volumes  $\pm 5.0\%$

The engineer shall include the following statement on the "As-Built" plans:

"I hereby declare that: I have performed a field review of the constructed drainage facilities on this plan, the facilities conform reasonably well to the approved drainage plan, appear to have been constructed in a workmanlike manner, and appear to be adequate for the intended purpose."

\_\_\_\_\_  
Registered P.E., State of Colorado  
No. \_\_\_\_\_

The "As-Built" plans must be on file before a Certificate of Occupancy will be issued. The engineer will obtain the city's original recorded mylar sepia of the approved Drainage Plan Sheet and place the certification and notations required for the "As-Built" drainage plan. The document will then be returned to the city for filing as the "As-Built" drainage plan. A deposit may be required.

### III. TECHNICAL DESIGN CRITERIA

A. Hydrology: The preliminary and final drainage reports shall take into consideration two separate storms: the initial storm and the major storm. Historic (existing development) and developed runoffs shall be determined for both storms for the site including the entire basin intercepted by the site.

- 1) Storm Frequency: The storm frequency to be used in drainage system design will be the storm frequency applicable for the design point under consideration.
  - a) Initial Storm: (Design Storm) The initial storm occurs at fairly frequent intervals, between two and ten years. The drainage system for the initial storm is to be designed to minimize inconvenience, protect against minor damage, and reduce maintenance costs. The design frequency interval for the initial storm depends upon land use. See Table II.
  - b) Major Storm: (Check Storm) The major storm shall be considered the 100 year storm. The drainage system for the major storm is to be designed to protect against loss of life or serious substantial property damage.

TABLE II. DESIGN STORM FREQUENCY BY LAND USE

<u>LAND USE</u>	<u>DESIGN STORM FREQUENCY</u>		
<u>Description</u>	<u>Zoning District</u>	<u>Initial Storm</u>	<u>Major Storm</u>
Residential (Low Density)	CN, 1R-3R	2 Year	100 Year
Residential (High Density)	4R-6R	5 Year	100 Year
Light Commercial	IC	5 Year	100 Year
Office & Ind.	OF, 2C-5C, IN	5 Year	100 Year
Parking, Parks, Other		2 Year	100 year

- 2) Rainfall Intensity: Runoff for both the initial and major storm shall be based on the Rainfall Intensity - Duration Curves for Lakewood, Colorado shown in Figure 2.
- 3) Runoff Computations: Both the initial and major storm runoff quantities shall be computed using the Colorado Urban Hydrograph Procedure for basins larger than 130 acres. The rational formula may be used for basins less than 130 acres.
  - a) Rational Formula - The rational formula ( $Q=CIA$ ) is well known and assumed familiar to the user. Figure 3 should be used to compute runoff for each design point.

The rational formula is:  $Q = CIA$  where:  $Q$  = discharge in cfs  
 $C$  = runoff coefficient  
 $I$  = rainfall intensity  
in in/hr  
 $A$  = area in acres

- 1) Runoff Coefficients: The runoff coefficients used with the Rational Method shall be based on land use as given in Table III. This table includes the adjustment factor ( $C_f$ ) and no adjustment is to be made to the runoff coefficients from Table III.
- 2) Time of Concentration: The time of concentration is necessary for use of the Rainfall Intensity - Duration Curve (Fig. 2). A separate time of concentration is necessary for the overall basin and each sub-basin or design point. The time of concentration is also known as the "inlet time" and represents the time for a unit of water to travel from the most remote portion of the basin to the design point. The time of concentration ( $T_c$ ) is composed of the overland flow time ( $t_o$ ) and channel or conduit flow time ( $t_t$ ). The time of concentration formula shown below, with a 5 year coefficient factor, shall be used to obtain the rainfall intensity for all frequencies of storms. The minimum time of concentration shall be assumed to be five minutes.

$$T_c = t_o + t_t$$

Where  $T_c$  = time of concentration, minutes  
(five minutes minimum)  
 $t_o$  = overland flow time  
 $t_t$  = channel or conduit flow time

From USDCM, the overland flow time ( $t_o$ ) may be taken as:

$$t_o = \frac{1.8 (1.1 - C_5) L^{\frac{1}{2}}}{(S)^{1/3}}$$

Where:  $t_o$  = time of overland flow, minutes  
 $L$  = distance of overland flow, ft (not to exceed 400')  
 $S$  = slope of basin, in percent  
 $C_5$  = Runoff coefficient for five year storm

or, for developed watersheds only,

$$t_o = \frac{L}{180} + 10 \text{ (min)}$$

whichever is lesser.

TABLE III. RUNOFF COEFFICIENTS FOR RATIONAL METHOD

SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	RUNOFF COEFFICIENTS			
		2	5	10	100
<u>Business:</u>					
Commercial Areas	95	.87	.88	.90	.93
Neighborhood Areas	65	.60	.65	.70	.80
<u>Residential:</u>					
Single-Family	40	.40	.45	.50	.70
Multi-Unit (detached)	50	.50	.55	.60	.75
Multi-Unit (attached)	70	.65	.70	.70	.80
1/2 Acre Lots or Larger	30	.30	.40	.45	.65
Apartments	70	.65	.70	.70	.80
<u>Industrial:</u>					
Light Areas	80	.75	.80	.80	.85
Heavy Areas	90	.80	.80	.85	.90
<u>Parks, Cemeteries</u>	7	.15	.25	.35	.60
<u>Playgrounds</u>	13	.20	.30	.40	.70
<u>Schools</u>	50	.50	.55	.60	.75
<u>Railroad Yard Areas</u>	40	.40	.45	.50	.70
<u>Undeveloped Areas:</u>					
Historic Flow Analysis, Greenbelts, Agricultural Natural Vegetation, Clayey Soils, Sandy Soils	2	.10 .00	.20 .05	.30 .15	.60 .35
Offsite Flow Analysis (when land use not defined)	45	.45	.50	.55	.72
<u>Streets:</u>					
Paved	100	.87	.88	.90	.93
Gravel	7	.15	.25	.35	.65
<u>Drives and Walks</u>	96	.85	.87	.90	.92
<u>Roofs</u>	90	.80	.85	.90	.90
<u>Lawns, Sandy Soil</u>	0	.00	.10	.20	.50
<u>Lawns, Clayey Soil</u>	0	.10	.20	.30	.60

The channel or conduit flow time ( $t_t$ ) is to be determined from the velocity of flow computed for the hydraulic properties of the channel, ditch, gutter, pipe or sewer. Manning's equation for channel flow is useful for these calculations. Figure 4 may be used to determine the velocity in the following formula for  $t_t$ :

$$t_t = \frac{L}{60v}$$

Where:

$L$  = distance of flow in hydraulic structure (ft)

$v$  = velocity of flow (fps)

For grassed swales or shallow gutter flow, Figure 5 may be used to determine  $t_t$ .

- b) Colorado Urban Hydrograph Procedure (CUHP) - Runoff for basins larger than 130 acres must be determined using the Colorado Urban Hydrograph Procedure. This procedure is detailed in USDCM. The incremental design rainfall for use with the CUHP method is given as Table IV. Figure 6 may be used for effective rainfall computation.
- 4) Offsite Flows: Flows entering the proposed development from outside the property are offsite flows. The offsite storm runoff shall be determined and included in the drainage system design. Available drainage reports for offsite developed areas affecting the property shall be reviewed and considered in the drainage system planning and design.  
  
Runoff entering the site from offsite shall be computed using runoff coefficients based upon existing development or, for undeveloped land, based on values in Table III for offsite flow analysis, whichever is greater. The initial system shall be designed for this runoff rate or  $Q=.2A$ , whichever is greater.
- 5) Irrigation Ditches: Irrigation ditches frequently intercept natural drainage. Although they may be adequate to convey the discharge from frequent storms, this ability is dependent upon the operation of control structures. Thus, a storm drainage system that relies on irrigation ditches to convey storm runoff may not adequately convey even the initial storm under all conditions of operation. Considering an irrigation ditch as part of the drainage system may result in redirection of storm waters possibly resulting in damage to downstream property owners. For the purposes of routing the initial and major storms, irrigation ditches are to be assumed flowing full at all sections, and to not intercept any storm drainage. Wherever possible, stormwaters are to be diverted from irrigation ditches.

TABLE IV  
INCREMENTAL DESIGN RAINFALL  
LAKEWOOD, COLORADO

TIME (MINUTES)	INCREMENTAL RAINFALL DEPTH (INCHES)				
	RETURN PERIOD				
	2-Year	5-Year	10-Year	50-Year	100-Year
5	0.02	0.03	0.03	0.04	0.04
10	0.04	0.05	0.06	0.08	0.08
15	0.08	0.12	0.14	0.12	0.14
20	0.16	0.21	0.25	0.20	0.21
25	0.27	0.39	0.48	0.36	0.41
30	0.16	0.21	0.22	0.67	0.75
35	0.08	0.12	0.12	0.28	0.32
40	0.05	0.08	0.09	0.20	0.21
45	0.04	0.06	0.07	0.12	0.16
50	0.04	0.05	0.06	0.10	0.12
55	0.03	0.04	0.05	0.08	0.08
60	0.03	0.03	0.04	0.06	0.06
65	0.03	0.03	0.04	0.04	0.05
70	0.02	0.03	0.03	0.04	0.05
75	0.02	0.02	0.03	0.03	0.04
80	0.02	0.02	0.03	0.03	0.04
85	0.02	0.02	0.03	0.03	0.03
90	0.01	0.02	0.02	0.02	0.03
95	0.01	0.02	0.02	0.02	0.03
100	0.01	0.01	0.02	0.02	0.02
105	0.01	0.01	0.02	0.02	0.02
110	0.01	0.01	0.02	0.02	0.02
115	0.01	0.01	0.01	0.01	0.02
120	0.01	0.01	0.01	0.01	0.02
	1.18	1.60	1.90	2.60	2.95



B. Hydraulic Criteria: The preliminary and final design reports shall be consistent with the hydraulic properties and behavior specified in this section and conform with the USDCM.

- 1) Open Channels are subdivided into two classes: major channels and minor channels. Major channels include all drainageways and all other channels which convey major storm discharges greater than 100 cfs or any channel which has a designated flood plain on the City's Official Flood Hazard Map. All other channels are minor channels.
  - a) Grass Lined: Grass lined channels are preferred and shall be used unless physical restraints make their use infeasible. Limiting criteria varies with size, capacity, soils, type of grass, irrigation, neighborhood, and other factors. Any design, however, which has characteristics outside of the limits of Tables V and VI shall receive special scrutiny in the review. Trees and shrubbery should not be permitted to grow in major channels.
  - b) Concrete Lined Channels: Concrete lined channels are to be avoided normally. For criteria for concrete lined channels refer to USDCM. Concrete lined channels must be used if the Froude Number exceeds 0.8.
  - c) Rock lined channels: Rip rap lined channels will be permitted only in areas of existing development where available right-of-way prohibits the use of grass lined channels. Riprap lined channels shall be designed to have a Froude No. less than 0.8 and be designed in accordance with USDCM (Volume 2, Major Drainage Section 5 - Riprap, as revised).
  - d) Trickle Channels: A trickle channel shall usually be provided in major channels to provide acceptable flow characteristics at low flows. Trickle channels shall be lined with grouted rip rap (preferred) or concrete.
- 2) Culverts: All culverts shall be designed in accordance with the procedures in USDCM. Figures 7 to 11 are most frequently used in culvert design and are included for ease of reference. Maximum headwater depth at inlets shall be one and one half times the pipe diameter ( $HW = 1.5 D$ ).

