Cheyenne Canyon Entryway

FINAL DRAINAGE REPORT

prepared for:

THE CITY OF COLORADO SPRINGS
PARK AND RECREATION DEPARTMENT

September 1994

prepared by:

CENTENNIAL

CENTENNIAL ENGINEERING, INC.
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(1436.00)

CENTENNIAL

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TEL: 303-420-0221
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September 19, 1994

Mr. Michael Shafer
Colorado Springs Park & Recreation
1401 Recreation Way
P.O. Box 1575, Mail Code 1200
Colorado Springs, CO 80901-1575

RE: Final Drainage Report - North Cheyenne Canyon Entryway

Dear Mr. Shafer:

Attached is the report for the referenced project. The report presents a summary of the analysis performed on the existing drainage patterns and structures that contribute to the intersection for the 10-year storm and utilizing the current City of Colorado Springs Drainage Criteria. Please review and if you have any questions, I will be available to answer them.

Sincerely,

Charles E. Weiss, PE

Reviewed by:

Douglas C. Weber, PE
Chief Civil Engineer

CEW:kam
d:\report\143600.2

cc: S. Behrens
D. Weber

TABLE OF CONTENTS

1.0
INTRODUCTION

1.1 PURPOSE AND SCOPE

This report has been prepared as part of the final design of drainage facilities for the North Cheyenne Canyon Entryway project, which is located at the intersection of Cheyenne Boulevard, South Cheyenne Canyon Road, North Cheyenne Canyon Road, and Evans Avenue. The Parks and Recreation Department proposes to modify the intersection to facilitate movements and to provide a more aesthetic entryway to North Cheyenne Canyon.

The intersection improvements include curb and gutter construction, placement of drainage facilities, and landscaping. A parking lot will be placed where the caretaker's resident previously existed. It will serve as overflow parking and a point for canyon residents to collect mail.

This report summarizes the results of the hydrology and hydraulic analyses performed as part of the final design of the drainage facilities. The analysis includes the following tasks:

- Background research.
- Field survey.
- Field reconnaissance.
- Hydrologic analysis of drainage basins (10-year and 100-year).
- Hydraulic analysis of existing and proposed drainage structures.

2.0
STUDY AREA DESCRIPTION

2.1 EXISTING CONDITIONS

The North Cheyenne Canyon Entryway project is located in the southwest section of the City of Colorado Springs (see Vicinity map - Figure 2.1). The intersection is paved and does not have curb and gutter. Upper Cheyenne Creek parallels North Cheyenne Road and Cheyenne Boulevard. The major drainage structures in the project area, such as bridges on Upper Cheyenne Creek, are outside the scope of this report.

2.2 DRAINAGE BASIN DESCRIPTIONS

The project is located in the Southwest Area Drainage Basin. The Master Drainage Report for this basin was prepared in February of 1984. Contributing drainage areas that impact the project are indicated on the attached drainage map.

In order to identify the tributary drainage basins for the site, several assumptions were made based on field investigations and topographic mapping. They are as follows:

1) A lake located in the offsite tributary area will capture all minor flows draining to it, thus becoming the upper basin limits for the minor storm.

2) The major flows tributary to the intersection will sheet flow over the lake and intersection and into Upper Cheyenne Creek, as it has historically.

The only existing drainage facility on the project site is a 15" RCP. It intercepts flows from the offsite tributary area via a roadside ditch along North Cheyenne Canyon Road and drains into Upper Cheyenne Creek. Any flow exceeding the capacity of either the roadside ditch or 15" RCP will sheet flow across the pavement and into Upper Cheyenne Creek. The 15" RCP is greatly undersized. It has a HW/D greater than six feet. The entrance of the 15" RCP is submerged and sheetflow across the intersection occurs during the 10-year storm.

10 YEAR CONTRIBUTING AREA

ADDITIONAL 100 YEAR CONTRIBUTING AREA

FIGURE 1.1

3.0
STUDY CRITERIA

3.1 REGULATIONS

The City of Colorado Springs/El Paso County Drainage Criteria Manual (CS/EPDCM) (Reference 1) was used as a basis for this study. In addition, the STORM computer program was used for design and sizing of the storm sewer. The City of Colorado Springs directed Centennial to design for the 10-year frequency and to use D-10-R inlets for design purposes.

3.2 HYDROLOGY

The Rational Method was used since the basins are less than 100 acres. Basin area delineation was determined from "Engineering Study of the Southeast Drainage Basin (Cheyenne Creek, Cheyenne Run, and Spring Run)" (Reference 2) and field survey. Runoff was determined to each design point and the proposed storm sewer system has been designed based on the 10-year storm frequency. The 100-year flow was evaluated to determine if historic flow patterns have changed. Rainfall intensities, C-values, times of concentration, and travel times were all taken from the CS/EPDCM.

3.3 HYDRAULICS

3.3.1 Street Drainage and Inlet Design

Street capacity calculations were completed for the 10-year minor storm. Street classification and allowable street capacities were obtained from the CS/EPDCM. All inlets were checked with the CS/EPDCM (Figures 7-9 & 7-11).

3.3.2 Storm Sewer Design

Storm sewer hydraulic calculations were completed using the STORM program. Hydraulic grade lines and various pipe flow characteristics were evaluated for the 10-year minor storm design. Backwater effects were assumed to occur on the outlet pipe into Upper Cheyenne Creek.

4.0
STORM DRAINAGE DESIGN

The proposed design of the intersection maintains existing drainage patterns. The existing substandard 15" RCP will be removed and replaced with a 24" storm sewer. The 24" storm sewer has the 10-year storm capacity and outfalls just downstream of the proposed pedestrian bridge.

Three inlets are connected to the 24" storm sewer. A D-10-R inlet is located along the north side of North Cheyenne Canyon Road just west of the proposed parking lot. A second D-10-R inlet was located east of the parking lot to receive runoff from the parking lot and carryover from the previous inlet. A third D-10-R inlet receives runoff along the south curb of North Cheyenne Canyon Road, and serves as a junction for the 24" storm sewer, which outlets into Upper Cheyenne Creek from this inlet. One other D-10-R inlet is located within the project limits, and it outlets directly to Upper Cheyenne Creek.

The STORM program was used to route the 10-year flow and to determine the hydraulic grade line. The City of Colorado Springs/El Paso County Drainage Criteria Manual was used to determine street and inlet capacities, as well as riprap protection.

The 100-year flow was evaluated and it was determined that historic drainage patterns would not be altered by this project. The 111 cfs would overtop the intersection, as it historically has, and sheetflow into Upper Cheyenne Creek.

Reference is made to the Appendix for the STORM computer run and Figures 1.1 and 2.1 for the Basin Delineation Map. Manhole and line reference numbers for STORM and flow patterns are shown on Figure 2.1.

5.0
SUMMARY

In summary, the existing 15" RCP along the north side of North Cheyenne Canyon Road is inadequate to handle the 10-year flow. Runoff presently sheetflows over the intersection and into Upper Cheyenne Creek. The addition of curb and gutter and D-10-R inlets captures runoff and conveys it to Upper Cheyenne Creek for the parking lot and design areas within the intersection. The southeast quadrant was not analyzed since the historic drainage patterns were not altered significantly.

The 24" storm sewer was found to be in partial to full flow for conveyance of the 10-year storm. For purposes of this report, it was assumed that the water surface level of Upper Cheyenne Creek would submerge the outfall and create a backwater effect on the hydraulic grade line of the sewer. Analysis of water surface profiles in Upper Cheyenne Creek is beyond the scope of this report.

6.0
REFERENCES

1. "City of Colorado Springs/El Paso County Drainage Criteria Manual," October 1987, revised November 1991.

2. "Engineering Study of Southwest Area Drainage Basin (Cheyenne Creek, Cheyenne Run, and Spring Run), Colorado Springs, Colorado," Lincoln Devore, February 1984.

3. "Final Drainage Report for North Cheyenne Canyon Entryway, Colorado Springs, Colorado," Centennial Engineering, Inc., September 1991.

4. "North Cheyenne Canyon Park Orientation Center, Sheets SD-1, SD-2," Morrell Wright Bean and Associates, September 1990, revised December 1990.

5. "Procedures for Determining Peak Flows in Colorado," Soil Conservation Service, March 1984.

FIGURE 2.1

STATEMENT:

THE CITY OF COLORADO SPRINGS RECOGNIZES THE DESIGN ENGINEER AS HAVING RESPONSIBILITY FOR THE DESIGN; THE CITY HAS LIMITED ITS SCOPE OF REVIEW ACCORDINGLY.
RESUBMITTAL REQUIRED IF CONSTRUCTION HAS NOT COMMENCED WITHIN 180 DAYS AFTER REVIEW DATE.

REVIEW:

STREET DESIGN:
ROUGH CUT REVIEW ____________ DATE ______
FINAL REVIEW ____________ DATE ______
DRAINAGE DESIGN:
FILED IN ACCORDANCE WITH SECTION 15-3-906 OF THE CODE OF COLORADO SPRINGS 1980, AS AMENDED ____________ DATE ______

DESIGN DATA:

SIDEWALKS: WIDTH ______
LOCATION: Attached ☐
Detached, 6" from P/L ☐

CURB TYPE 1 ☐ 2 ☐ 3 ☐
R/W WIDTH ______ F/C – F/C ______
STREET TYPE ______ HVEEM ______

ASPHALT THICKNESS:
AC Surface ______
AC Base ______
AGG. BASE THICKNESS:
Class 6 ______
Class 5 ______
Class 2 ______

SCALE: HORIZ. 1" = 20'

BENCHMARK: All Elevations shown are based on a COLORADO SPRINGS DEPARTMENT of UTILITIES INFORMATION MANAGEMENT SYSTEMS (CSDU FIMS) BENCH MARK. It is a BRASS CAP in rock NO. 183 located southerly of the project site. The elevation of BRASS CAP NO. 183 is 6379.35

REVISIONS:

NO.	DESCRIPTION	DATE
1.)		
2.)		
3.)		
4.)		

ENGINEER:
CENTENNIAL
CENTENNIAL ENGINEERING, INC.
DESIGNED BY: ______ DATE: ______
DRAWN BY: ______ DATE: ______
CHECKED BY: ______ DATE: ______

PROJECT *NORTH CHEYENNE CANYON ENTRYWAY DESIGN*
FROM ______ TO ______
SUBDIVISION *CHEYENNE CANYON PARK*
DRAINAGE BASIN *CHEYENNE CREEK*
JOB NO. 1436.00 SHEET 1 OF 1

APPENDIX

CENTENNIAL ENGINEERING, INC.
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Office Location: 15000 W. 64th Ave., Arvada, Colo. 80004

JOB NO. 1436.00 CLIENT C. SPGS. PARK & RECREATION DATE

JOB TITLE/SUB-TITLE CHEYENNE CANYON ENTRYWAY

SUBJECT DRAINAGE BY CEW CK'D BY

DESCRIPTION: THE BASIN TRIBUTARY TO THE 15" RCP IS A SUB-BASIN OF BASIN I-J, AS DEFINED IN THE LINCOLN DEVORE STUDY. FOR THE 10-YR FREQUENCY, ONLY THE AREA BELOW THE LAKE IS TRIBUTARY TO THE PIPE. USE TYPE A SOIL

HYDROLOGY: BASIN AREA = 58.0 ACRES *

* - USE RATIONAL METHOD

OVERLAND FLOW

$\Delta H = 6700 - 6665 = 35'$ $L = 500'$

$S = 35/500 = 0.07$ FT/FT $C = 0.10$

$T_c = 1.87(1.1 - 0.1)(500)^{0.5}(0.07 \times 100)^{-0.33} = 22.0$

$T_o = 22.0$ min

CHANNEL FLOW

$S = 0.07$ FT/FT

$n = 0.030$

$V = \frac{1.49}{0.030}(1.447)^{2/3}(.07)^{1/2} = 7.7$ FPS

$1200/7.7(60) = 2.6$ min $= T_c$

$T_T = T_o + T_c = 22 + 2.6 = 24.6$ min

$I_{10} = 3.05$ in/hr

$Q_{10} = C I_{10} A = 0.10(3.05)(58) = 17.7$ cFS

DITCH HYDRAULICS:

$n = 0.030$ ✓
SIDESLOPES = 10:1
SLOPE = 9'/840' = 1.07%

CAPACITY = 32 CFS OK
(SEE SHEET 8)

PIPE HYDRAULICS:

SINCE THE BASIN Q_{10} = 17.7 CFS IS LESS THAN THE DITCH CAPACITY, THE 15" RCP WAS CHECKED AGAINST THE BASIN FLOW. THE 15" RCP IS GREATLY UNDERSIZED, IT HAS A HW/D OF 5.5. TO ACHIEVE A DESIGN HW/D ≤ 1.5, A 24" RCP IS REQUIRED, ASSUMING THE PIPE IS IN INLET CONTROL AT THE TIME. THE PIPE MAY BE IN OUTLET CONTROL DURING THE SPRING RUNOFF.