Outlet velocities of all culverts must be checked. When the outlet velocity exceeds the maximum permissible channel velocity listed in Table V. or Table VI, energy dissipators shall be provided to minimize potential erosion at outlet.

- 3) Energy Dissipators: Typical acceptable energy dissipators are shown in USDCM. Design of energy dissipators, where required, shall be in accordance with USDCM or CDOH Erosion Control Manual.

TABLE V  
DESIGN CRITERIA, MAJOR GRASS LINED CHANNELS

	<u>Major Runoff Discharge</u>	<u>Initial Runoff Discharge</u>
Velocity	Not more than 7.0 fps 5.0 fps in sandy channels	Not less than 2.0 fps
Depth	Not more than 5.0 ft.	N/A
Side Slopes	Not steeper than 3:1 4:1 preferred	Not steeper than 3:1 4:1 preferred
Curvature	Radius twice top width but not less than 100 ft.	N/A
Freeboard	Not less than 1 foot	N/A
Froude No.	Not greater than 0.8	Not greater than 0.8
*Roughness Factor	between 0.025 and 0.035	between 0.035 and 0.100

\*Higher values should be used for computing depth of flow; use lower values for computing velocity and Froude No. ( $N_F = V/\sqrt{gD}$ ) where "D" is the hydraulic depth = (area/top width)

TABLE VI. DESIGN CRITERIA, MINOR GRASS LINED CHANNELS

	<u>Initial and Major Runoff Discharge</u>
Velocity	less than 7.0 fps
Depth	less than 2.0 ft.
Side Slopes	not steeper than 2:1
Freeboard	at least 0.5 ft.
Top Width (major storm)	less than 10.0 ft.
Froude No.	less than 0.7

- 4) Storm Runoff in Streets: The primary use of streets is for traffic. The allowable gutter flow in streets shall not exceed the values given in Figure 12 unless the allowable gutter flow is determined using Figures 14 and 15. The use of streets for storm runoff shall be limited by the criteria in Table VII. The allowable flow in the gutter shall be limited to the gutter capacity multiplied by the factor from Figure 15. The reduction factor is included in Figure 12 and should not be applied to values obtained from Figure 12.
- 5) Inlets Inlet design shall be in accordance with USDCM. Curb opening inlets shall be utilized in the design of storm sewer systems. For slopes up to 5 percent, the use of depressed curb opening inlets shall be used. For steep slopes (over 5 percent), curb opening inlets with deflectors in the gutter adjacent to the curb opening shall be used. For details, see design standards No. 19 and 20 and 20A in the Engineering Regulations, Construction Specifications, and Design Standards.
- 6) Storm Sewers Final grades, street geometrics, types of construction, and all other street details relative to the design, construction, or operation of the storm sewer system must be approved by the City Engineer.

Storm sewers shall be constructed of reinforced concrete or corrugated aluminum pipe meeting current Colorado Department of Highways Specifications. A minimum of class III concrete pipe will be required.

The minimum pipe diameter of storm sewers shall be 15 inches.

Storm sewers shall usually be straight between manholes. Long radius curves are permitted for pipe diameters equal or larger than 24". The radius of curvature shall not be less than 100 feet.

Spacing of manholes shall conform to Table VIII. Manholes shall conform to design standards No. 29 through 39 in the Engineering Regulations, Construction Specifications and Design Standards.

TABLE VII  
ALLOWABLE DEPTH OF FLOW IN STREETS

Allowable Use of Streets for Initial Storm Runoff In  
Terms of Pavement Encroachment

<u>Street Classification</u>	<u>Maximum Encroachment</u>
Local	No curb overtopping. Flow may spread to crown of street.
Collector	No curb overtopping. Flow spread must leave at least one lane free of water.
Arterial	No curb overtopping. Flow spread must leave at least one lane free of water in each direction.

Major System - The major system shall be based on design storm of one hundred (100) years. Planning and design objectives for the major drainage system as to public streets shall be based upon the following limiting criteria.

Major Storm Runoff: Allowable Street Inundation

<u>Street Classification</u>	<u>Allowable Depth</u>
Local & Collectors	Residential dwellings, public, commercial, and industrial buildings shall not be inundated at the groundline, unless buildings are flood-proofed. The depth of water over the gutter flowline shall not exceed eighteen inches (18").
Arterial	Residential dwellings, public, commercial, and industrial buildings shall not be inundated at the ground line, unless buildings are flood proofed. Depth of water at the street crown shall not exceed six inches (6") in order to allow operation of emergency vehicles. The depth of water over the gutter flowline shall not exceed eighteen inches (18").

TABLE VIII  
Manhole Spacing

<u>Pipe Size</u>	<u>Maximum Spacing</u>
15" to 36"	500 feet
42" or greater	600 feet

Sewer grades shall be such that a minimum 1'6" cover over the crown of the pipe is maintained. If less cover is shown, the Engineer shall submit his pipe structural design to the City Engineer for approval. Uniform slopes shall be maintained between manholes. Final grades shall be set with full consideration to capacity required, sedimentation problems, and other design parameters. The minimum slope shall be capable of producing a velocity of 3 feet per second when the sewer is flowing full carrying the initial storm.

When an existing culvert is to be extended and the grade changed, a concrete collar as shown in design standard No. 28 in the Engineering Regulations, Construction Specifications, and Design Standards shall be used.

The minimum width of easement for installation of a storm sewer shall be the pipe diameter plus 10 feet with the pipe normally centered in the easement.

Storm Sewer Criteria shall be as shown in Table IX.

TABLE IX. STORM SEWER DESIGN CRITERIA

	<u>Initial Storm</u>	<u>Major Storm</u>
Min. velocity	3.0 fps	n/a
Depth of flow	pipe diameter	n/a
Max. velocity	16.0 fps	20.0 fps
Pressure head	0 (open channel flow)	$\frac{1}{2}$ pipe diameter

The hydraulic grade line shall be plotted for all storm sewers. The hydraulic grade line (depth plus pressure head) shall be 1.0 ft. lower than the gutter line. When the hydraulic grade line is not 1.0 ft. below the gutter line, then the capacity of the storm sewer shall be taken as the maximum capacity flowing full without pressure head and all excess flow carried in the street. The depth of flow in the street shall meet the criteria specified in Table VII.

- C. Detention Facilities: Detention facilities shall be provided as specified in Ordinance 0-81-165 excerpted below:

"Any person, firm, corporation or business proposing to construct buildings, or develop or redevelop land within the City, shall be required to provide storm water runoff control meeting the requirements of Ordinance 0-81-165 whenever the total area of land under identical ownership, including the land to be developed or upon which buildings are to be constructed, equals or exceeds those shown

in the following chart. This chart applies to both building permits and subdivision of land.

<u>Type of Development</u>	<u>Zoning Classification</u>	<u>Area</u>
New and Infill	CN	Exempt
New and Infill	1R, 2R, 3R and single family and duplex portions of MU.	2 acres
New and Infill	4R, 5R, 6R, OF, 1-C, 2-C, 3-C, 4-C, 5-C, IN, and multi-family thru industrial portions of MU	1 acre

"Any person meeting the application provisions of this ordinance . . . shall control the release rate of storm water runoff so that runoff after development shall not exceed the runoff from the same parcel of land in its natural state for the 5 and 100-year storm respectively."

Large detention ponds or existing ponds which are utilized for detention may be classified as reservoirs. These ponds must conform to "Manual of Rules and Regulations for Plans and Specifications of Reservoirs." State of Colorado.

- 1) Volume and Release Criteria: Provision for detention of storm water is intended to reduce the impact of development upon the peak discharge of the major drainage basin. Controlling the rate of discharge of storm water runoff at calculated historic levels for a number of small sites often will not reduce the discharge to historic levels for the entire watershed. In order to control the combined discharge at more nearly historic levels, detention facilities are to be provided which meet the following criteria:

5 year Storm

$$V_5 = (36 C_i) A$$

$$Q_5 = .2 A$$

100 year Storm

$$V_{100} = (66 C_i) A$$

$$Q_{100} = 1.0A$$

where: V = Volume of pond in cubic feet  
 $C_i$  = Percent Imperviousness of basin  
 $A_i$  = Area of Basin in Acres \*  
 $Q_x$  = Release rate in cfs for x year storm

\*Note: The area of basin for purpose of computing pond volumes shall be the area being developed. The area of basin used for determining the release rate shall be the entire basin intercepted by the detention facility which includes the area of basin contributing offsite flows.

A suggested procedure for computing the required detention facilities is included in Appendix C.

### Water Quality Capture Volume

Water quality capture volume (WQCV) shall be provided in all detention ponds. The WQCV must be contained within landscaped areas and may not be in underground systems or paved lots. The WQCV is added to the 100-year volume to determine total volume required.

$$(\text{Total Volume Required}) = (100\text{-year vol}) + (\text{WQCV})$$

The methodology for Extended Detention Basins (40-hour drain time) in Volume 3 of the Urban Storm Drainage Criteria Manual shall be used for the design.

## 2) Detention Facility Construction Criteria

a. Detention Ponds

- Minimum turf slope 2%
- Minimum paved slope (parking areas) = .75%
- Pond embankment side slopes:
  - grassed                4:1 desirable  
                          3:1 maximum
  - protected            2:1 desirable  
                          1:1 maximum (w/ slope stabilization)
- Minimum freeboard at  $H_{100} = 1.0'$   
    = 0.25' for parking lots  
    and cul-de-sacs
- Outlet pipe diameter - 12" minimum with  
orifice control if required

b. Outlet Structures: The outlet structures shown in Volume 3 of the Urban Storm Drainage Criteria Manual are to be used unless an alternate is approved by the City Engineer.

### c. Detention Duration

<u>Land Use</u>	<u>5 year</u>	<u>100 year</u>
Parks, Playgrounds, other	6 hrs	24 hours
Parking Lots	2.5 hours*	4 hours*

d. Detention Pond Depth - Parking Areas

5 year storm - 0.5 feet maximum\*

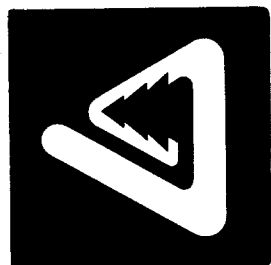
100 year storm - 1.0 feet maximum\*

\*These values may be doubled for remote, little used areas of parking lots. If remote areas are not used for detention or are not available, the volume and release rate criteria specified herein will result in some detention being required off the parking lot (roughly 50% of the five year volume).

- 3) Excess Storm Water Passage: The detention pond shall be so designed to safely pass the maximum peak discharge for a major storm (100 year) assuming the outlet structure is inoperative and the upstream watershed is fully developed to current zoning or current development, whichever provides the greater runoff. No buildings or structures shall be constructed in the path of such excess storm water passage.