7/14

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CHEYENNE CANYON

Description: DITCH CAPACITY

Solve For Discharge

Given Constant Data:

Z-Left............. 10.00
Z-Right............ 10.00
Mannings 'n'....... 0.030
Channel Slope...... 0.0107

Variable Input Data	Minimum	Maximum	Increment By
Channel Depth	0.50	2.00	0.50

8/14

Z-Left (H:V)	Z-Right (H:V)	Mannings 'n'	Channel Slope ft/ft	VARIABLE Channel Depth ft	COMPUTED Channel Discharge cfs	COMPUTED Velocity (fps)
10.00	10.00	0.030	0.0107	0.50	5.07	2.03
10.00	10.00	0.030	0.0107	1.00	32.17	3.22 12.7
10.00	10.00	0.030	0.0107	1.50	94.85	4.22
10.00	10.00	0.030	0.0107	2.00	204.27	5.11

NEW CHANNEL FLOW VELOCITY

9/14

PROJECT: CHEYENNE CANYON ENTRYWAY

STATION: ______ **SHEET** ____ **OF** ____

CULVERT DESIGN FORM

DESIGNER/DATE: CEW / 7-21-94

REVIEWER/DATE: ____ / ____

HYDROLOGICAL DATA

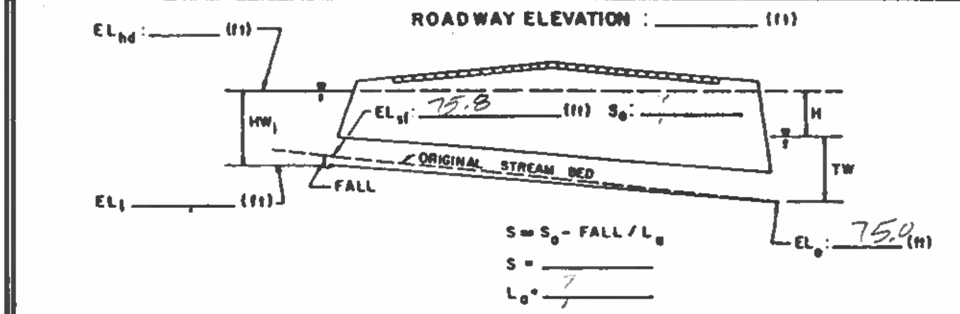
SEE ADD'L SHTS.

- ☐ METHOD: RATIONAL
- ☐ DRAINAGE AREA: 58.0 ☐ STREAM SLOPE: ____
- ☐ CHANNEL SHAPE: ____
- ☐ ROUTING: ____ ☐ OTHER: ____

DESIGN FLOWS/TAILWATER

R.I. (YEARS)	FLOW (cfs)	TW (ft)

ROADWAY ELEVATION: ____ (ft)



$S = S_o - FALL / L_a$

S = ____

L_a = ?

CULVERT DESCRIPTION: MATERIAL - SHAPE - SIZE - ENTRANCE	TOTAL FLOW Q (cfs)	FLOW PER BARREL Q/N (1)	INLET CONTROL HW_i/D (2)	HW_i	FALL (3)	EL_{hi} (4)	OUTLET CONTROL TW (5)	d_c	$\frac{d_c+D}{2}$	h_o (6)	k_e	H (7)	EL_{ho} (8)	CONTROL HEADWATER ELEVATION	OUTLET VELOCITY	COMMENTS
15" RCP	16		5.5	6.9	—	77.8	3'	1	1.13	3	0.2	5.7	83.7	83.7		
	18		6+	7.5				1.25	1.3?	3	.2					SHORT/LEAK... CULVERT
18" RCP	16															

TECHNICAL FOOTNOTES:

(1) USE Q/NB FOR BOX CULVERTS

(2) $HW_i/D = HW/D$ OR HW_i/D FROM DESIGN CHARTS

(3) $FALL = HW_i - (EL_{hd} - EL_{sf})$; FALL IS ZERO FOR CULVERTS ON GRADE

(4) $EL_{hi} = HW_i + EL_i$ (INVERT OF INLET CONTROL SECTION)

(5) TW BASED ON DOWN STREAM CONTROL OR FLOW DEPTH IN CHANNEL.

(6) $h_o = TW$ or $(d_c + D/2)$ (WHICHEVER IS GREATER)

(7) $H = \left[1 + k_e + (29n^2 L)/R^{1.33}\right] v^2/2g$

(8) $EL_{ho} = EL_o + H + h_o$

SUBSCRIPT DEFINITIONS:

- a. APPROXIMATE
- f. CULVERT FACE
- hd. DESIGN HEADWATER
- hi. HEADWATER IN INLET CONTROL
- ho. HEADWATER IN OUTLET CONTROL
- i. INLET CONTROL SECTION
- o. OUTLET
- sf. STREAMBED AT CULVERT FACE
- tw. TAILWATER

COMMENTS / DISCUSSION:

CULVERT IS SMALL FOR A 100 YEAR ... REMOVE 15" RCP, INSTALL 18" RCP ... TO NEW ... INLET DRAIN ...

CULVERT BARREL SELECTED:

SIZE: ____

SHAPE: ____

MATERIAL: ____

ENTRANCE: ____

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Drainage Criteria Manual

Date: OCT. 1987

Figure 9 - 40

REFERENCE: Federal Highway Administration, Hydraulic Design of Highway Culverts; Hydraulic Design Series No. 5 1985

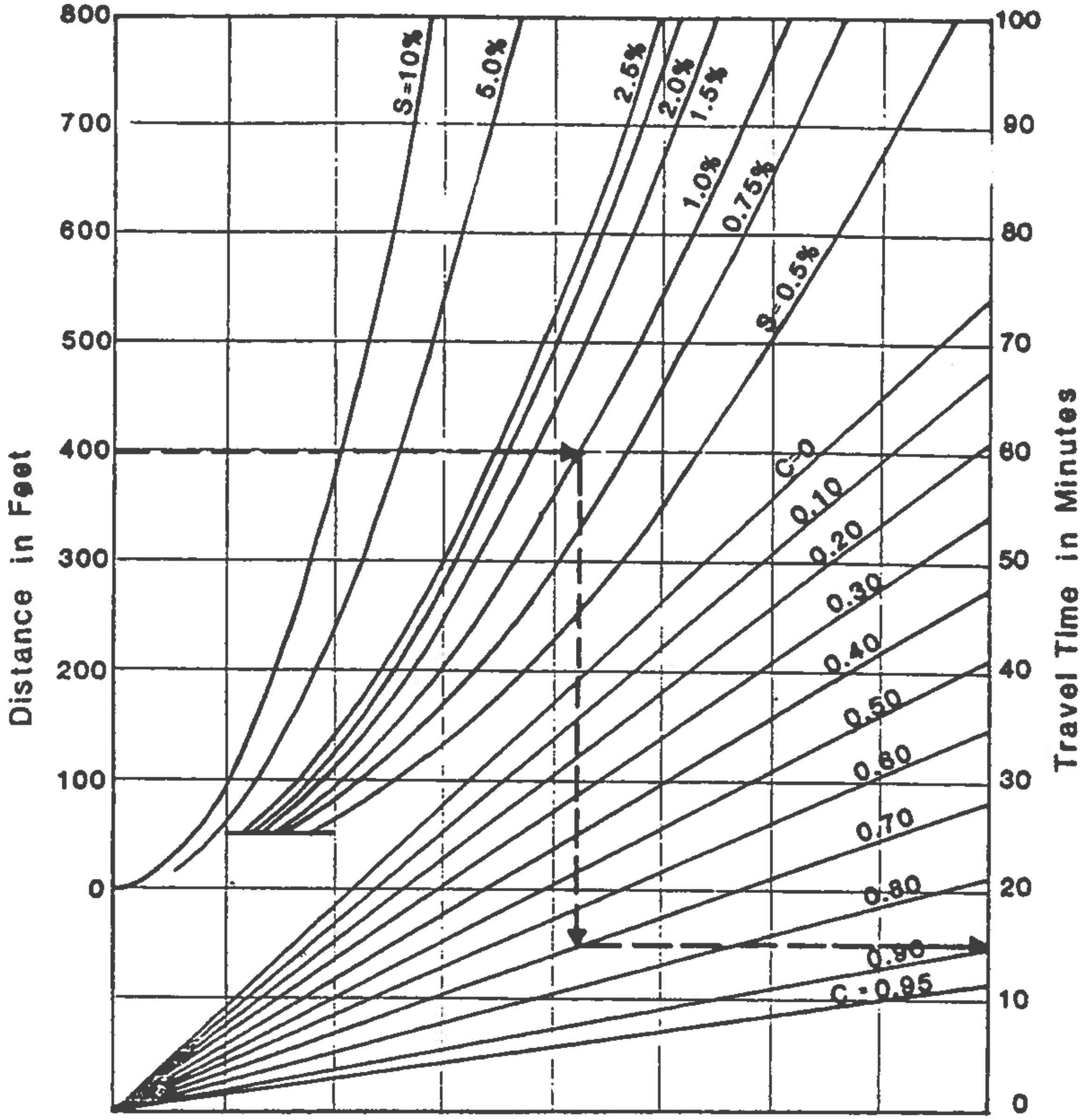
4/14

TABLE 5-1

RECOMMENDED AVERAGE RUNOFF COEFFICIENTS AND PERCENT IMPERVIOUS

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	"C" FREQUENCY 10 A&B*	10 C&D*	100 A&B*	100 C&D*
Business					
Commercial Areas	95	0.90	0.90	0.90	0.90
Neighborhood Areas	70	0.75	0.75	0.80	0.80
Residential					
1/8 Acre or less	65	0.55	0.65	0.65	0.75
1/4 Acre	40	0.50	0.60	0.60	0.70
1/3 Acre	30	0.40	0.50	0.55	0.60
1/2 Acre	25	0.35	0.45	0.45	0.55
1 Acre	20	0.30	0.40	0.40	0.50
Industrial					
Light Areas	80	0.70	0.70	0.80	0.80
Heavy Areas	90	0.80	0.80	0.90	0.90
Parks and Cemeteries	7	0.30	0.35	0.55	0.60
Playgrounds	13	0.30	0.35	0.60	0.65
Railroad Yard Areas	40	0.50	0.55	0.60	0.65
Undeveloped Areas					
Historic Flow Analysis- Greenbelts, Agricultural	2	0.15	0.25	0.20	0.30
Pasture/Meadow	0	0.25	0.30	0.35	0.45
Forest	0	→0.10	0.15	0.15	0.20
Exposed Rock	100	0.90	0.90	0.95	0.95
Offsite Flow Analysis (when land use not defined)	45	0.55	0.60	0.65	0.70
Streets					
Paved	100	0.90	0.90	0.95	0.95
Gravel	80	0.80	0.80	0.85	0.85
Drive and Walks	100	0.90	0.90	0.95	0.95
Roofs	90	0.90	0.90	0.95	0.95
Lawns	0	0.25	0.30	0.35	0.45

* Hydrologic Soil Group



REFERENCE : Wright – McLaughlin Engineers, Urban Storm Drainage Criteria Manual, Vol. 1, Denver Regional Council of Governments, Denver, Co. 1977