## FIGURES



CITY  
OF  
LAKEWOOD

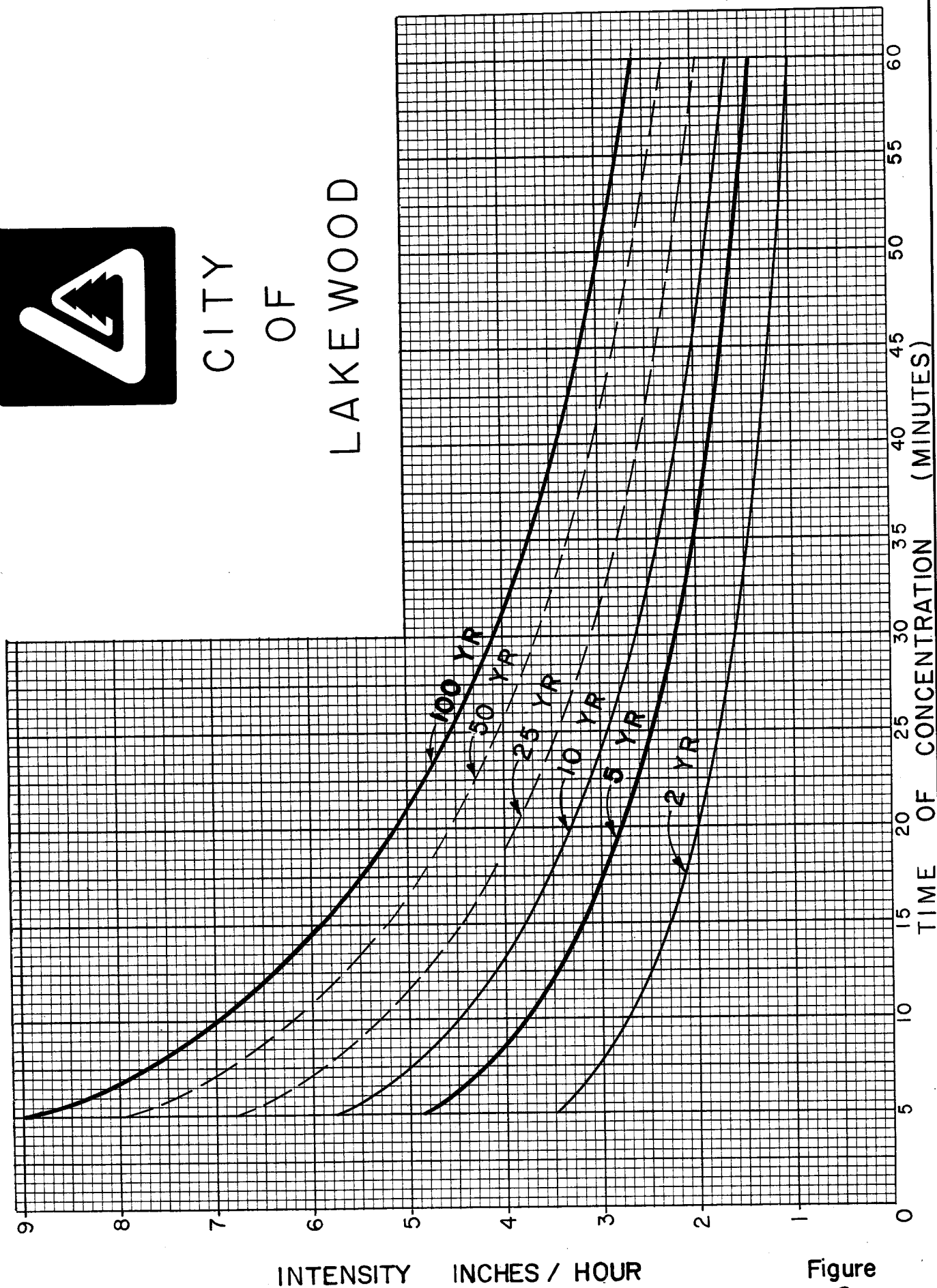
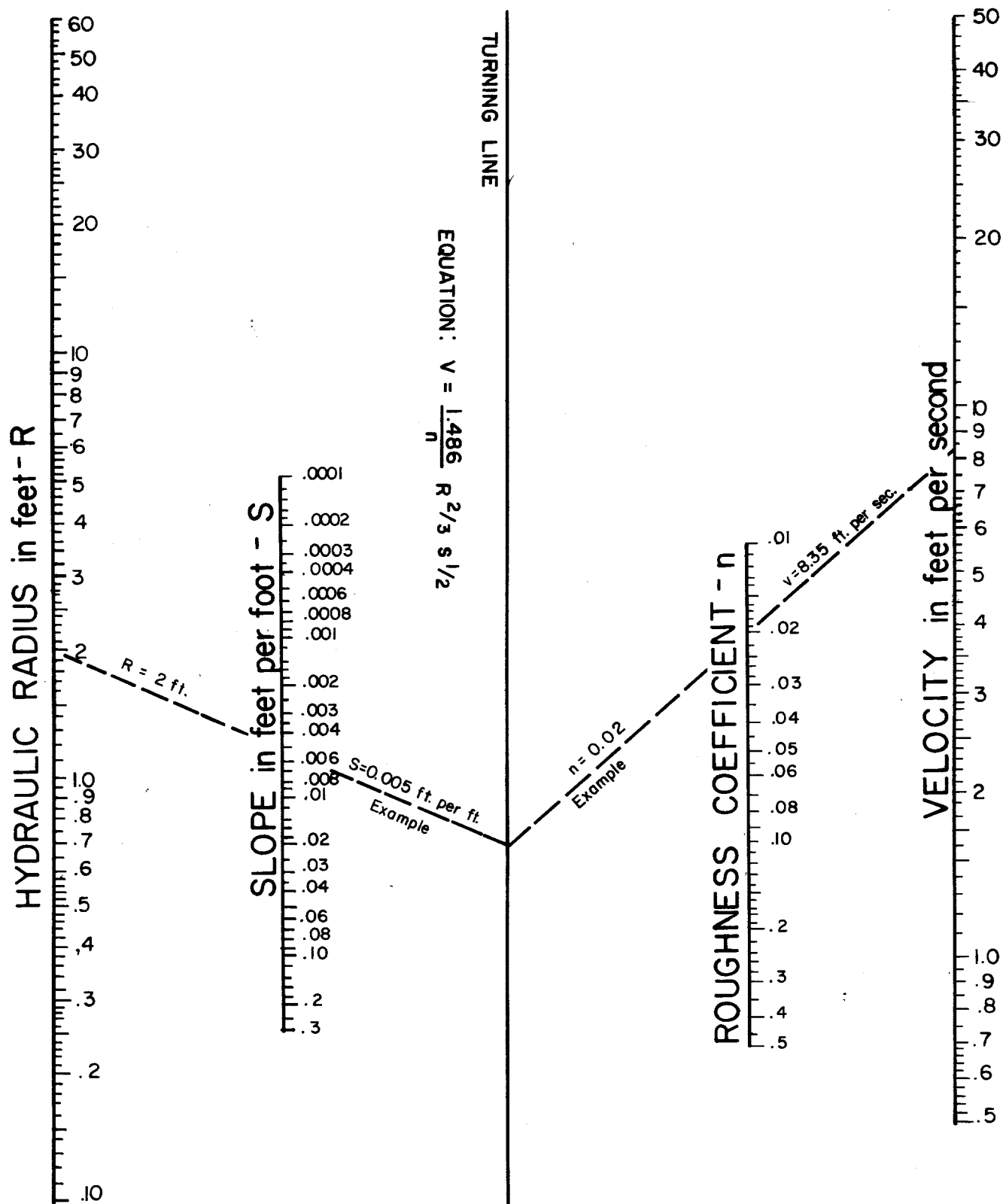


Figure  
2

SUBDIVISION: \_\_\_\_\_ DESIGN STORM \_\_\_\_\_ YR. RECURRENCE INTERVAL \_\_\_\_\_  
LOCATION \_\_\_\_\_ COMPUTED BY: \_\_\_\_\_ DATE: \_\_\_\_\_ PAGE \_\_\_\_\_ OF \_\_\_\_\_

[illegible]



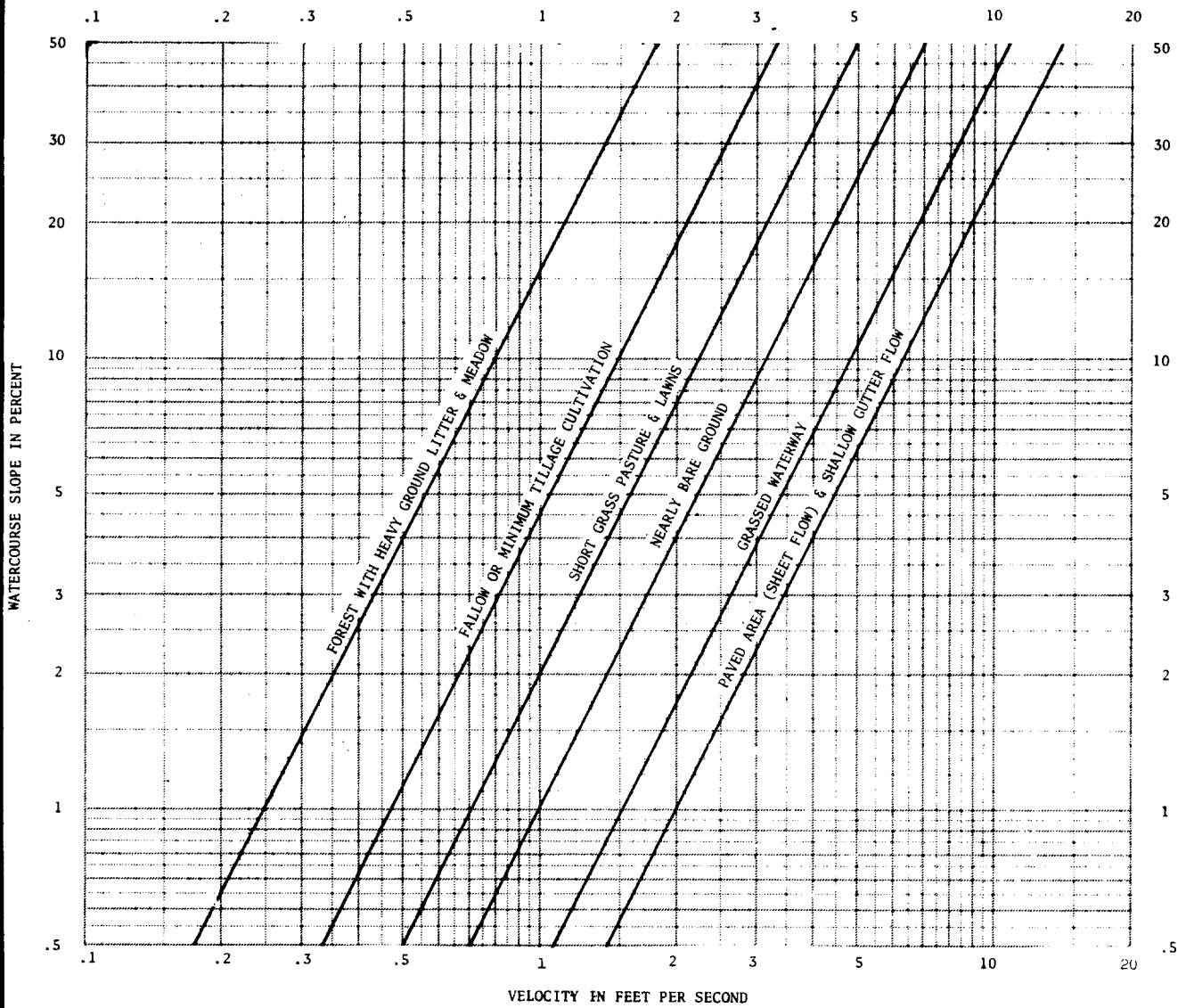
BI

CITY  
OF  
LAKEWOOD

Nomograph for solution  
of manning equation

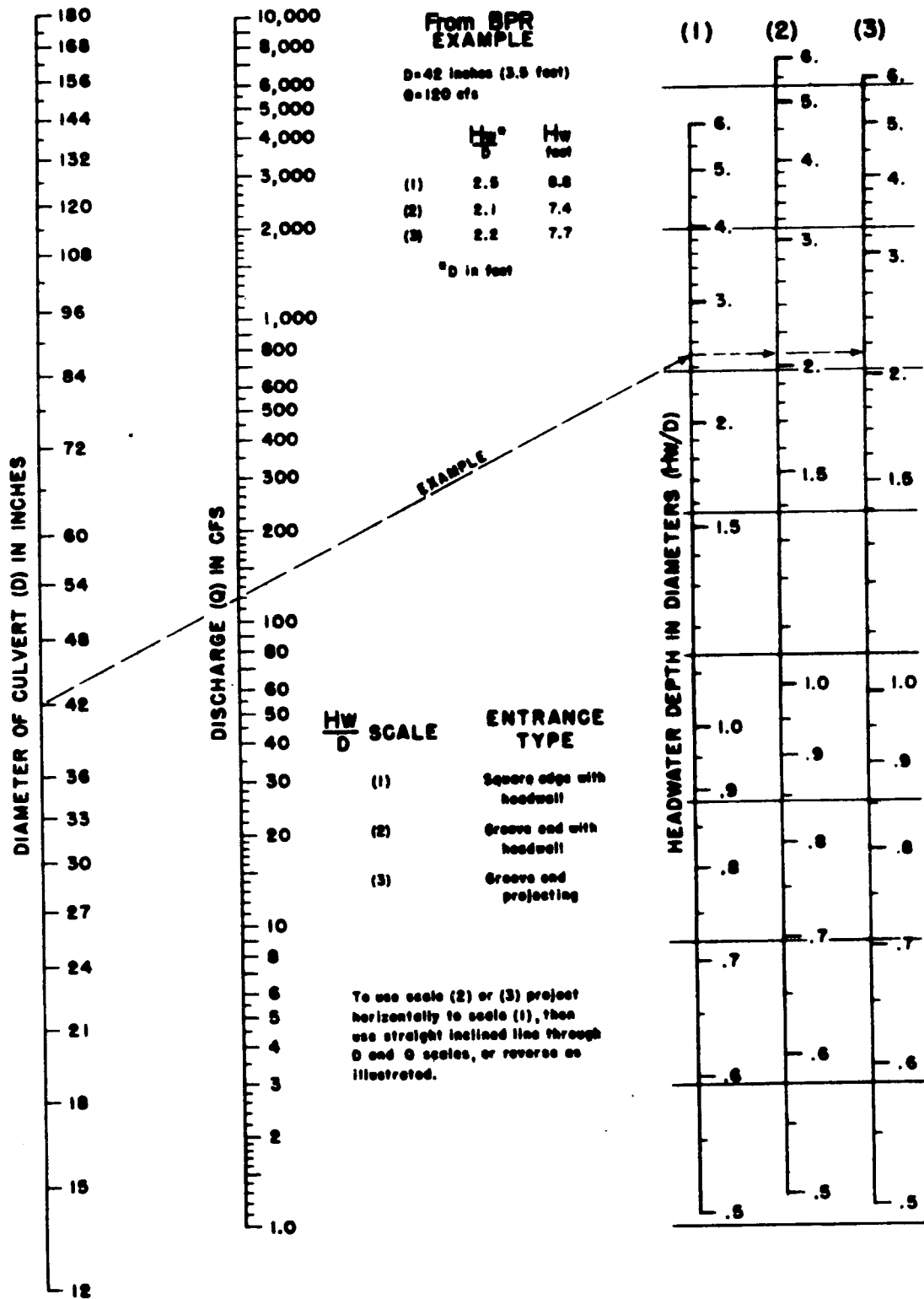
MVC

Figure  
4



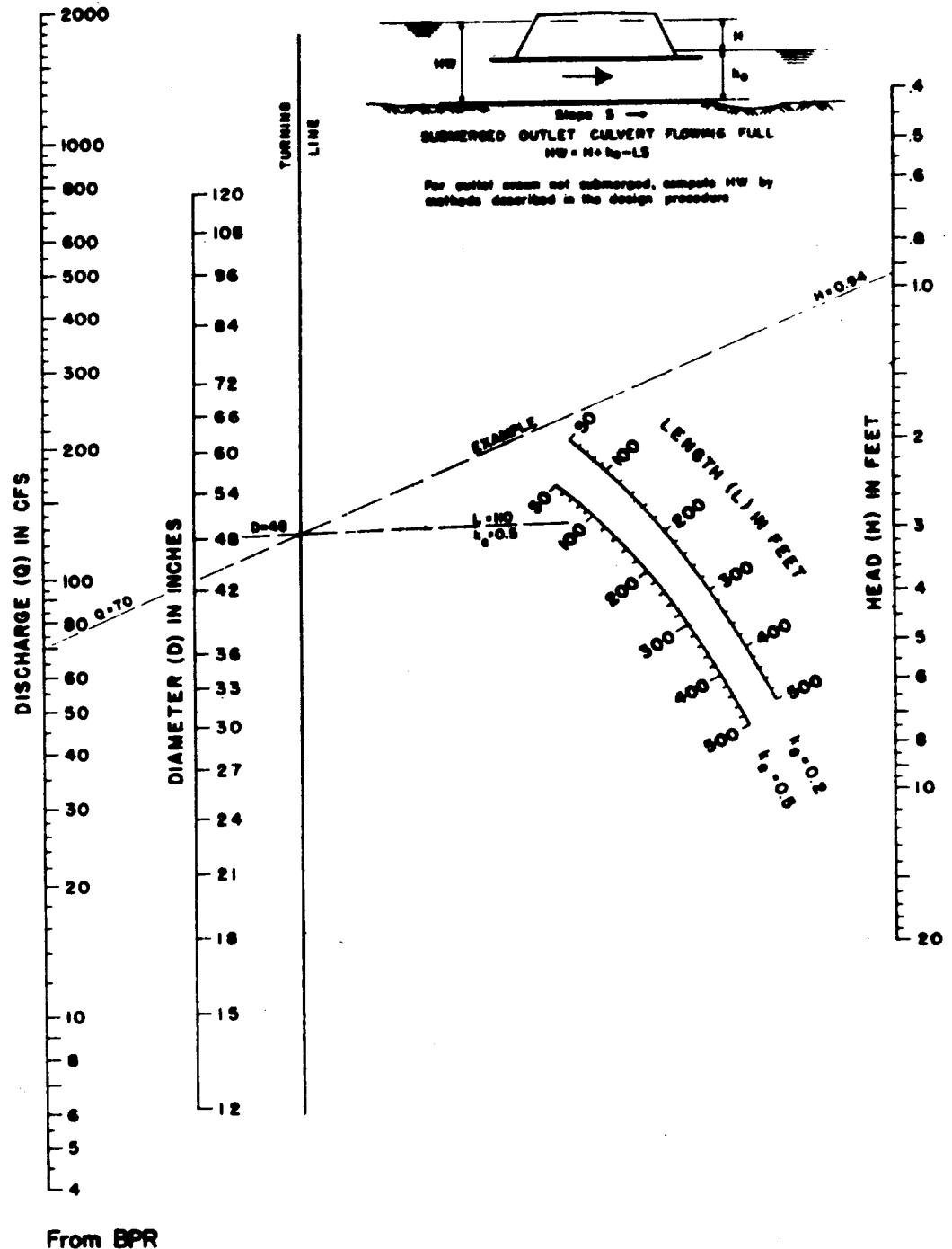


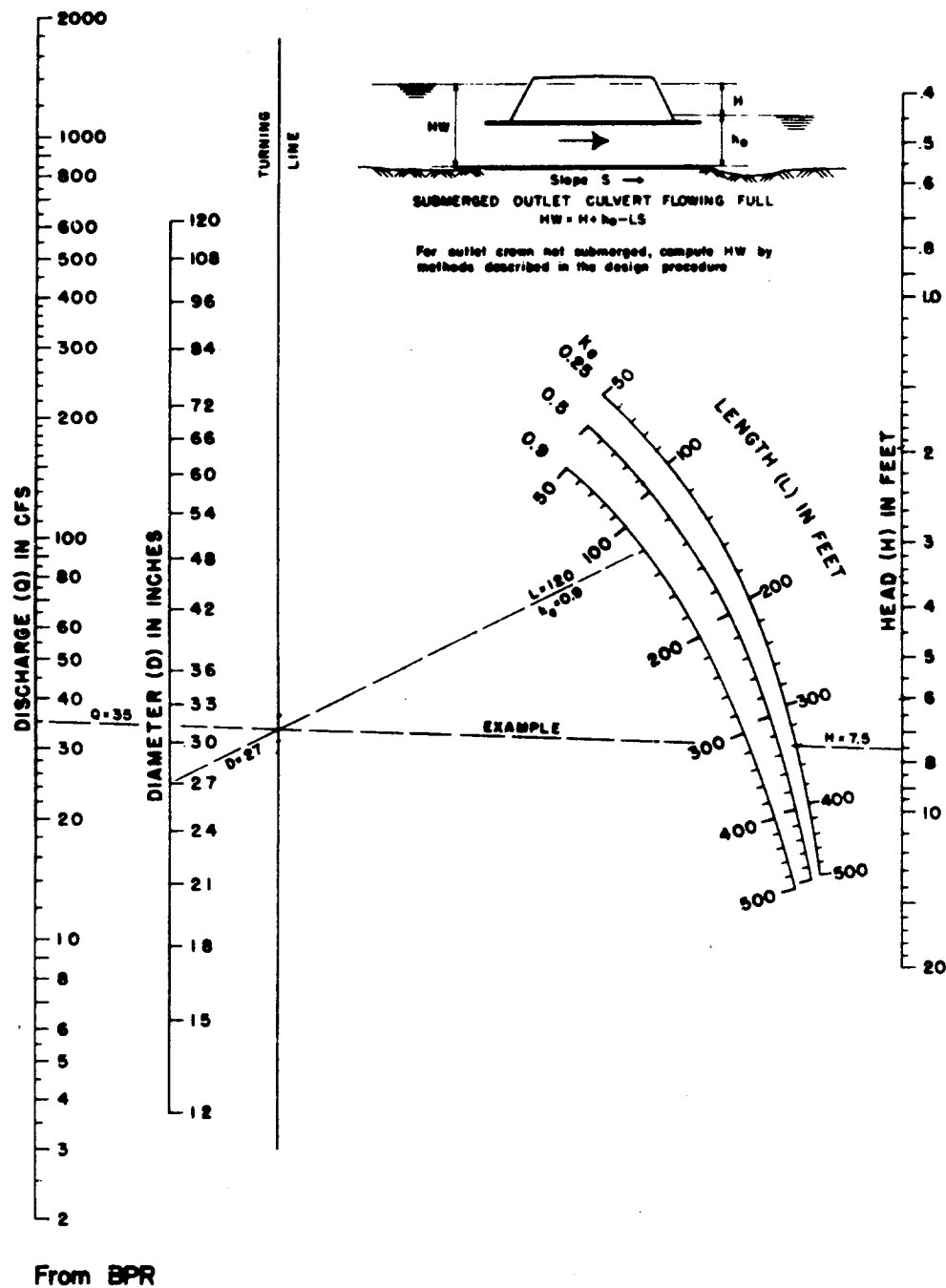


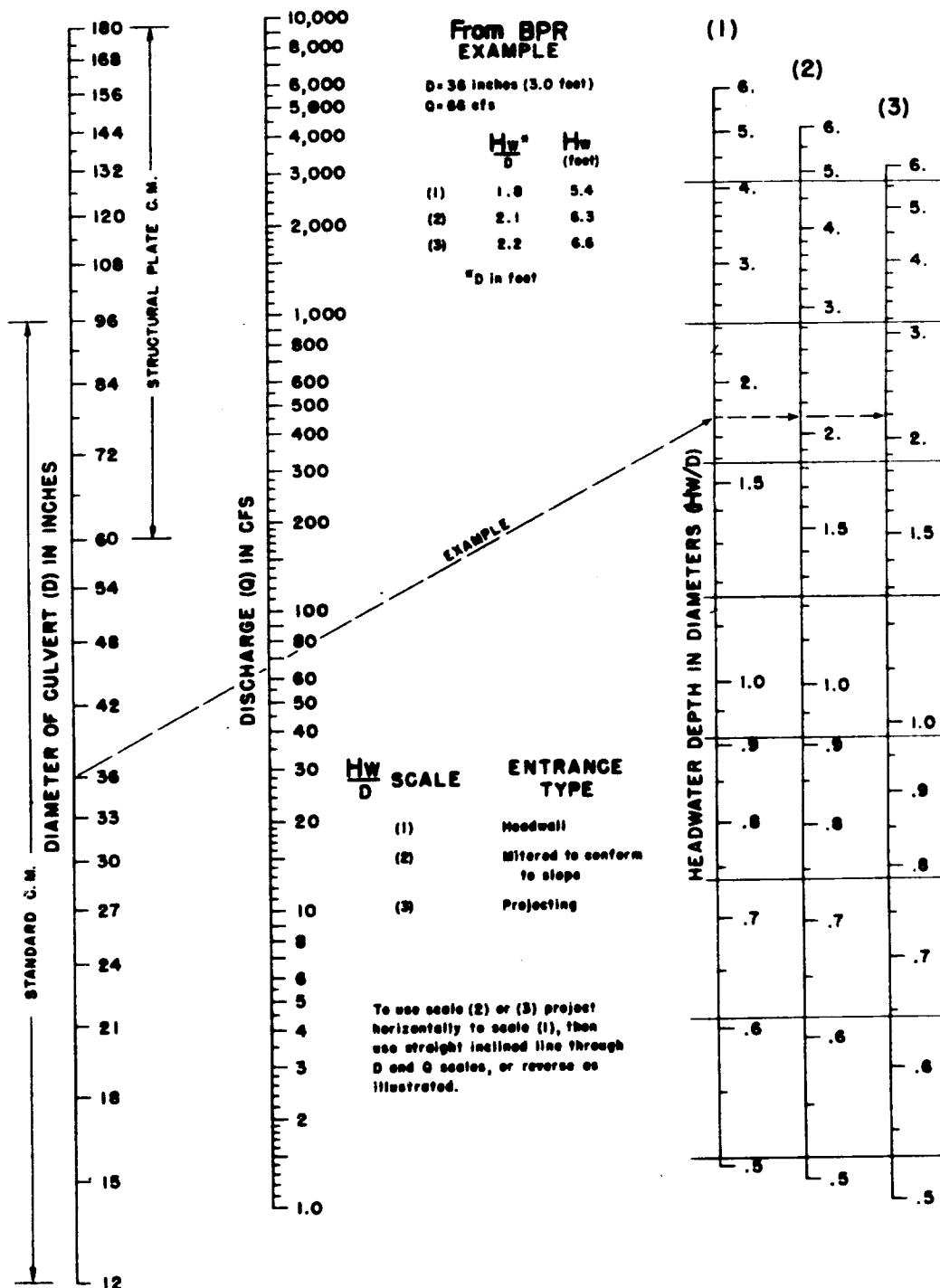


From BPR



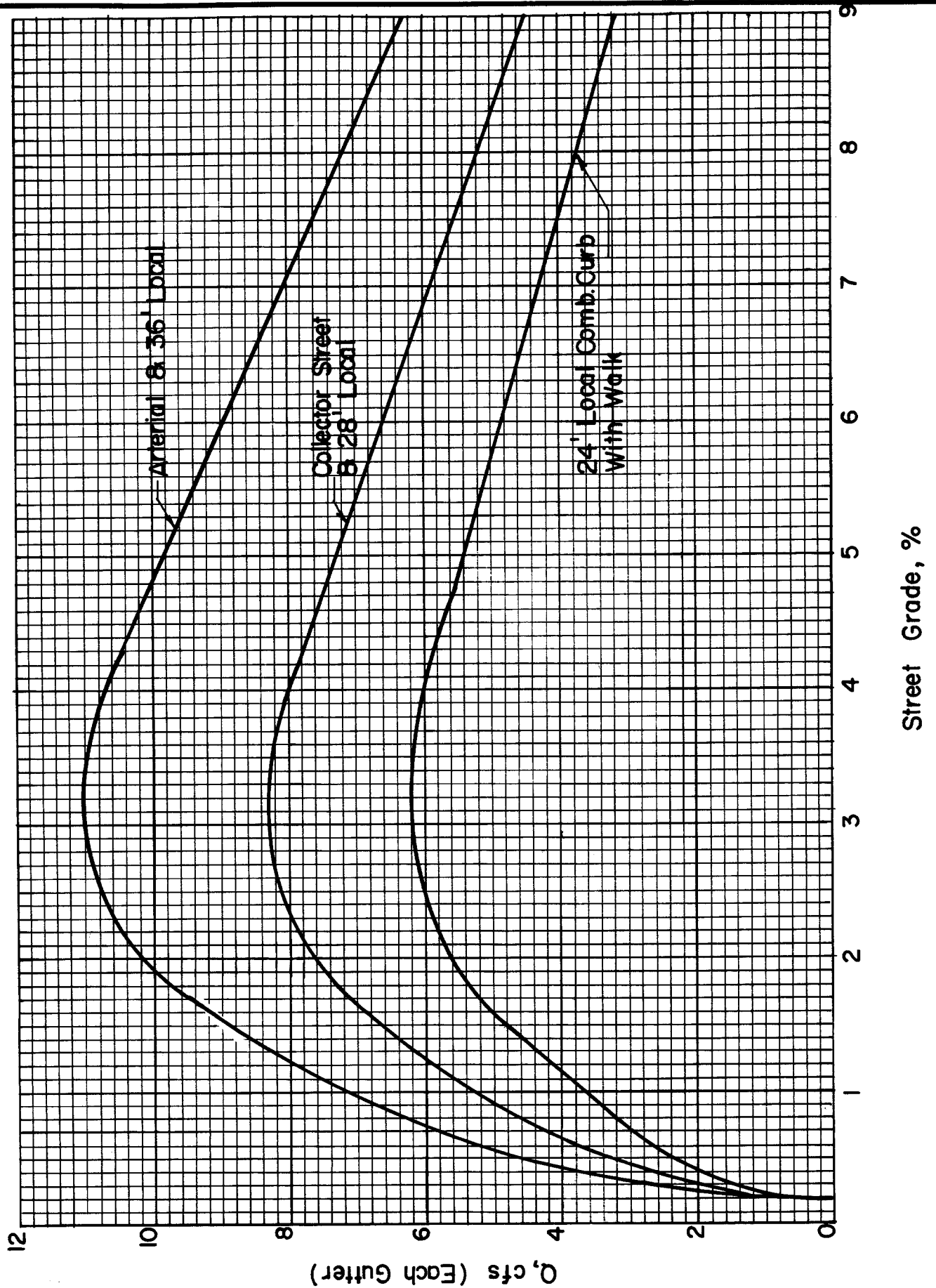






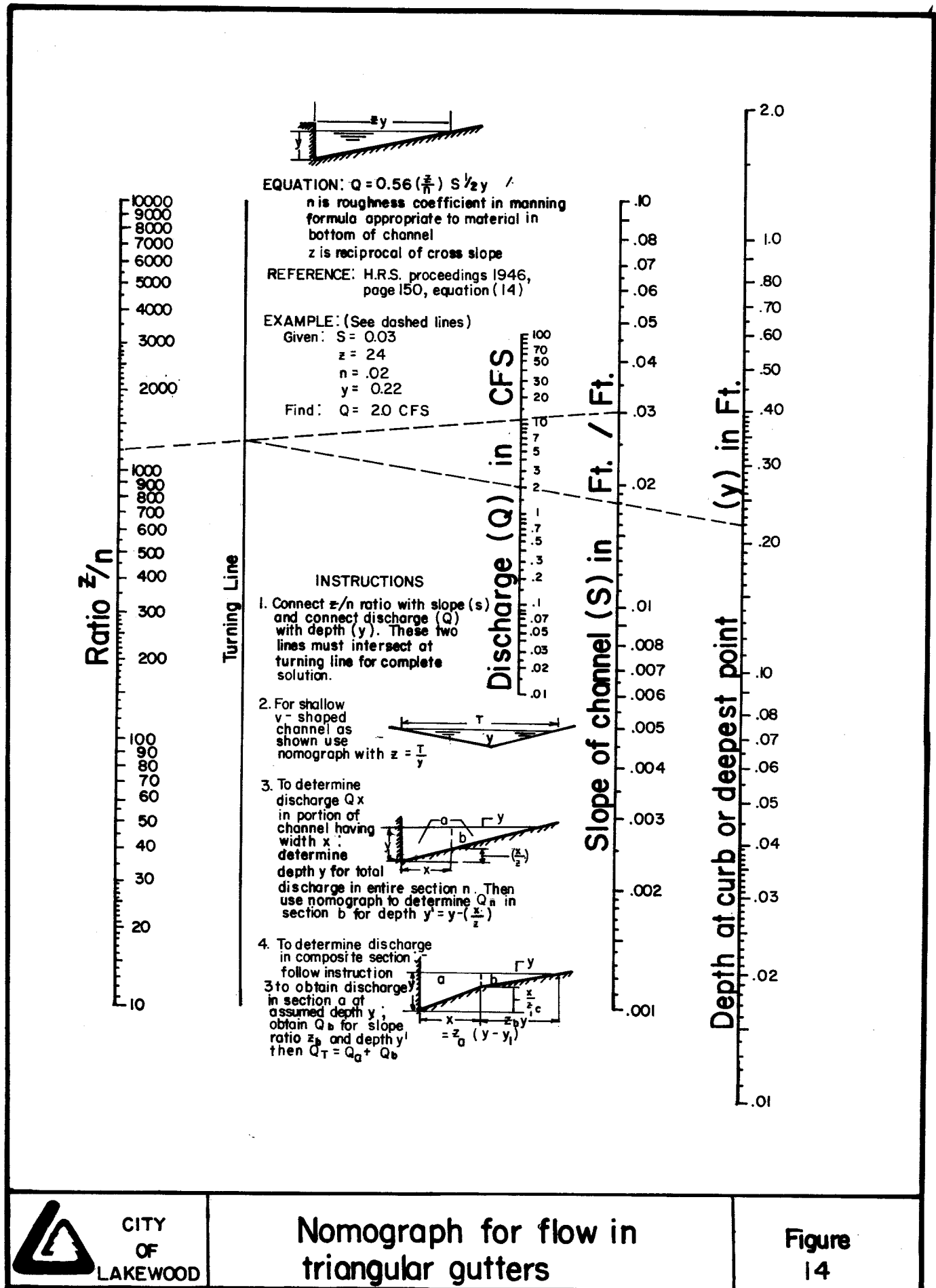
From BPR

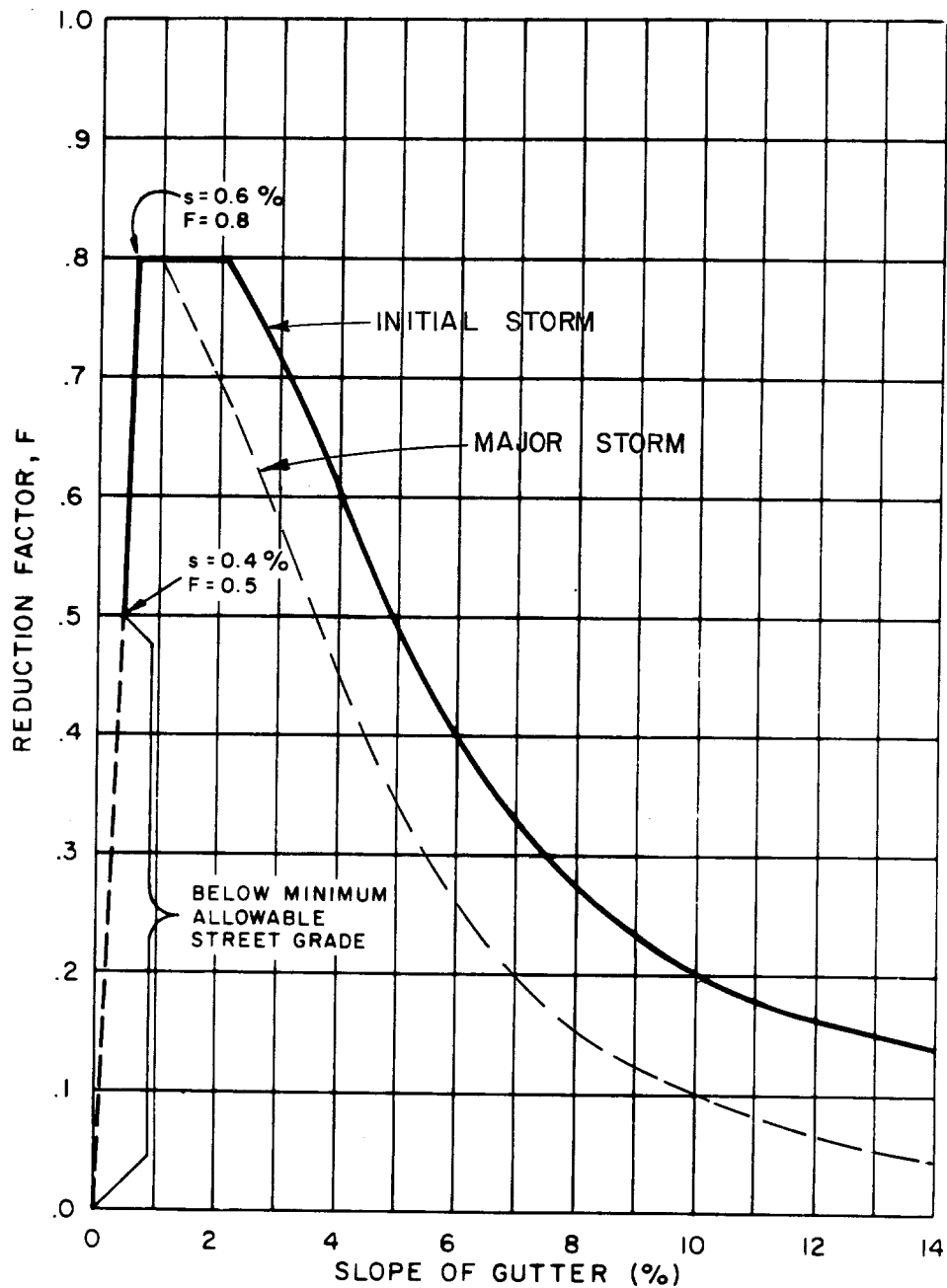
CITY  
OF  
LAKEWOODHeadwater depth for C.M. Pipe  
Culverts with inlet controlFigure  
11



Initial Storm Allowable Gutter Capacity  
(for .02 1/2 Cross Slope Only)

Figure  
12





APPLY REDUCTION FACTOR FOR APPLICABLE SLOPE TO THE THEORETICAL GUTTER CAPACITY TO OBTAIN ALLOWABLE GUTTER CAPACITY.

## **APPENDIX A**

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INTENTIONALLY NOT USED



INTENTIONALLY NOT USED

## **APPENDIX B**

## APPENDIX B

### PRELIMINARY AND FINAL DRAINAGE REPORT - OUTLINE AND REQUIRED INFORMATION GUIDELINE

(Note, those items marked with an asterisk (\*) are not required for a preliminary report.)

#### I. TITLE PAGE

- A. TYPE REPORT (Prelim, Final, Flood Hazard)
- B. PROJECT NAME
- C. PREPARER NAME, FIRM, DATE
- D. P. E. SEAL OF PREPARER

#### II. INTRODUCTION

- A. SITE LOCATION
  - 1. City, County, Street Grid
  - 2. Adjacent Development
- B. SITE DESCRIPTION
  - 1. Existing Topography, Ground Cover, Use, etc.
  - 2. Existing Drainage Facilities, Major Channels, Flood Hazard Zones and Studies, Irrigation Ditches
- C. PROPOSED PROJECT DESCRIPTION
- D. FLOOD HAZARD AND DRAINAGE STUDIES RELEVANT TO SITE

#### III. HISTORIC DRAINAGE SYSTEM (discuss the following)

- A. MAJOR BASIN
  - 1. Relationship to Major Basin Channel
  - 2. Major Basin Drainage Characteristics, Topography, Runoff, Use, Cover, etc.
- B. SUB-BASIN AND SITE DRAINAGE
  - 1. Initial & Major Storms
  - 2. Off-site Flows
  - 3. Existing Drainage Patterns: Channelized or Overland Flow, Volumes, Points of Discharge from Site
  - 4. Effect of Historic Flows upon Adjacent Properties

#### IV. PROPOSED (DEVELOPED) DRAINAGE SYSTEM (discuss the following)

- A. CRITERIA
  - 1. Size Basin and Subbasins.
  - 2. Hydrologic Method (Rational or CUHP)
  - 3. Design Storm Frequencies - Initial and Major

B. RUNOFF

1. Developed Flow Rates and Paths

C. DETENTION

1. Volumes Required and Provided
2. Release Rates and Method of Release
3. Excess Storm Water Passage

D. STREETS