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Overland Flow Curves

Figure
5-2

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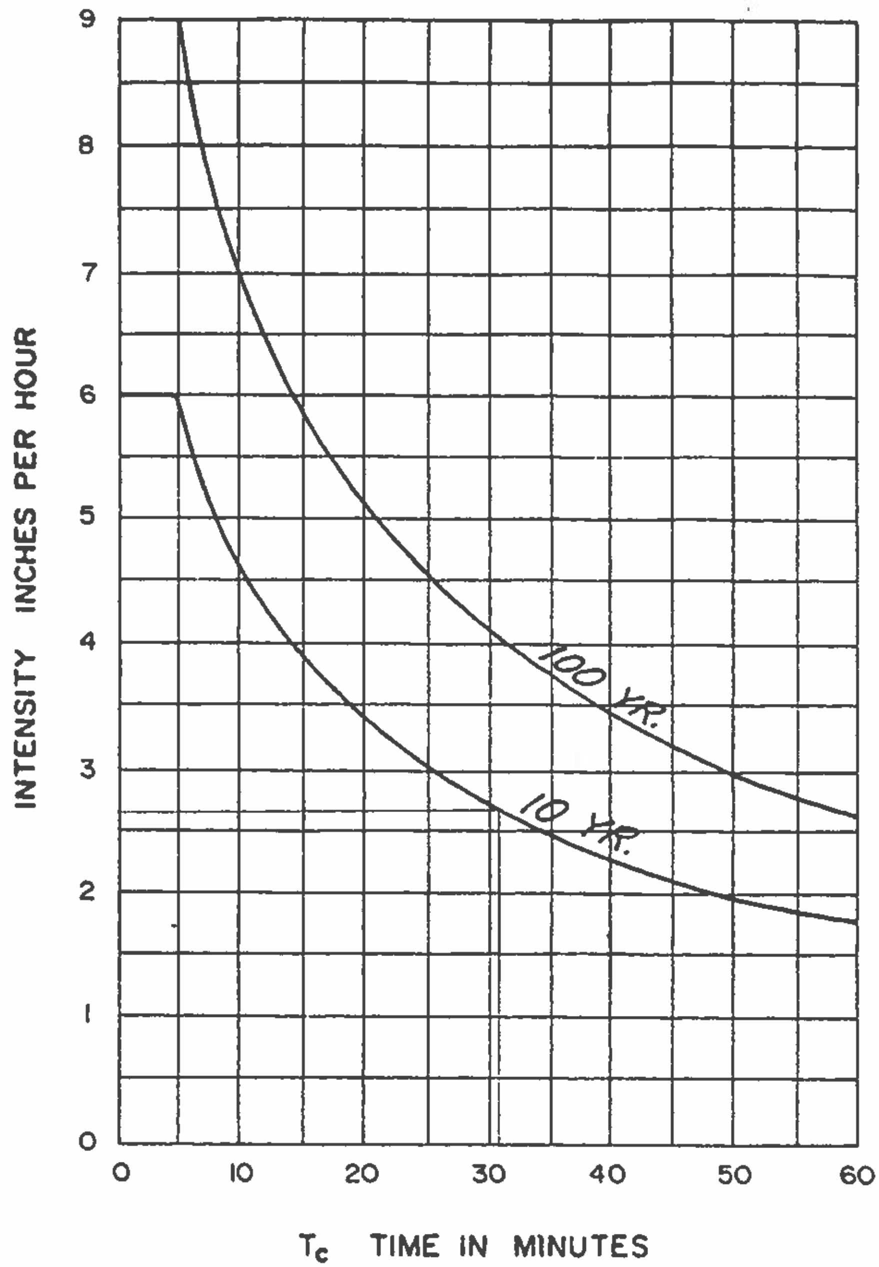

RE: Based upon Pikes Peak area council of governments/ areawide urban runoff control manual.

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Storm Rainfall
Time Intensity-Frequency Curves

Date
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Figure
5 - 1

TABLE 9-1

Entrance Loss Coefficients

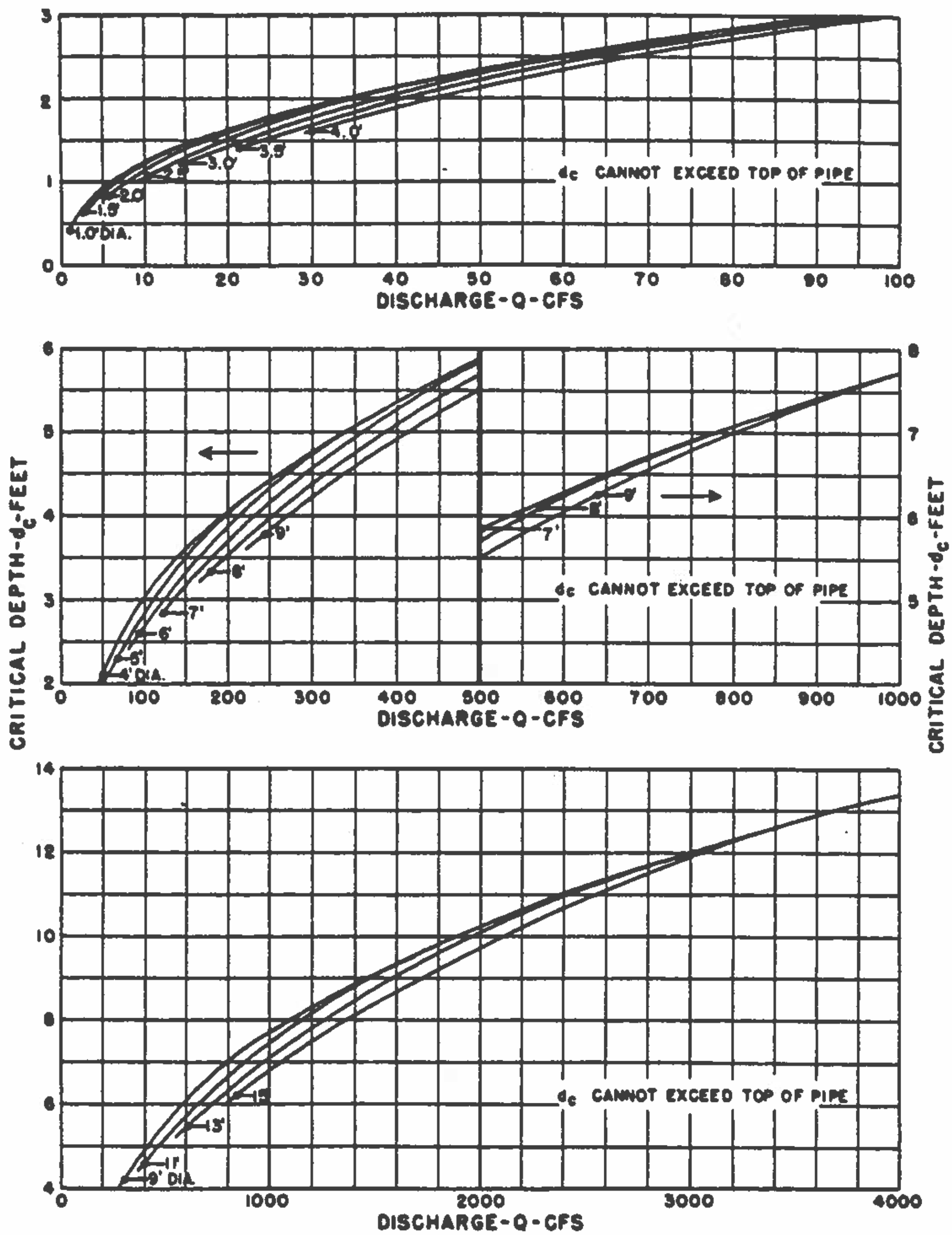
Outlet Control, Full or Partly Full

Type of Structure and Design of Entrance	Coefficient k_e
Pipe, Concrete	
Projecting from fill, socket end (groove end)	0.2
Projecting from fill, square-cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove end)	0.2
Square-edged	0.5
Rounded (radius = 1/12D)	0.2
Mitered to conform to fill slope	0.7
*End section conforming to fill slope	0.5
Beveled edges, 33.7-degree to 45-degree bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
*End section conforming to fill slope	0.5
Beveled edges, 33.7-degree to 45-degree bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30 degrees to 75 degrees to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10 degrees to 25 degrees to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

*Note: End sections conforming to fill slope are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections incorporating a closed taper in their design have a superior hydraulic performance.

Federal Highway Administration, HEC No. 13

12/14



BUREAU OF PUBLIC ROADS

JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

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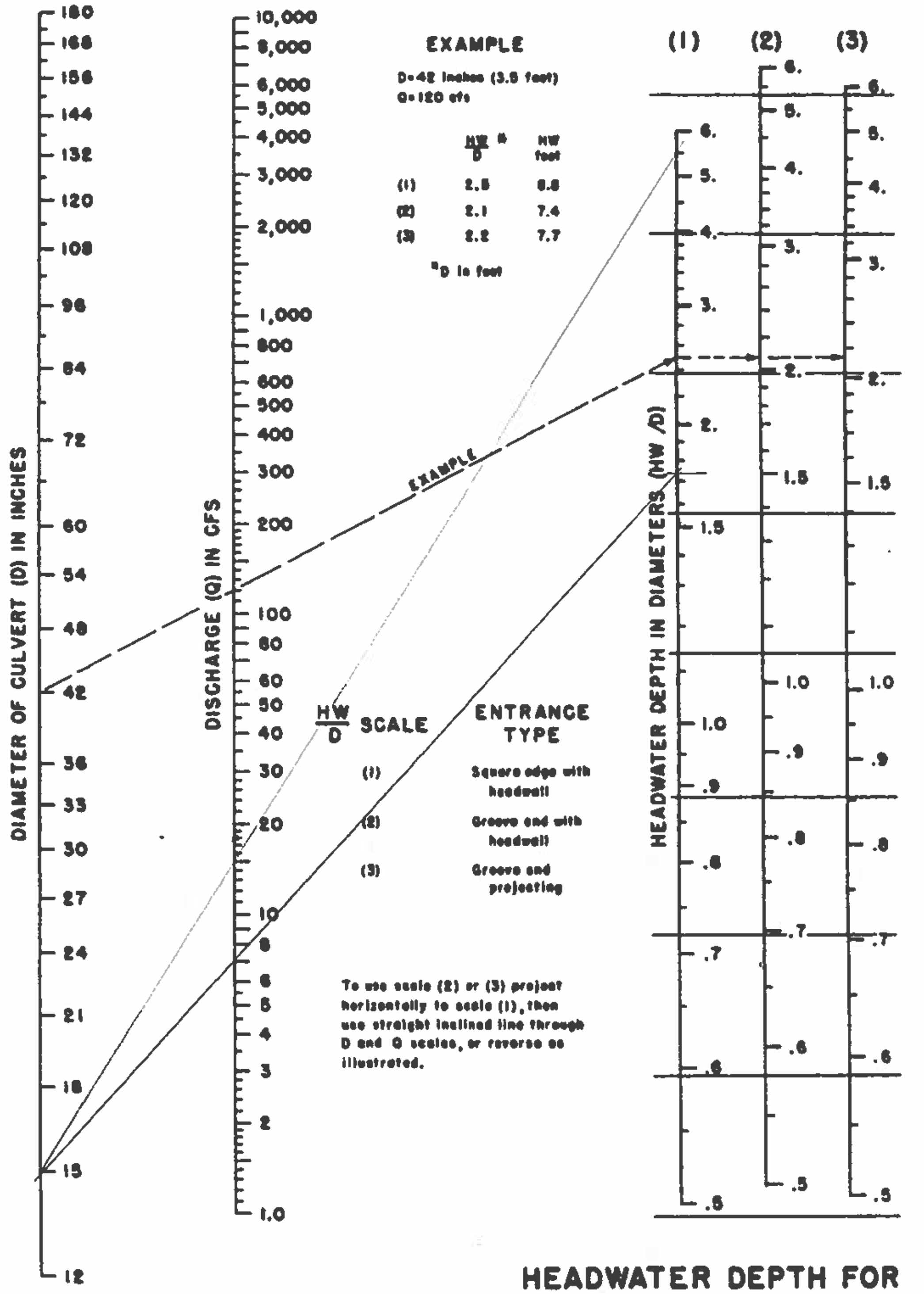
Figure
9 - 27



HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

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Figure
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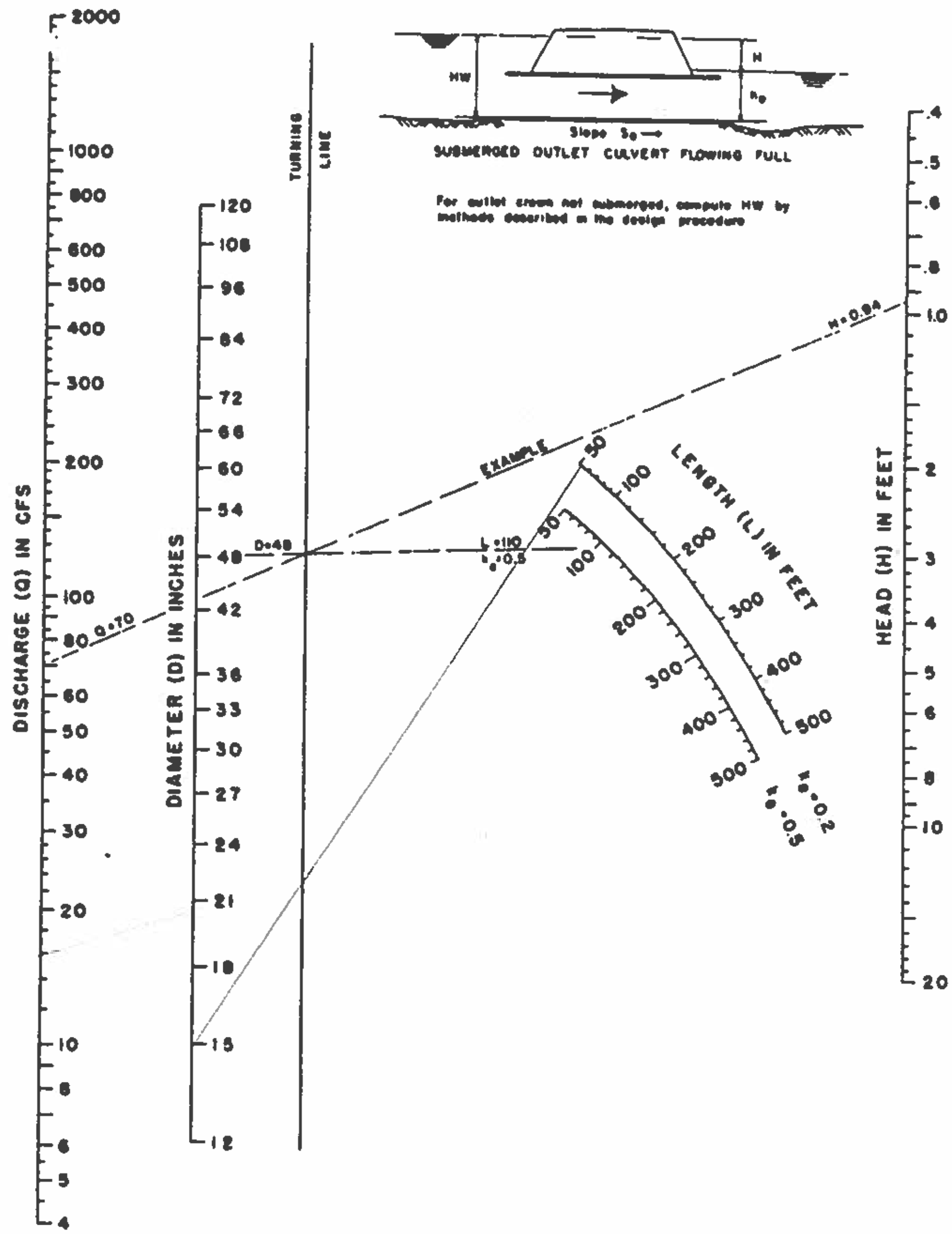
13/14



BUREAU OF PUBLIC ROADS JAN. 1963

HEAD FOR CONCRETE PIPE CULVERTS FLOWING FULL n = 0.012

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Figure
9 - 22

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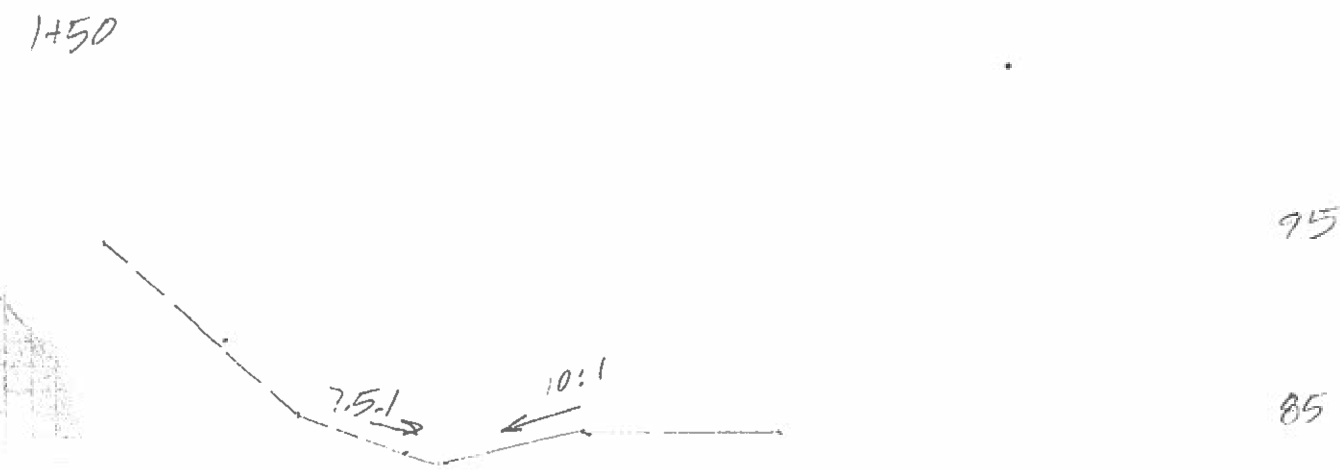
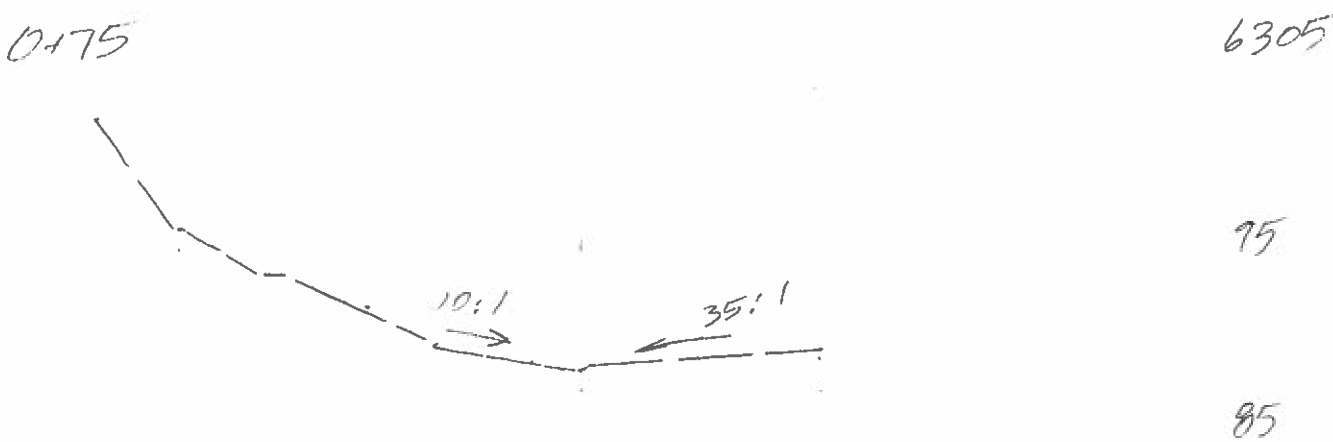
JOB NO. ________ CLIENT ________ DATE ________

JOB TITLE/SUB-TITLE ________

SUBJECT ________ BY ________ CK'D BY ________





ASSUME TRIANGULAR DITCH
10:1 SIDESLOPES , DEPTH = 1 FT.

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PAGE ______ OF ______

JOB NO. 1436.00 CLIENT COLO. SPGS. PARK & RECREATION DATE 7-26-94

JOB TITLE/SUB-TITLE CHEYENNE CANYON ENTRYWAY

SUBJECT DRAINAGE BY CEW CK'D BY ______

PARKING LOT RUNOFF

DESCRIPTION : AN AREA TRIBUTARY TO THE PARKING LOT IS ASSUMED TO BE 75' WIDE AND IS 1000' LONG. PARKING LOT AREA IS ASSUMED TO BE 40'x45' = 1800 SF

HYDROLOGY : BASIN AREA - OVERLAND 1000x75 = 75,000
PARKING 40x45 = 1800
76,800
= 1.76 AC

OVERLAND FLOW

$\Delta H = 6500 - 6400 = 100 \qquad L = 500'$

$S = 100/500 = 20\% \qquad C = 0.10$

$T_c = 1.87(1.1 - 0.10)(500)^{0.5}(0.20 \times 100)^{-0.33} = 15.6 \text{ min}$

DITCH FLOW - 2:1 DITCH, 1' DEEP

$S = 20\% \qquad n = 0.030$

$L = 500'$

$R = 2/4.47 = 0.447$

$V = 1.49 R^{2/3} S^{1/2} / n = 12.98 \text{ FPS}$

$T_c = 500/12.98(60) = 0.7 \text{ min}$

USE $T_c = 16$ min $\qquad i_{10} = 3.85$

COMPOSITE C

$.98(.10) + .02(.90) = 0.12$

$Q_{10} = C i_{10} A = (0.12)(3.85)(1.76) = 0.81 \text{ cfs}$

LOOK @ PEAK PARKING LOT FLOW

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Office Location: 15000 W. 64th Ave., Arvada, Colo. 80004

PAGE ________ OF ________

JOB NO. ____________ CLIENT ____________ DATE ____________

JOB TITLE/SUB-TITLE ____________

SUBJECT ____________ BY ____________ CK'D BY ____________

ASSUME $T_C = 5$ min

$i_{10} = 6$

$Q_{10} = C i_{10} A = 0.90(6)(0.04) = 0.22$ c

USE 15" RCP FOR 1 cFS

CENTENNIAL ENGINEERING, INC.

Mailing Address: P.O. Drawer 1307, Arvada, Colo 80001
Office Location: 15000 W. 64th Ave., Arvada, Colo. 80004

JOB NO. 1436.00 CLIENT Colo. Sts. Park & Recreation DATE 8-28-94

JOB TITLE/SUB-TITLE Cheyenne Canyon Entryway

SUBJECT Drainage BY CEW CK'D BY ______

100 YEAR DISCHARGE: THE LAKE USED AS UPPER BASIN LIMITS FOR Q_{10} IS NOT OF SUFFICIENT SIZE TO CONTAIN Q_{100} FOR AREA TRIBUTARY TO IT. ASSUME WORST-CASE & LAKE HAS NO STORAGE

AREA = 172 AC *
* - USE SCS METHOD

$CN_{AV} = 65$
TYPE IIA, 6 HOUR, 3.5 inch STORM } MASTER DRAINAGE REPORT

<u>OVERLAND FLOW</u>

$S = \frac{7500-7280}{500} = 0.44$ FT/FT

FIGURE 3.1 - FOREST COVER V = 1.65 FPS

500'/1.65 FPS = 303 SEC = T_O

SHALLOW CHANNEL

$S = \frac{7280-6350}{4700} = 0.20$ FT/FT

FIGURE 3.1 FOREST COVER V = 1.50 FPS

4700/1.50 = 3133 SEC = T_C

$T_T = T_C + T_O = \frac{303 + 3133}{60} = 57.3$ MIN
$= 0.96$ HR

SLOPE AVE = 0.22%

RUNOFF FOR 3.5" & CN = 65 = 0.75"

FIGURE 5-1A, q = 130 cfs/in (1% SLOPE)

$Q_{MAX} = 0.75 (130) = 98$ cFS

TABLE 5-1 - FOR 22% SLOPE, Q_{MAX} = 98 x 1.15

CURVE 65

RUNOFF FOR INCHES OF RAINFALL

Inches \ Tenths	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0										
1		0.00	0.00	0.01	0.02	0.03	0.05	0.06	0.09	0.11
2	0.14	0.16	0.19	0.23	0.26	0.30	0.34	0.38	0.42	0.46
3	0.51	0.55	0.60	0.65	0.70	0.75	0.81	0.86	0.92	0.97
4	1.03	1.09	1.15	1.21	1.27	1.33	1.39	1.46	1.52	1.59
5	1.65	1.72	1.79	1.86	1.93	2.00	2.07	2.14	2.21	2.28
6	2.35	2.43	2.50	2.57	2.65	2.72	2.80	2.87	2.95	3.03
7	3.10	3.18	3.26	3.34	3.42	3.50	3.58	3.66	3.74	3.82
8	3.90	3.98	4.06	4.14	4.22	4.30	4.39	4.47	4.55	4.64
9	4.72	4.80	4.89	4.97	5.06	5.14	5.23	5.31	5.40	5.48
10	5.57	5.65	5.74	5.83	5.91	6.00	6.09	6.17	6.26	6.35
11	6.44	6.52	6.61	6.70	6.79	6.88	6.96	7.05	7.14	7.23
12	7.32	7.41	7.50	7.59	7.68	7.77	7.86	7.95	8.04	8.13
13	8.22	8.31	8.40	8.49	8.58	8.67	8.76	8.85	8.94	9.03
14	9.13	9.22	9.31	9.40	9.49	9.58	9.68	9.77	9.86	9.95
15	10.04	10.14	10.23	10.32	10.41	10.51	10.60	10.69	10.78	10.88
16	10.97	11.06	11.16	11.25	11.34	11.44	11.53	11.62	11.72	11.81
17	11.90	12.00	12.09	12.18	12.28	12.37	12.47	12.56	12.65	12.75
18	12.84	12.94	13.03	13.12	13.22	13.31	13.41	13.50	13.60	13.69
19	13.79	13.88	13.98	14.07	14.17	14.26	14.35	14.45	14.54	14.64
20	14.73	14.83	14.93	15.02	15.12	15.21	15.31	15.40	15.50	15.59