- \*1. Depth and Velocity of Flow for Initial and Major Storms
2. Storm Drainage System

\*E. OPEN CHANNEL FLOW

1. Type Channel (lining)
2. Maximum Depth and Velocity

F. STORM SEWERS and CULVERTS

V. CONCLUSIONS

A. DISCUSS IMPACT OF IMPROVEMENT

1. Benefits - Does improvement reduce existing drainage problems?
2. Adverse impacts with solutions to mitigate impact

B. STATE COMPLIANCE WITH APPLICABLE CRITERIA

1. Detention Ponds - Water Quality
- \*2. Depth and Velocity of Street Flow
- \*3. Channel Flow Depth and Velocity

C. AREAS IN FLOOD HAZARD ZONE MEET ARTICLE 14 OF THE LAKEWOOD ZONING ORDINANCE. (Special Use Permit may be Required).

VI. APPENDIXES

A. HYDROLOGIC & HYDRAULIC COMPUTATIONS

1. Runoff (Historic)
  - a. Historic off-site + site for as many design points as required
    1. Separate time of concentration (Tc) for each design point (Rational Method)
    2. Runoff coeff. or permeability coeff. from Table III
    3. Existing drainage facilities carrying flows - must include flow for entire tributary area for each design point
    4. Irrigation ditch flows

2. Runoff (developed)
  - a. Off-site + site for as many design points as required
    1. Separate time of concentration ( $T_c$ ) for each design point (Rational Method)
    2. Runoff coeff. or permeability coeff. from Table III
    3. Existing drainage facilities carrying flows - must include flow for entire tributary area for each design point
    4. Irrigation ditch flows
3. Detention
  - a. Storage Volumes - WQCV, 5 year and 100 year; Release Rates - 5-year and 100-year.
  - \*b. Pond Outlet - Control Structures
    1. Outlet control structure type
    2. Use appropriate outlet discharge calculations - Include offsite flows
    3. Consider head at entrance
    4. Provide excess capacity for grates
    5. Use restricter plate to reduce inlet area when necessary
    6. Compute outlet velocity and provide energy dissipator if velocity exceeds maximum permissible channel velocity
    7. Check excess storm water passage effects
  - \*c. Size outlet structures for parking areas
  - \*d. Depths of ponding in parking areas, durations of storage for each storm
- \*4. Streets
  - a. Compute depths and velocity of flow, for initial & major storm unless flow is less than that allowed by Figure 12.
  - b. Inlet capacities and depths at inlet.
  - c. Meet street standards in Table VII.
- \*5. Open Channel Flow
  - a. Roughness coefficient
  - b. Trickle channel