NOTE: Runoff value determined by equation $Q = \frac{(P-0.2\,S)^2}{P+0.8\,S}$

REFERENCE: National Engineering Handbook, Section 4, HYDROLOGY

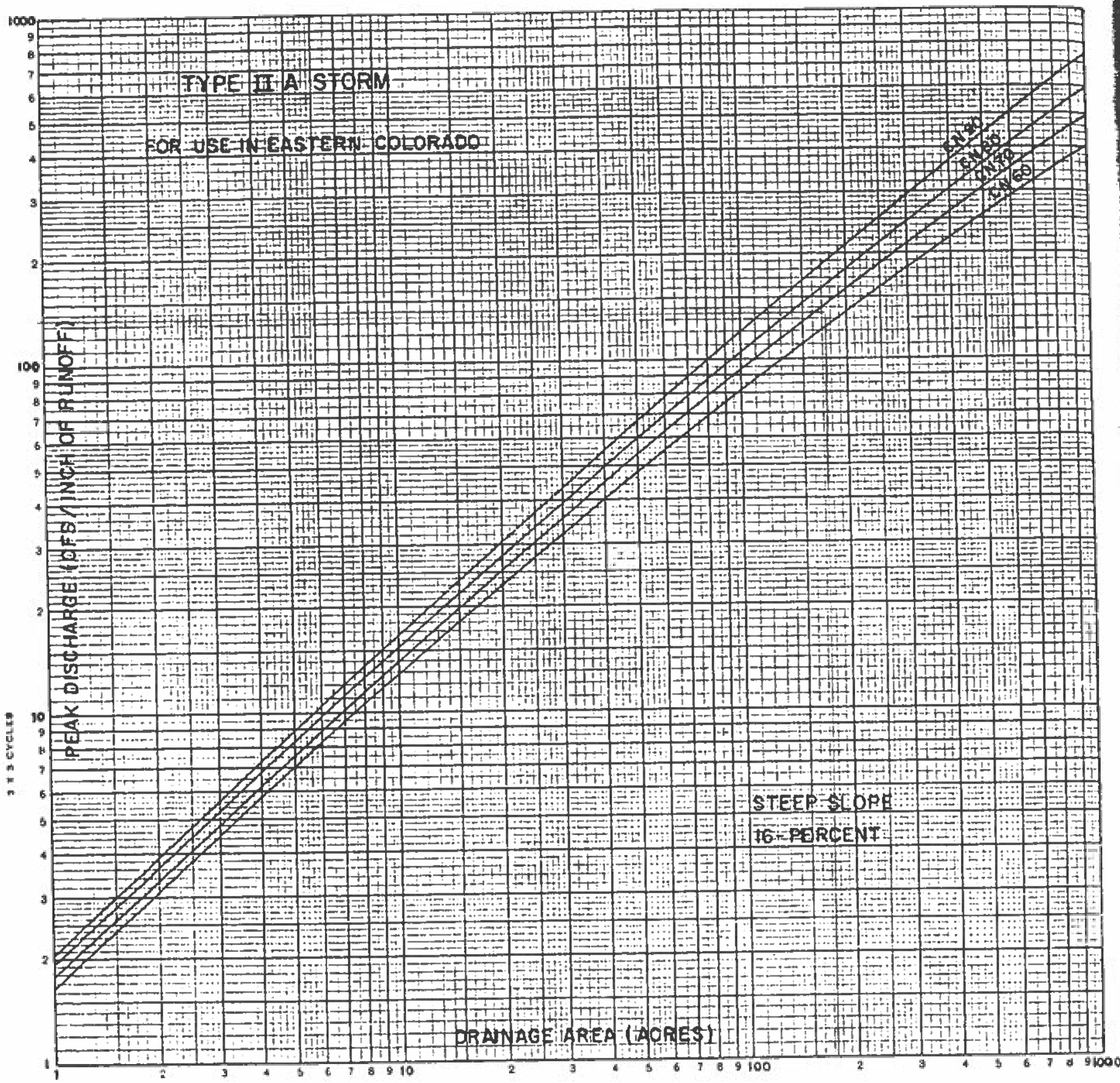

FIGURE S-IA Peak Rates of Discharge for Small Watersheds (24 Hour Type II A Storm Distribution). SHEET 3 OF 6

Table E-1.--Slope adjustment factors by drainage areas

Slope (percent)	10 acres	20 acres	50 acres	100 acres	200 acres	500 acres	1,000 acres	2,000 acres
FLAT SLOPES								
0.1	0.49	0.47	0.44	0.43	0.42	0.41	0.41	0.40
0.2	.61	.59	.56	.55	.54	.53	.53	.52
0.3	.69	.67	.65	.64	.63	.62	.62	.61
0.4	.76	.74	.72	.71	.70	.69	.69	.69
0.5	.82	.80	.78	.77	.77	.76	.76	.76
0.7	.90	.89	.88	.87	.87	.87	.87	.87
1.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.5	1.13	1.14	1.14	1.15	1.16	1.17	1.17	1.17
2.0	1.21	1.24	1.26	1.28	1.29	1.30	1.31	1.31
MODERATE SLOPES								
3	.93	.92	.91	.90	.90	.90	.89	.89
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.04	1.05	1.07	1.08	1.08	1.08	1.09	1.09
6	1.07	1.10	1.12	1.14	1.15	1.16	1.17	1.17
7	1.09	1.13	1.18	1.21	1.22	1.23	1.23	1.24
STEEP SLOPES								
8	.92	.88	.84	.81	.80	.78	.78	.77
9	.94	.90	.86	.84	.83	.82	.81	.81
10	.96	.92	.88	.87	.86	.85	.84	.84
11	.96	.94	.91	.90	.89	.88	.87	.87
12	.97	.95	.93	.92	.91	.90	.90	.90
13	.97	.97	.95	.94	.94	.93	.93	.92
14	.98	.98	.97	.96	.96	.96	.95	.95
15	.99	.99	.99	.98	.98	.98	.98	.98
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10
25	1.06	1.08	1.12	1.14	1.15	1.16	1.17	1.19
30	1.09	1.11	1.14	1.17	1.20	1.22	1.23	1.24
40	1.12	1.16	1.20	1.24	1.29	1.31	1.33	1.35
50	1.17	1.21	1.25	1.29	1.34	1.37	1.40	1.43

COMPUTATION FORM
DRAINAGE & STORM SEWER DESIGN
RATIONAL METHOD

Q = ACi

A - acres
I - inches/hr
Q - cfs
t - min
V - ft/sec

Project Cheyenne Canyon Entryway
Comp. by C. Weiss date 8-16-94
Ck by ____________ date ______

LOCATION			A		C	TIME OF CONCENTRATION		i	Q	DESIGN					PROFILE				
STREET	FROM	TO	INCRE-MENT	TOTAL		TO INLET	PIPE OR CHANNEL			SIZE	SLOPE %	n	CAP. FULL	V	LENGTH FT.	FALL FT.	OTHER LOSSES	UPPER INV. EL.	LOWER INV. EL.
Ditch (10)			58.0	58.0	0.10	24.3		3.05	17.7	24"	9.83	0.016	70.9	18.7					
* (100)			172.0						111.0										
Inlet I-1			0.04		.90	5		6.0	0.22										
			0.04		.95	5		9.0	0.34										
Inlet I-2			0.06		.90	5		6.0	0.32										
			0.06		.95	5		9.0	0.51										
Inlet I-3			0.13		.90	5		6.0	0.70										
			0.13		.95	5		9.0	1.11										
Inlet I-4			0.08		.90	5		6.0	0.44										
			0.08		.95	5		9.0	0.68										

* Due to size, SCS method used

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JOB NO. 1436.00 CLIENT Colo. Spgs. Park & Recreation DATE 7-28-94

JOB TITLE/SUB-TITLE Cheyenne Canyon Entryway

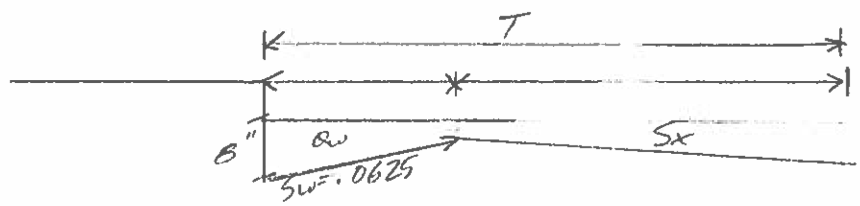
SUBJECT Drainage BY CEW CK'D BY

NORTH CURB INLETS CAPACITIES

$Q_{10} = 0.3$ cfs

GUTTER CAPACITY – 8" VERTICAL CURB
2' WIDE × 1½" DEEP GUTTER
NO CROSS SLOPE
ARTERIAL STREET
SLOPE (STREET) = 5.6%
n = 0.016

CAPACITY (FIG. 7-2) T = NA', W = 2', Ts = NA
Sw = 0.0625, Sx = N.A., S = 0.056
$Z/n = 16/.016 = 1000$



$Q_w = 0.56(1000)(0.056)^{1/2}(0.67)^{2/3} = 10$ cfs CAPACITY

FIG 7-9 FOR L = 4', INLET I-1

$Q_i/Q = 0.3$

$Q_i = 0.3(0.22) = 0.07$

0.15 cfs CARRYOVER

L = 4', INLET I-2

$Q_i/Q = 0.3$

$Q_i = 0.3(0.15 + 0.32) = 0.14$

0.33 cfs CARRYOVER

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JOB NO. 1436.00 CLIENT COLO. SPGS. PARK & RECREATION DATE 7-28-94

JOB TITLE/SUB-TITLE CHEYENNE CANYON ENTRYWAY

SUBJECT DRAINAGE BY CEW CK'D BY

SOUTH CURB INLET CAPACITIES

$Q_{10} = 0.3$ CFS

GUTTER CAPACITY – 8" VERTICAL CURB
2' WIDE x 1½" DEEP GUTTER
4% CROSS SLOPE
ARTERIAL STREET
SLOPE (STREET) – 4.85%
$n = 0.016$

CAPACITY (FIG. 7-2) $T = 29'$, $W = 2'$, $T_S = 27'$

$S_W = 0.06$
$S_x = 0.04$
$S = 0.0$
$z/n = 1563$

$Q_W = .56 \frac{(16.6)}{.016} (.049)^{1/2} (.67$

Q_W: 983 CFS

$Q_S = .56 \frac{(50)}{.016} (.049)^{1/2} (.54)^{8/3}$

$Q_S = 74.9$ CFS

FIG 7.3 – $W/T = 0.069$
$S_W/S_x = 1.5$
$E_o = 0.20$

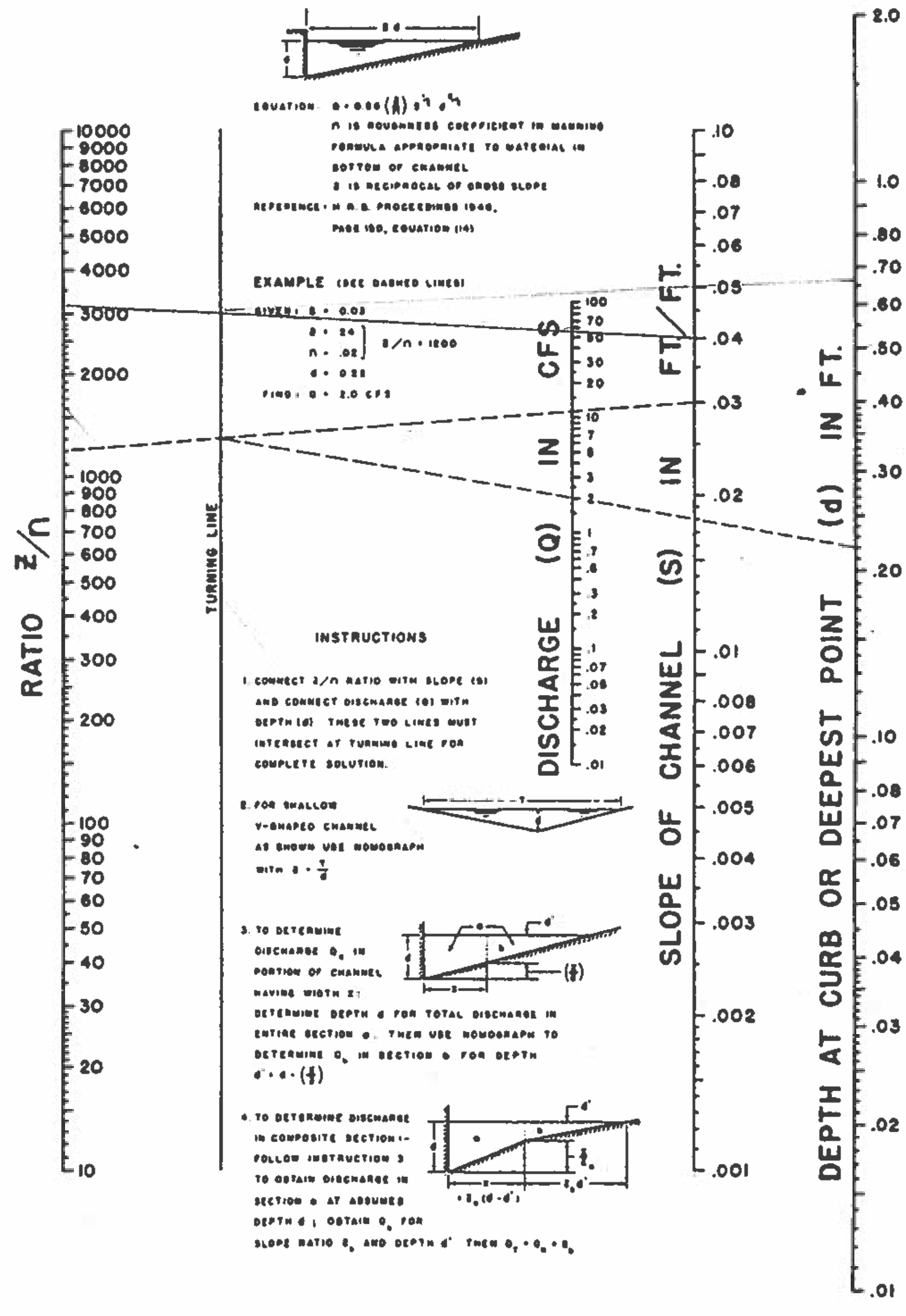
$Q_T = Q_S / 1 - E_o = 93.6$ CFS > 0.5 CFS OK

FIG. 7-9 FOR $L = 4'$, INLET I-3

$Q_i/Q = 0.18$

$Q_i = 0.18(0.3) = 0.05$ CFS

0.25 CFS CARRYOVER



11-15-68
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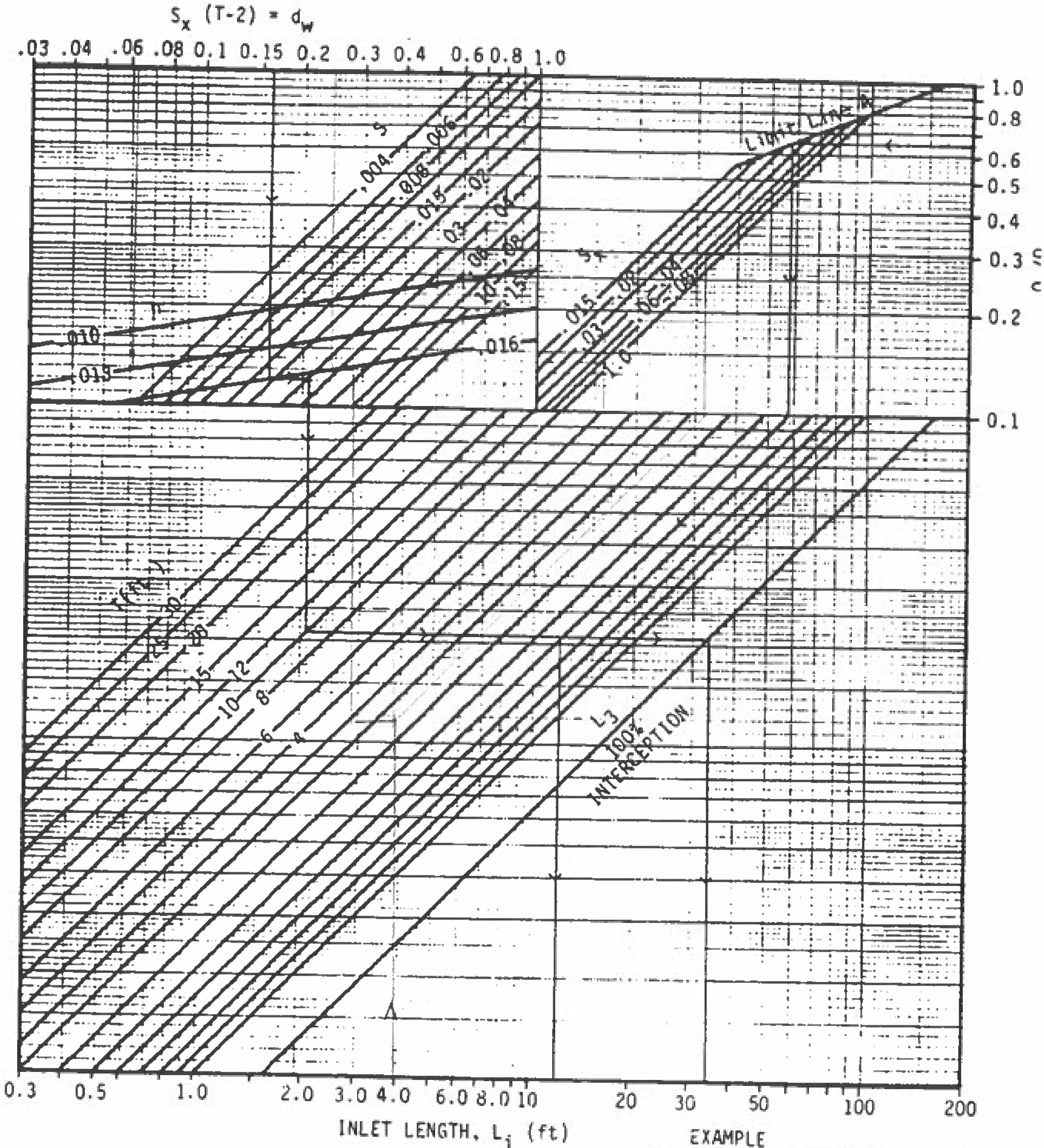
Drainage Criteria Manual

NOMOGRAPH FOR FLOW IN TRIANGULAR GUTTERS.

Date
OCT. 1987

Figure
7 - 2



This chart assumes, w=2 ft., a = 2" and h=6in.

REFERENCE :

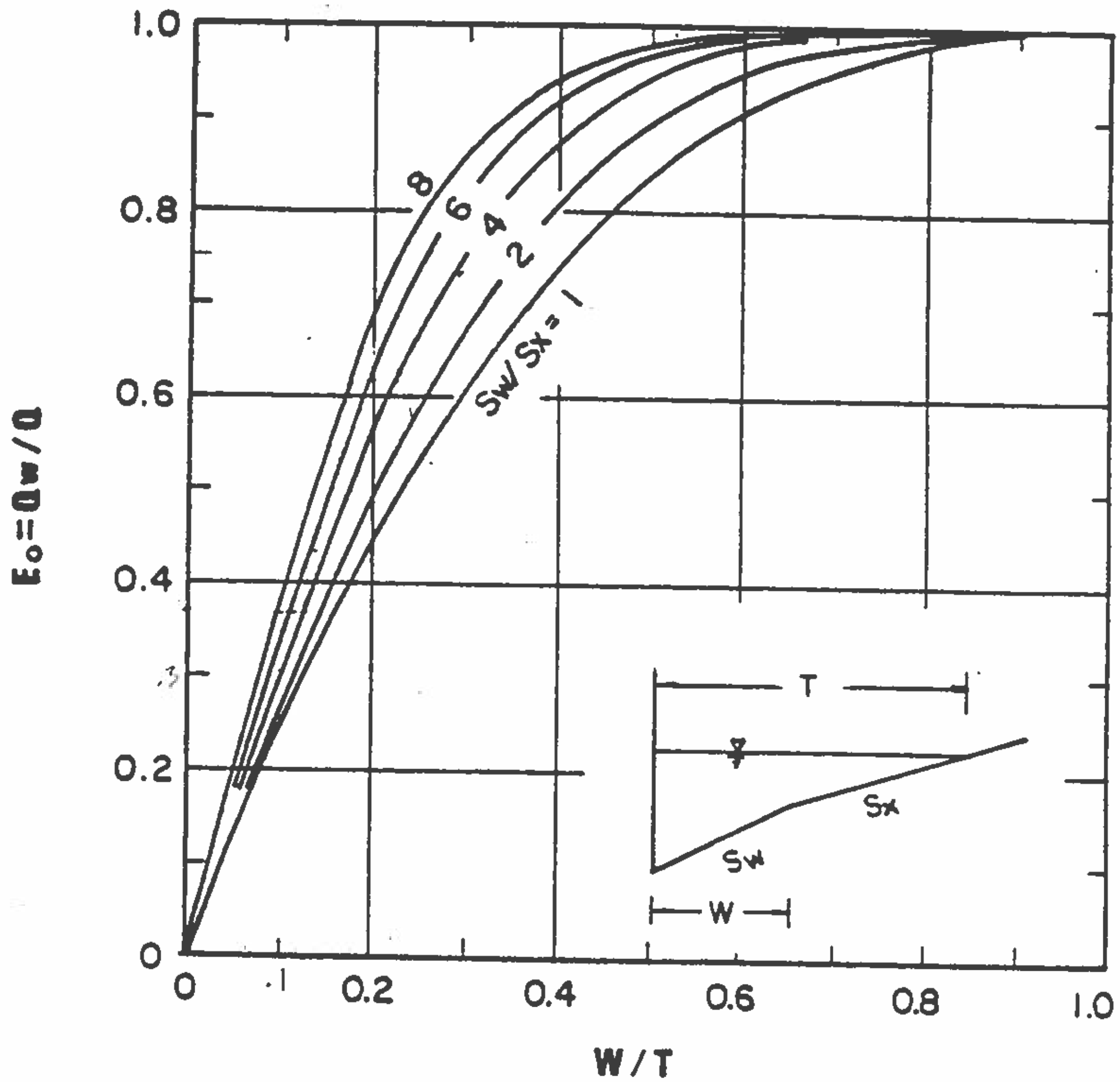
Izzard, Carl. f., Report presented at the Annual Meeting of the National Transportation Board, January 1977; Simplified Method For Design of Curb-opening Inlets