  - c. Depth and velocity for initial and major storms
  - d. Channel protection
  - e. Minimum freeboard
  - g. Hydraulic grade line
- \*6. Hydraulic Structures - pipes, culverts, inlets, etc.
  - a. Culvert capacity using standard nomographs (Fig 7 to 11)
  - b. Storm sewer capacity at each design section
  - c. Inlet capacity
  - d. Flow depth or headwater depth at inlet
  - e. Drops
  - f. Weirs
  - g. Streets, gutters, and crosspans

- h. Energy dissipators
- i. Hydraulic grade lines
- j. Minimum and maximum velocities

## B. DRAINAGE PLAN SHEET(S)

1. SITE LOCATION MAP - a portion from the Map in Appendix D
  - a. Major drainage basin
  - b. Sub basin boundaries and acreage
  - c. Floodway and Flood Plain area
  - d. Site location
2. SITE DRAINAGE PLAN - SHOW THE FOLLOWING:
  1. Existing and proposed 2-foot contours based on USGS datum (existing contours to extend at least 50' beyond property line.)
  2. Location and elevation of USGS benchmarks or benchmarks referenced to USGS.
  3. Existing and proposed property lines.
  4. Present drainage easements.
  5. Street names and grades.
  6. Right-of-way and easement requirements.
  7. Routing and accumulative flows at the upstream and downstream ends of the site and at various critical points on-site for both initial and major storm run-off. The inflow and outflow from each subbasin shall be shown for both the initial and major storms.
  - \*8. Finished floor elevations for protection from major storm run-off.
  - \*9. Street cross-sections showing the 100-year flood levels.
  10. Existing and proposed flood plains and major channels.
  11. Detention pond design and drawings including the following:
    - a. Location of each detention area.
    - b. Release rates for 5 year and 100 year storms.
    - c. Storage volumes required and provided.
    - \*d. Site plan on 1" = 50' scale or larger with two-foot contour intervals.
    - \*e. Inlet and outlet structure design details and operational data (WQCV, 5 year and 100 year depths).
    - \*f. Emergency excess storm water passage design details.
    - \*g. Side slopes.
  - \*12. Open channel flow in major channels shall be provided with the following information for both storms:
    - a. Profiles showing existing and proposed channel grades and water surface profiles.
    - b. Cross-sections on 100-foot stations showing existing and proposed cross sections and required rights-of-way.
    - c. Locations and size of all existing and proposed structures.

- d. Locations and profiles of adjacent utilities.
  - e. Typical channel section and lining details.
- \*13. Storm sewers shall be indicated and the following information shown:
- a. Profile grade line of pipes with water surface profile and hydraulic grade line.
  - b. Invert elevations at each manhole and inlet and grades between manholes and inlets.
  - c. Locations and elevations of adjacent and intersecting utilities.
  - d. Flows for both initial and major storms at each design point.
  - e. Easements required.
- \*14. Outlet structure details
- \*15. All hydraulic structure details in conformance with design.
16. Seal by professional engineer licensed to practice in Colorado.
17. Standard notes.

Required Notes on Drainage Plan.

"No building, structure, or fill will be constructed in the detention areas. No changes or alterations affecting the hydraulic characteristics of the detention areas or affecting water quality features will be made without approval of the City Engineer.

Maintenance and operation of the detention areas and water quality features will remain the responsibility of the property owner. If the property owner fails in this responsibility, the City has the right to enter the property, maintain the detention areas and water quality features, and obtain reimbursement for the costs that are incurred.

The detention pond volumes, water quality features, and all related drainage appurtenances (including basin boundaries) shall be determined and certified by a Colorado registered Professional Engineer prior to issuance of a certificate of occupancy for any structure on the site or in the development."

C. OTHER

Substantiating documents relating to discussions or agreements with local jurisdictions, utility companies, irrigation companies or local property owners.

## **APPENDIX C**

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## APPENDIX C

## DETENTION POND DESIGN

1. Determine Pond Geometry
2. Determine depth - volume relationships
3. Compute Depths at  $Q_5$  and  $Q_{100}$
4. Size Discharge for  $Q_5$  @ Depth 5
5. Compute Discharge for 5 yr. release at 100 year depth and subtract from  $Q_{100}$
6. Size 100 year outlet for  $Q_{100}$  less value obtained in 5

Sample Calculation:

Provide detention pond for a basin of 3.5 Ac and % Impervious = 70%

$$Q_5 = .2 \times 3.5 = .70 \text{ cfs}$$

$$Q_{100} = 1.0 \times 3.5 = 3.5 \\ = 3.5 \text{ cfs}$$

$$\text{Vol}_5 = (36 \times 70) 3.5 = 8800 \text{ cf}$$

$$\text{Vol}_{100} = (66 \times 70) \times 3.5 \\ = 16,200 \text{ cf.}$$

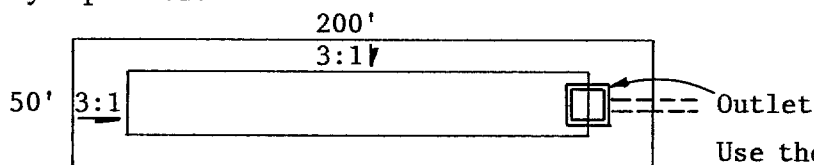
Determine Depth/Volume Curve for Pond:

Assume 3' Deep Pond, shown below

Say  $A_{\text{Top}}$  is roughly twice the volume/depth or

$$A_{\text{Top}} = \frac{16200 \times 2}{3} = 10800 \text{ SF}$$

try a pond of:

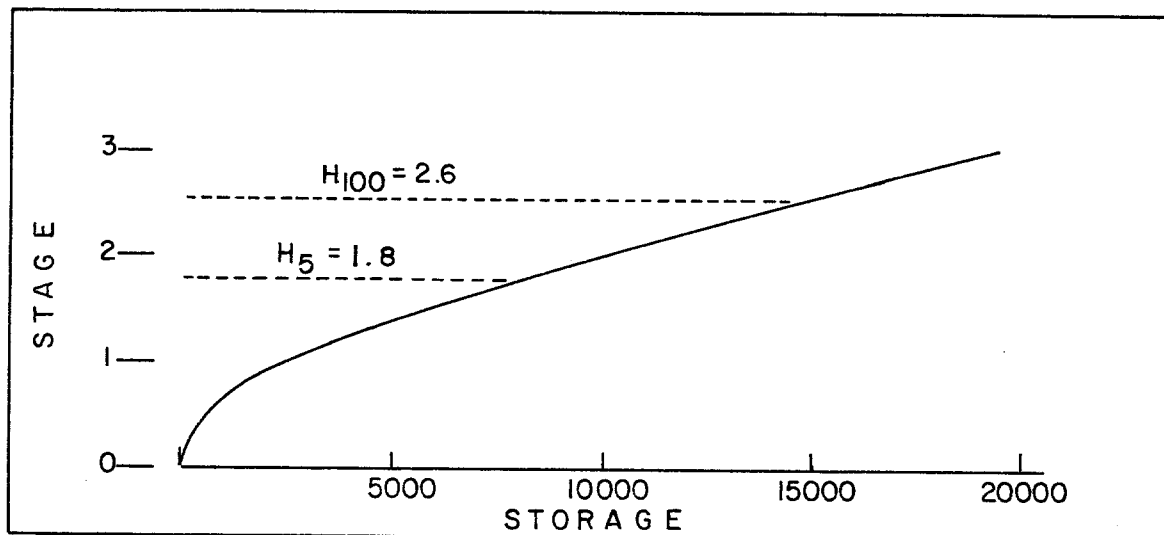


Use the formula:

$$\text{Vol} = 1/3 (A_1 + A_2 + \sqrt{A_1 \times A_2}) D$$

Compute Stage-Storage:

H=Depth	A	V	$\sum V$
0	0		
1	38 x 188 = 7100	2370	2370
2	44 x 194 = 8500	7790	10160
3	50 x 200 = 10000	9240	19400



Find Diameter of Outlet @  $Q_5$

$$H_5 = 1.8' \quad Q_5 = 0.70 \text{ cfs}$$

for this depth and discharge, inlet control nomographs are not applicable, therefore, use orifice equation

$$Q = .6A \sqrt{2gh} \quad A = \frac{\pi D^2}{4}$$

Try  $h = .9H$

$$Q = .6 \times \frac{\pi}{4} \times D^2 \times \sqrt{2 \times 32.2 \times .9 \times 1.8} = 4.82D^2$$

$$D = \left( \frac{0.70}{4.82} \right)^{\frac{1}{2}} = .38 \text{ ft. } 4.7'' \text{ use } 4\frac{1}{2}''$$

$$\frac{h}{H} = \frac{1.8 - .19}{1.8} = .89 \text{ say OK}$$

use  $4\frac{1}{2}'' \text{ } \emptyset$  orifice

$$\text{For } Q_{100} = 3.5 \text{ cfs} \quad H = 2.6'$$

Using inlet control nomographs for RCP

Trial	Q	Pipe Dia.	H/D	H
1	3.5	12	1.4	1.4

Since  $H = 2.6$  is large than 1.4,  $Q$  is more than 3.5 cfs

Must use:

- a) restricter plate and orifice calcs
- or b) wier control

If a restricter plate was used, we would calculate the size as before.

Let's use a notch to control  $Q_{100}$

$$Q_{\text{Notch}} = Q_{100} - Q_{\text{Orifice}}$$

$$Q_{\text{Orifice}} = .6 \times \frac{\pi \times .38^2}{4} \times (2 \times 32.2 \times 2.6)^{\frac{1}{2}} \\ = 0.85$$

$$Q_{\text{Notch}} = 3.50 - 0.85 = 2.65 \text{ cfs}$$

A V-notch provides a theoretically neat solution where the depth of the notch,  $D = H_{100} - H_5$ , but this writer prefers a contracted weir as follows:

To assure proper proportioning: Let  $B = 3H$

Substituting in the Francis Eqn.

Where:  $Q$  = discharge  
 $B$  = width of wier  
 $N$  = no. of contractions  
 $H$  = depth

$$\text{Where: } Q = 3.33 (B - .1nH) H^{3/2} \\ = 3.33 (3H - .2H) H^{3/2} \\ = 3.33 (2.8H) H^{3/2} \\ = 9.32 H^{5/2}$$

$$\text{Thus: } H = \left( \frac{Q}{9.32} \right)^{2/5} = \left( \frac{2.65}{9.32} \right)^{2/5} = .60' = 7\frac{1}{4}''$$

$$B = 3H = 1.80' = 1' - 9\frac{1}{2}''$$

Check emergency overflow from excess stormwater passage:

for this problem let  $T_c = 15$  minutes

then  $Q_{100} = .7 \times 5.9 \times 3.5 = 14.4 \text{ cfs}$  from Fig 2,  $I = 5.9 \text{ in/hr.}$

thru 12"Ø outlet pipe with  $H/D = 3.6$ ,  $Q = 8.0 \text{ cfs}$  which is less than  $Q_{100} = 14.4 \text{ cfs}$  thus any other excess stormwater passage overtops the berm

Normally, it would be preferred to have excess storm water passage overtop the detention basin and revert to sheet flow. For this case, when there is a level berm, the berm becomes a broad crested weir. Check the depth and velocity of flow and assess any likely undesirable effects of this type of flow.

Where it is desirable to concentrate the excess storm water passage into a channel, swale, gutter or ditch, or when the velocity of flow overtopping the berm is great, then sufficient protection shall be provided to prevent damage to the detention pond.

## **APPENDIX D**

DRAINAGE BASIN MAP AVAILABLE FROM CITY OF LAKEWOOD  
PUBLIC WORKS DEPARTMENT, ENGINEERING DEVELOPMENT ASSISTANCE  
480 SOUTH ALLISON PARKWAY  
CIVIC CENTER NORTH  
303-987-7500

## **APPENDIX E**

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0-81-165

A BILL FOR AN

ORDINANCE ADOPTING REGULATIONS DESIGNED TO LESSEN HAZARDS TO PERSONS AND PROPERTY CAUSED BY INCREASED STORM WATER RUNOFF AND TO OTHERWISE PROMOTE THE PUBLIC HEALTH, SAFETY, AND GENERAL WELFARE

SECTION 1. Title - This ordinance shall be known as the Storm Water Management Ordinance of the City of Lakewood, Colorado.

SECTION 2. Purpose - In order to promote the public health, safety, and general welfare of the citizens of Lakewood, Colorado, these storm water management regulations are enacted for the general purpose of assuring the proper balance between use of land and the preservation of a safe and beneficial environment. More specifically, the provisions of these regulations are intended to reduce property damage and human suffering and minimize the hazards of personal injury and loss of life due to flooding. This is to be accomplished by establishing runoff control, establishing responsibilities for maintenance and operation, and establishing technical standards and criteria for implementation of storm water management.

SECTION 3. General Interpretation. For purposes of this ordinance, the words and terms used, defined, interpreted, or further described herein shall be construed as follows:

City. The City of Lakewood, Colorado.

Control Structure. A facility constructed to regulate the rate of discharge of storm water.

Development. Any man-made change to real estate or property, including buildings or other structures, streets, parking lots, mining, dredging, filling, grading, paving, or excavating.

Director. The City Administrator or his/her designee.

Easement. Authorization by a property owner for use by another party or parties of all or any portion of his/her land for a specified purpose.

Emergency Excess Storm Water Passage. A channel or swale formed in the ground surface to carry storm water runoff through a specific area.

Excess Storm Water. That portion of storm water runoff which exceeds the transportation capacity of storm sewers or natural drainage channels serving a specific watershed.

Infill Development. The development of land which 1) has previously been subdivided or 2) is described by a metes and bounds description and which can legally be developed without subdivision.

Natural Drainage. Water which flows by gravity in channels formed by the surface topography of the earth prior to changes made by the efforts of man.