EXAMPLE

Given — S_x = 0.02 ft/ft, T = 10 ft., S = 0.03 ft/ft

Find — L_i = 11.8 ft, Q_i/Q = 0.65; L_i = 34 ft., Q_i/Q = 1.0

Standard Curb-Opening Inlet Chart



REFERENCE : FHWA Hydraulic Engineering Circular No. 12

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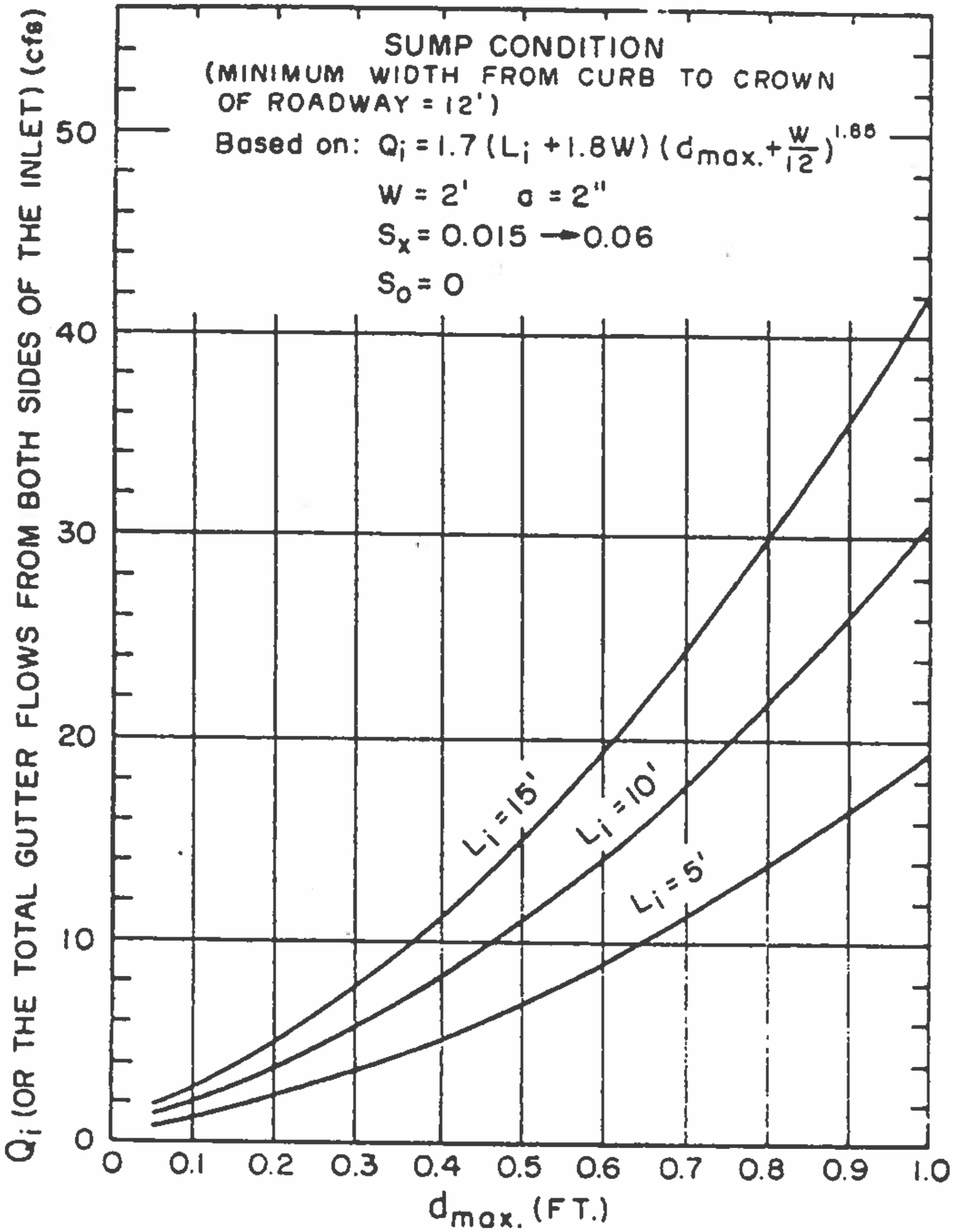
The City of Colorado Springs / El Paso County Drainage Criteria Manual	Date OCT. 1987
Ratio of Frontal Flow to Gutter Flow	Figure 7 - 3



REFERENCE : Izzard, Carl. f., Report presented at the Annual Meeting of the National Transportation Board, January 1977; Simplified Method For Design of Curb-opening Inlets

Sump Capacity for Curb-opening Inlets

INPUT DATA LISTING

CD	L2	MAX Q	ADJ Q	LENGTH	FL 1	FL 2	CTL/TW	D	N	S	KJ	KE	KM	LC	L1	L3	L4	A1	A3	A4	J	N
3	1						6272.50															
2	2	18.0	18.0	12.00	6270.28	6270.40	6274.00	24.	0.	3	.20	.00	.00	1	3	0	0	0.	30.	0.	5.00	.013
2	3	18.0	18.0	57.00	6270.45	6271.00	6275.20	24.	0.	3	1.52	.00	.00	0	4	0	0	0.	90.	0.	5.00	.013
2	4	18.0	18.0	93.00	6271.20	6275.80	6273.00	24.	0.	3	.10	.00	.00	0	5	0	0	0.	0.	0.	5.00	.013
2	5	18.0	18.0	29.00	6275.80	6279.75	6282.00	24.	0.	1	.50	1.25	.00	0	0	0	0	0.	0.	0.	.00	.013

STORM DRAIN ANALYSIS RESULTS

Line No	Q (cfs)	D (in)	W (in)	Dn (ft)	Dc (ft)	Flow Type	Sf-full (ft/ft)	V 1 (fps)	V 2 (fps)	FL 1 (ft)	FL 2 (ft)	HG 1 Calc	HG 2 Calc	D 1 (ft)	D 2 (ft)	TW Calc	TW Ck	
1	Hydraulic grade line control = 6272.50																	
2	13.0	24	0	1.35	1.53	Full	.00633	5.7	5.7	6270.28	6270.40	6272.50	6272.58	2.22	2.18	.00	.00	
3	18.0	24	0	1.37	1.53	Seal	.00633	5.7	15.1	6270.45	6271.00	6272.71	6271.81	2.26	.81	.00	.00	HJ
4	15.0	24	0	.83	1.53	Part	.00633	14.2	14.6	6271.20	6275.80	6272.02	6276.62	.82	.82	.00	.00	HJU HJD
5	12.0	24	0	.63	1.53	Part	.00633	14.9	7.0	6276.80	6279.75	6277.62	6281.28	.82	1.53	6282.99	6282.00	

X = 7.92 X(N) = .00 X(J) = 7.92 F(J) = 7.08 D(BJ) = 1.00 D(AJ) = 2.22

LIST OF ABBREVIATIONS

V 1, FL 1, D 1 and HG 1 refer to downstream end

V 2, FL 2, D 2 and HG 2 refer to upstream end

X - Distance in feet from downstream end to point where HG intersects soffit in seal condition

X(N) - Distance in feet from downstream end to point where water surface reaches normal depth by either drawdown or backwater

X(J) - Distance in feet from downstream end to point where hydraulic jump occurs in line

F(J) - The computed force at the hydraulic jump

D(BJ) - Depth of water before the hydraulic jump (upstream side)

D(AJ) - Depth of water after the hydraulic jump (downstream side)

SEAL indicates flow changes from part to full or from full to part

HJ indicates that flow changes from supercritical to subcritical through a hydraulic jump

HJU indicates that hydraulic jump occurs at the junction at the upstream end of the line

HJD indicates that hydraulic jump occurs at the junction at the downstream end of the line

Project : CHEYENNE CANYON ENTRYWAY
Date: 9/15/1994 Time: 15:54:41

PIPE NUMBER 2

COMPOSITE ANALYSIS

Discharge = 18.00 cfs

	Downstream	Upstream
Velocity	5.73 fps	5.73 fps
Depth of flow	2.22 ft	2.18 ft
Area of flow	3.14 sf	3.14 sf
HGL	6272.50 ft	6272.58 ft
EGL	6273.01 ft	6273.09 ft
Invert	6270.28 ft	6270.40 ft
Soffit	6272.28 ft	6272.40 ft
Diameter	2.00 ft	
Width	.00 ft	

PRIMARY ANALYSIS

Channel length	12.00 ft	Normal depth	1.35 ft
Channel slope	.01001 ft/ft	Critical depth	1.53 ft
Friction slope	.00633 ft/ft	Flow condition	Steep
Adjusted Q	18.00 cfs		
Mannings n	.0130	Loss due to friction	.08 ft
Entrance loss coeff	.00	Minor losses	.00 ft
Junction loss coeff	.20	Length of junction	5.00 ft
Minor loss coeff	.00		
Tailwater control	.00 ft	Structure code	3

STORM DRAIN CONNECTIVITY

Downstream pipe (L0) 1

Upstream pipe	(L1)	3	Angle to d.s. pipe (A1)	.00 deg
Lateral #1	(L3)	0	Angle to d.s. pipe (A3)	90.00 deg
Lateral #2	(L4)	0	Angle to d.s. pipe (A4)	.00 deg

CONNECTIVITY DIAGRAM

```
           1          2        3
  ---------0----------0---------       <--- Flow
```

Project : CHEYENNE CANYON ENTRYWAY
Date: 3/15/1994   Time: 15:54:41

PIPE NUMBER : 3

COMPOSITE ANALYSIS

Discharge = 18.00 cfs

	Downstream	Upstream
Velocity	5.73 fps	15.13 fps
Depth of flow	2.26 ft	.81 ft
Area of flow	3.14 sf	1.19 sf
HGL	6272.71 ft	6271.81 ft
EGL	6273.22 ft	6275.37 ft
Invert	6270.45 ft	6271.00 ft
Soffit	6272.45 ft	6273.00 ft
Diameter	2.00 ft	
Width	.00 ft	

PRIMARY ANALYSIS

Channel length	57.00 ft	Normal depth	1.37 ft
Channel slope	.00965 ft/ft	Critical depth	1.53 ft
Friction slope	.00633 ft/ft	Flow condition	Steep
Adjusted Q	18.00 cfs		
Mannings n	.0130	Loss due to friction	.36 ft
Entrance loss coeff	.00	Minor losses	.00 ft
Junction loss coeff	1.32	Length of junction	5.00 ft
Minor loss coeff	.00		
Tailwater control	.00 ft	Structure code	3

STORM DRAIN CONNECTIVITY

Downstream pipe	(LC)	0		
Upstream pipe	(L1)	4	Angle to d.s. pipe (A1)	.00 deg
Lateral #1	(L3)	0	Angle to d.s. pipe (A3)	90.00 deg
Lateral #2	(L4)	0	Angle to d.s. pipe (A4)	.00 deg

CONNECTIVITY DIAGRAM

```
          2          3         4
---------0---------0---------     <--- flow
```

Project : CHEYENNE CANYON ENTRYWAY
Date: 9/15/1994 Time: 15:54:41

PIPE NUMBER 4

COMPOSITE ANALYSIS

Discharge = 13.00 cfs

	Downstream	Upstream
Velocity	14.82 fps	14.83 fps
Depth of flow	.82 ft	.82 ft
Area of flow	1.21 sf	1.21 sf
HGL	6272.02 ft	6276.62 ft
EGL	6275.43 ft	6280.04 ft
Invert	6271.20 ft	6275.80 ft
Soffit	6273.20 ft	6277.80 ft
Diameter	2.00 ft	
Width	.00 ft	

PRIMARY ANALYSIS

Channel length	93.00 ft	Normal depth	.83 ft
Channel slope	.04946 ft/ft	Critical depth	1.53 ft
Friction slope	.00633 ft/ft	Flow condition	Steep
Adjusted Q	13.00 cfs		
Mannings n	.0130	Loss due to friction	.59 ft
Entrance loss coeff	.00	Minor losses	.00 ft
Junction loss coeff	.10	Length of junction	5.00 ft
Minor loss coeff	.00		
Tailwater control	.00 ft	Structure code	3

STORM DRAIN CONNECTIVITY

Downstream pipe (L0) 0

Upstream pipe	(L1)	5	Angle to d.s. pipe (A1)	.00 deg
Lateral #1	(L3)	0	Angle to d.s. pipe (A3)	.00 deg
Lateral #2	(L4)	0	Angle to d.s. pipe (A4)	.00 deg

CONNECTIVITY DIAGRAM

```
        3         4        5
---------0---------0---------     <--- Flow
```

Project : CHEYENNE CANYON ENTRYWAY
Date: 9/15/1994 Time: 15:54:41

PIPE NUMBER 5

COMPOSITE ANALYSIS

Discharge = 18.00 cfs

	Downstream	Upstream
Velocity	14.88 fps	7.00 fps
Depth of flow	.82 ft	1.53 ft
Area of flow	1.21 sf	2.57 sf
HGL	6277.62 ft	6281.28 ft
EGL	6281.06 ft	6282.04 ft
Invert	6276.80 ft	6279.75 ft
Soffit	6278.80 ft	6281.75 ft
Diameter	2.00 ft	
Width	.00 ft	

PRIMARY ANALYSIS

Channel length	29.00 ft	Normal depth	.68 ft
Channel slope	.10173 ft/ft	Critical depth	1.53 ft
Friction slope	.00633 ft/ft	Flow condition	Steep
Adjusted Q	18.00 cfs		
Mannings n	.0130	Loss due to friction	.18 ft
Entrance loss coeff	1.25	Minor losses	.00 ft
Junction loss coeff	.00	Length of junction	.00 ft
Minor loss coeff	.00		
Tailwater control	6282.99 ft	Structure code	1