Natural State. Land with soil and vegetation conditions that existed prior to any man-made activity on the land.

New Development. The development of land which has not been previously legally subdivided.

Safe Storm Water Drainage Capacity. The quantity of storm water runoff that can be transported within a channel, passage, conduit, tube, duct, or combination thereof in such a manner that the elevation of the water does not rise above the level of the adjacent ground surface so as to cause any damage to structures or facilities located thereon.

Storm Water Runoff. Water that results from precipitation which is not absorbed by the soil, evaporated into the atmosphere, or entrapped by ground surface depressions and vegetation, and which flows over the ground surface.

Storm Water Management System. All facilities used to control storm water including storm water pipes, storm water detention areas, berms, channels, swales, control structures, easements, emergency excess storm water passages, irrigation systems, improved water courses, and any other facility or appurtenances used in the management of storm water.

Storm Water Runoff Release Rate. The rate (quantity per unit of time) at which storm water runoff is released from upstream to downstream land.

Storm Water Detention Area. An area designated to temporarily accumulate excess storm water.

Tributary Watershed. The entire catchment area that contributes storm water runoff to a given point.

100-year Storm Rainstorms of a specific duration having a 1% chance of occurrence in any given year.

5-year Storm. Rainstorms of a specific duration having a 20% chance of occurrence in any given year.

**SECTION 4. Applicability** - Any person, firm, corporation or business proposing to construct buildings or develop or redevelop land within the City shall be required to provide storm water runoff control meeting the requirements of this ordinance whenever the total area of land under identical ownership including the land to be developed or upon which buildings are to be constructed, equals or exceeds those shown in the following chart. This chart applies to both building permits and subdivision of land.

<u>Type of Development</u>	<u>Zoning Classification</u>	<u>Area</u>
New and Infill	CN	Exempt
New and Infill	1R, 2R, 3R and single family and duplex portions of MU.	2 acres



New and Infill

4R, 5R, 6R, OF, 1-C, 1 Acre  
2-C, 3-C, 4-C, 5-C, IN,  
and multi-family thru  
industrial portions of MU

**SECTION 5. Design Criteria and Performance Standards.** It shall be the duty of an applicant for a building permit or subdivision of land to provide a storm water management system as provided herein.

A. Design Criteria - Unless otherwise provided, the Engineering Regulations, Construction Specifications, Design Standards, and amendments adopted by the City Council, Lakewood, Colorado, shall govern the design of improvements with respect to managing storm water runoff.

B. Storm Water Runoff Release Rate - Any person meeting the application provisions of this ordinance as specified in Section 4 shall control the release rate of storm water runoff so that runoff after development shall not exceed the runoff from the same parcel of land in its natural state for the 5 and 100-year storm respectively.

C. Determination of Detention Volume. The volume of required water detention shall be calculated on the basis of runoff from the 5- and 100-year return frequency storms. Such calculations should be made in accordance with a method of analysis in the Urban Storm Drainage Criteria Manual published by the Denver Regional Council of Governments unless specified otherwise by the Director.

D. Compensating Detention. In the event that orderly and reasonable development of an area requires that the detention of storm water be located elsewhere, compensating detention (the detention of an equal volume of storm water) may be provided at an alternative location if approved by the Director.

E. Partial and Full Exemption - When it can be demonstrated by the applicant to the Director that a higher storm water release rate will not be contrary to the purpose and intent of this ordinance and where such proposed release rate will not exceed the safe storm water drainage capacity in the downstream portion of the watershed, the release rate may be increased or decreased as deemed appropriate by the Director. When determining the safe storm water drainage capacity in the downstream portion of the watershed, it shall be assumed that all undeveloped land in the tributary watershed would be granted the same exemption as the applicant. If the safe storm water drainage capacity is exceeded under these conditions, the applicant's release rate will be decreased so that the safe stormwater drainage capacity is not exceeded.

F. Emergency Excess Storm Water Passage - An excess storm water passage shall be provided for all storm water detention areas. Such passage shall have the capacity to convey through the proposed development the excess storm water from the tributary watershed. The capacity of such storm water passage shall be constructed in a manner to transport the peak rate of runoff from the 100-year frequency storm assuming all storm sewers are inoperative, all upstream areas are fully developed, and that antecedent rain fall has saturated the tributary water shed.

No buildings or structures shall be constructed within the excess storm water passage; however, streets, parking lots, playgrounds, park areas, pedestrian walkways, utility easements and other open space uses shall be considered compatible uses within the excess storm water passage.

Where a proposed development contains an existing natural drainage channel, appropriate land planning shall be undertaken to preserve the natural drainage channel as part of the excess storm water passage.

**SECTION 6. General Provisions.**

A. Administration - This ordinance shall be administered by the Director.

B. Administrative Appeals - Any person affected by any decision of the Director which has been given in connection with the application and enforcement of this ordinance may appeal the decision to the Planning Commission. The appeal shall be filed within seven (7) days of the decision of the Director.

Any person appealing the decision shall file a written petition with the Director and set forth a brief statement concerning the purpose of the hearing. Upon receipt of the petition, the Director shall set a time and place for such hearing and shall provide written notice to the petitioner. At such hearing, the petitioner shall be given the opportunity to be heard and show why any decision should be modified or withdrawn. The hearing shall be commenced not later than forty-five (45) days after the date on which the petition was filed.

Any person aggrieved by the decision of the Planning Commission may seek relief in any court of competent jurisdiction as provided by the laws of Colorado. An appeal pursuant to this section shall not stay the effect of the Director's order unless so ordered by the Planning Commission.

**C. Public and Private Responsibilities for Maintenance of the Storm Water Management System**

1. Public Responsibilities. In areas constructed exclusively as single-family detached dwellings or two-family detached dwellings, the City of Lakewood shall be responsible, after acceptance of the storm water management system, for the maintenance and operation of any storm water management system within a public easement. It is the intent of the City to provide for maintenance and operation of storm water facilities in areas of single family detached dwellings and two-family detached dwellings, provided there are public easements within which maintenance and operation can be done and provided all design, construction, and maintenance criteria of the City are followed. Maintenance and operation of condominiums, multi-family, commercial, industrial and other uses shall be done by other persons as stated in Section 6.C.2. In areas of mixed use such as multi-family housing and single family detached dwellings, the Director will decide on a case-by-case basis whether maintenance and operation will be performed by the City.

2. Private Responsibilities. If the Director has determined that the City will not accept the responsibility for maintenance and operation of a storm water management system, the owner of the land then has the responsibility for the maintenance and operation of the storm water management system. Such responsibility shall be assumed by subsequent owners.

If the City has determined that the property owner has not properly maintained or operated the storm water management system, the Director shall cause notice to be served upon the property owner. Such notice shall be in writing, signed by the Director and shall be personally served upon the property owner. The notice shall specifically state why the storm water management system has been determined to be improperly maintained or operated and the procedures which must be undertaken to correct the system's deficiencies.

Any person wishing to appeal the City's determination that the storm water management system has not been properly maintained or operated shall file a written petition with the Director as described in Section 6.B. of this Ordinance. If the property owner does not appeal or correct the deficiencies within fourteen days of service of the notice, the City has the right to enter the property, maintain the storm water management facilities, and require reimbursement for the costs that may be incurred by the City.

**SECTION 7. Easements.** Easements which cover the outlet structure, low flow pipe, storm water pipes, detention area berms, and other parts of the storm water management system as the City deems desirable shall be granted to the City. These easements are to be deeded for the purposes of operation, repair, alteration, and maintenance in areas composed of single family detached dwellings and two-family dwellings or in other developments when the City has accepted maintenance and operation responsibilities.

All developments which have publicly owned easements shall provide covenants running with the land stating that no buildings, fills, excavations, structures, fences, or other alterations shall be constructed within a publicly owned easement without the express written consent of the City.

The enactment of this ordinance is not intended to modify or alter any existing easement or rights-of-way for storm drainage purposes, but is intended to establish criteria for construction and maintenance and operation of new storm drainage facilities, both public and private.

**SECTION 8. Statement on Building Permit, Final Plat and/or Site Plan.** When the City has determined that maintenance and operation of the storm water management system is to be a private responsibility, the building permit, final plat and/or site plan of that development shall have language stating that the maintenance and operation of the storm water management system will remain the responsibility of the property owner and his heirs, successors, and assigns.

**SECTION 9. Disclaimer of Liability** - The criteria set forth in this ordinance establish minimum requirements which must be implemented with good engineering practice and workmanship. Use of the requirements in this ordinance shall not constitute a representation, guarantee, or warranty of any kind by the City of Lakewood as to the adequacy or safety of any storm water management system. Larger storms may occur or storm water runoff heights may be increased by man-made or natural causes. These regulations shall not create liability on the part of the City with respect or any legislative or administrative decision made hereunder.

**SECTION 10. Repealer.** All ordinances or parts of ordinances in conflict with the provisions of this ordinance are hereby repealed.

SECTION 11. Severability. If any section, provision or part of the ordinance shall be adjudged to be invalid or unconstitutional, such adjudication shall not affect the validity of the ordinance as a whole or any section, provision, or part thereof not adjudged invalid or unconstitutional.

SECTION 12. Effect. This ordinance shall take effect thirty (30) days after final publication.

INTRODUCED, READ AND PASSED on first reading at a regular meeting of the City Council on December 14, 1981; ordered published in full in the Lakewood Sentinel and Public Hearing and consideration on final passage set for December 28 1981, at 7 o'clock p.m. at Lakewood City Hall, 44 Union Boulevard, Lakewood, Colorado.

**APPENDIX F**

**ORDINANCE**

**0-82-102**

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A BILL FOR AN

ORDINANCE ADOPTING STORM WATER DRAINAGE CRITERIA MANUAL, AN ADDENDUM TO THE ENGINEERING REGULATIONS, CONSTRUCTION SPECIFICATIONS, AND DESIGN STANDARDS FOR THE CITY OF LAKEWOOD, COLORADO.

WHEREAS, by Ordinance 0-81-63, the City Council of the City of Lakewood ("City") adopted Engineering Regulations, Construction Specifications, and Design Standards ("Regulations") for the City;

WHEREAS, Section IV (5), "Drainage and Flood Control," and Appendix 2, "Guidelines for Drainage Studies," of said Regulations, pertain to storm water mangement; and

WHEREAS, the Storm Water Drainage Criteria Manual ("Manual") has been developed as an addendum to said Regulations and as a replacement for said Section IV (5) and said Appendix 2, and the City Council wishes to adopt said Manual to establish standards for the management of storm water within the City.

NOW, THEREFORE, BE IT ORDAINED by the City Council and the City of Lakewood, Colorado, that:

SECTION 1. The Storm Water Drainage Criteria Manual, an Addendum to the Engineering Regulations, Construction Specifications, and Design Standards, and dated August 9, 1982, be and hereby is adopted. Said Manual shall replace Section IV (5), "Drainage and Flood Control," and Appendix 2, "Guidelines for Drainage Studies," of said Regulations.

SECTION 2. A copy of the Manual shall be available for review in the City Clerk's Office during regular business hours.

SECTION 3. This ordinance shall take effect thirty (30) days after final publication.

INTRODUCED, READ AND PASSED on first reading at a regular meeting of the City Council on July 26, 1982; ordered published in full in the Lakewood Sentinel and Public Hearing and consideration on final passage set for August 9, 1982, at 7 o'clock p.m. at Lakewood City Hall, 44 Union Boulevard, Lakewood, Colorado.