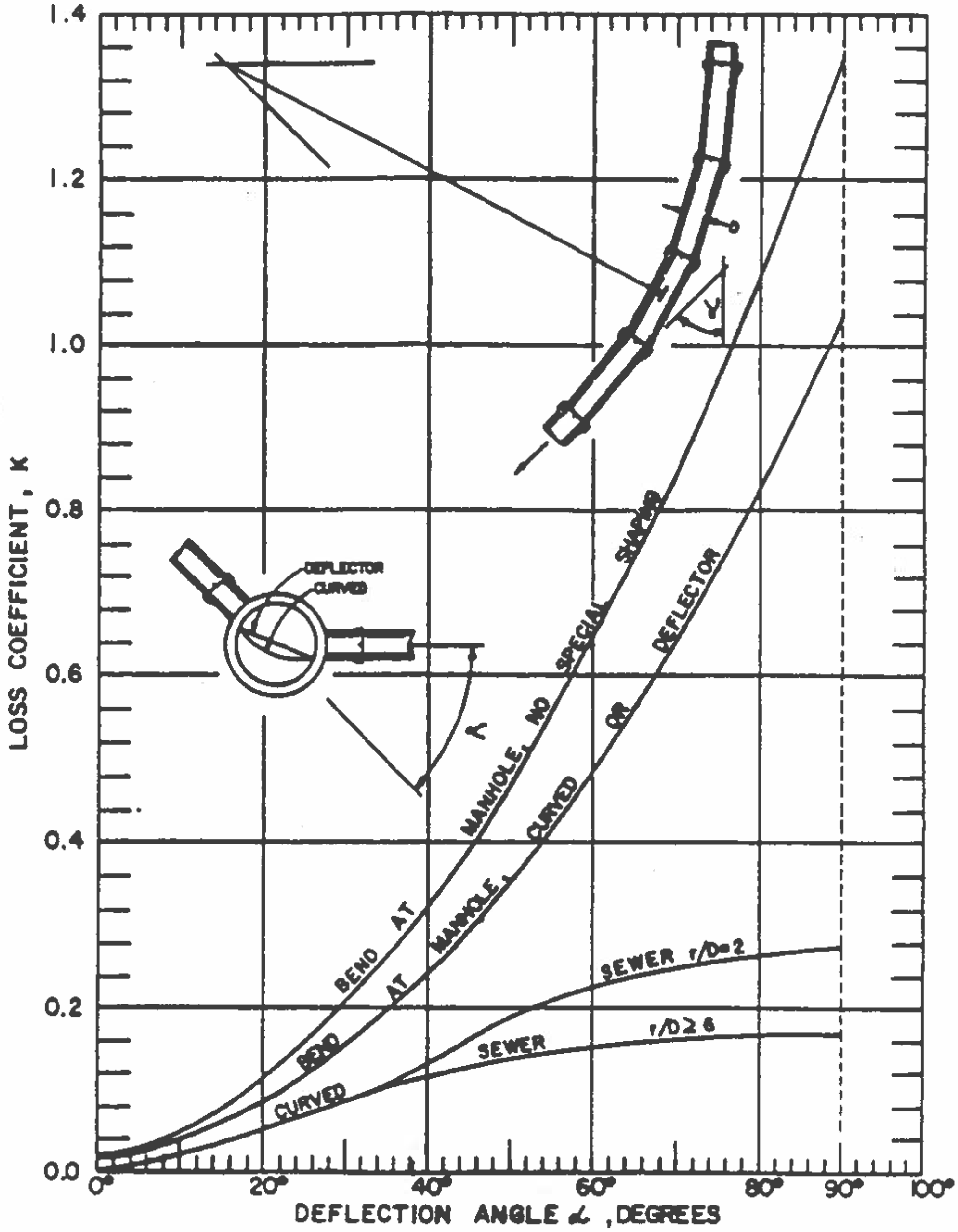
STORM DRAIN CONNECTIVITY

Downstream pipe (I0) 0

Upstream pipe	(I1)	0	Angle to d.s. pipe (A1)	.00 deg
Lateral #1	(I3)	0	Angle to d.s. pipe (A3)	.00 deg
Lateral #2	(I4)	0	Angle to d.s. pipe (A4)	.00 deg

CONNECTIVITY DIAGRAM

```
             4          5
  ---------0---------0    <--- Flow
```



SEWER BEND LOSS COEFFICIENT (15,16,17)

1-15-69
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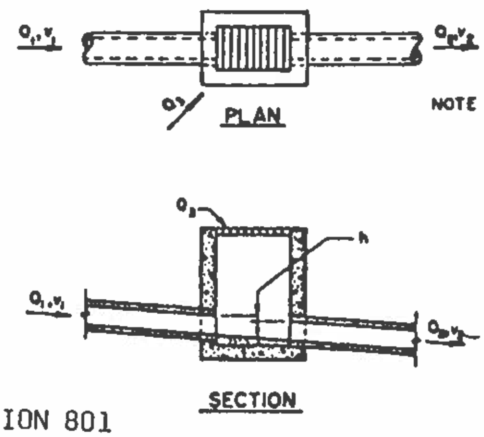
	Figure: 8 - 13

MANHOLE AND JUNCTION LOSSES

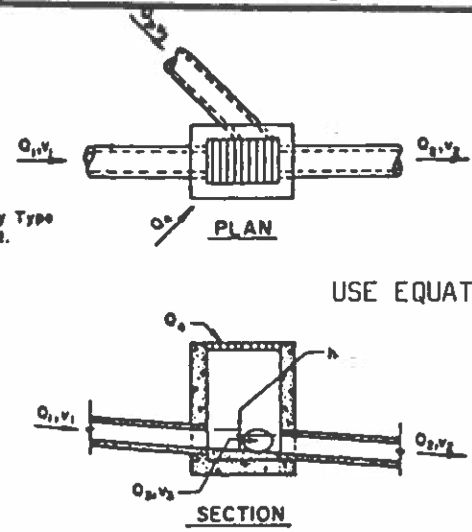


NOTE For Any Type of Inlet.

USE EQUATION 801

CASE I

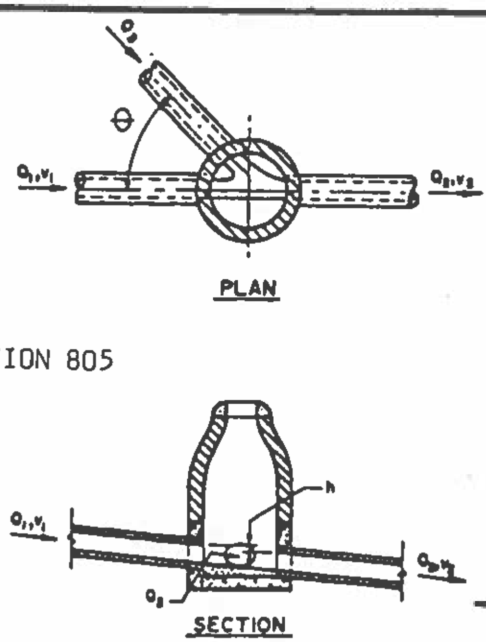
INLET ON MAIN LINE



USE EQUATION 805

CASE II

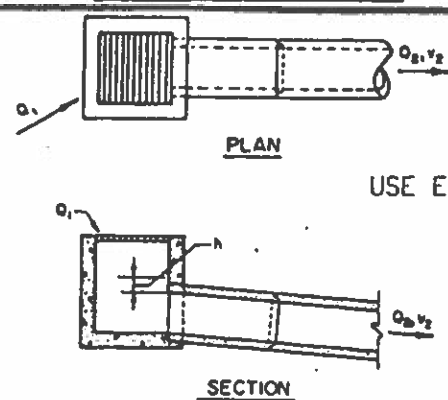
INLET ON MAIN LINE WITH BRANCH LATERAL



USE EQUATION 805

CASE III

MANHOLE ON MAIN LINE WITH θ° BRANCH LATERAL



USE EQUATION 801

CASE IV

INLET OR MANHOLE AT BEGINNING OF LINE

CASE NO.	K_j
I	0.05
II	0.25
IV	1.25

CASE III

θ°	K_j
22-1/2	0.75
45	0.50
60	0.35
90	0.25
No Lateral	See Case I

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PAGE ______ OF ______

JOB NO. 1136.00 CLIENT Co. STATE PARKS & RECREATION DATE 8-23-94

JOB TITLE/SUB-TITLE CHEYENNE CANYON ENTRYWAY

SUBJECT RIPRAP BY CBW CK'D BY ______

CULVERT OUTLET PROTECTION FOR FOLLOWING PIPES
ASSUME $Y_t/D = 0.40$

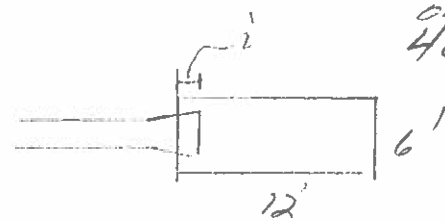
15"	18"	24"
$Y_t/D = 0.4$	$Y_t/D = 0.4$	$Y_t/D = 0.4$
$Y_t = 0.5$	$Y_t = 0.6$	$Y_t = 0.8$
$Q/D^{1.5} = 1.36$	$Q/D^{1.5} = 2.27$	$Q/D^{1.5} = 6.36$

FIG 5.7 TYPE L RIPRAP REQUIRED

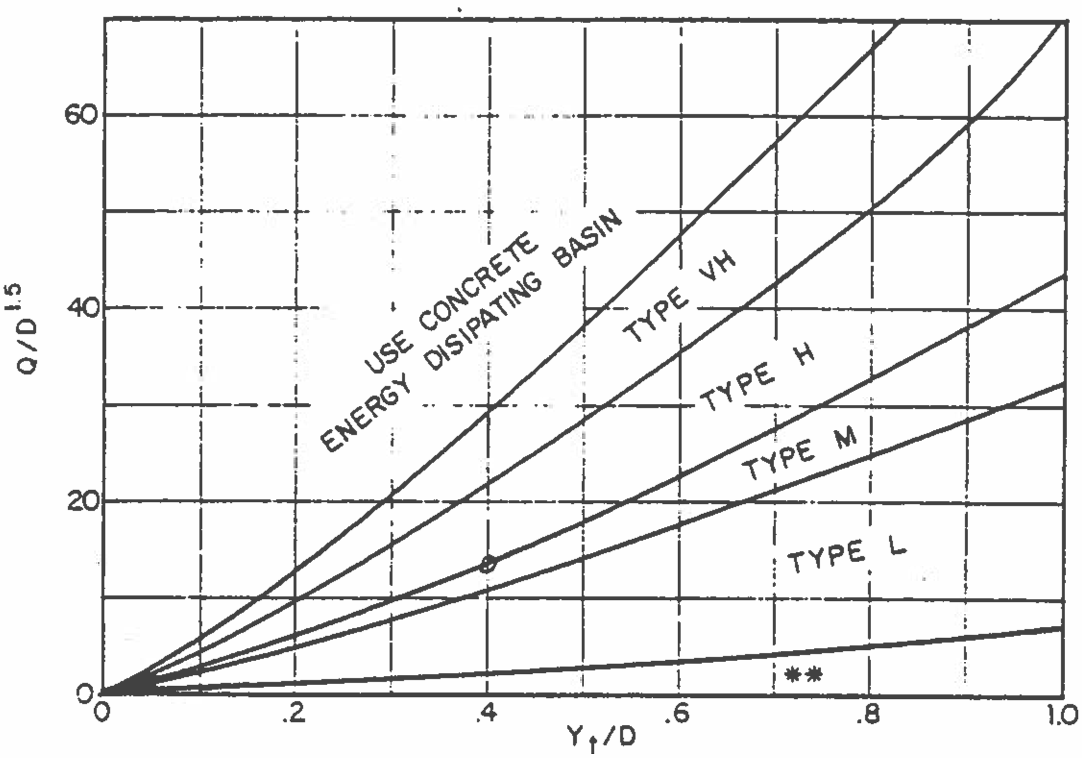
TABLE 5.1 $d_{50} = 9$ in.

	15"	18"	24"
	$Q/D^{2.5} = 0.29$	$Q/D^{2.5} = 0.16$	$Q/D^{2.5} = 3.18$
FIG 5.9	$1/2\tan\theta = 6.7$	$1/2\tan\theta = 6.7$	$1/2\tan\theta = 4.1$
$A_t = Q/V$	$A_t = 0.1$	$A_t = 0.1$	$A_t = 22/5.5 = 3.27$
$L = (1/2\tan\theta)(A_t/Y_t - W)$	$L = 0$	$L = 0$	$L = 12.3'$
$W = 3D$	$W = 0$	$W = 0$	$W = 6'$

USE $12' \times 6' \times 1.5' = 108$ OR 4 CY



USE 5 CY



Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

FIGURE 5-7. RIPRAP EROSION PROTECTION AT CIRCULAR CONDUIT OUTLET.

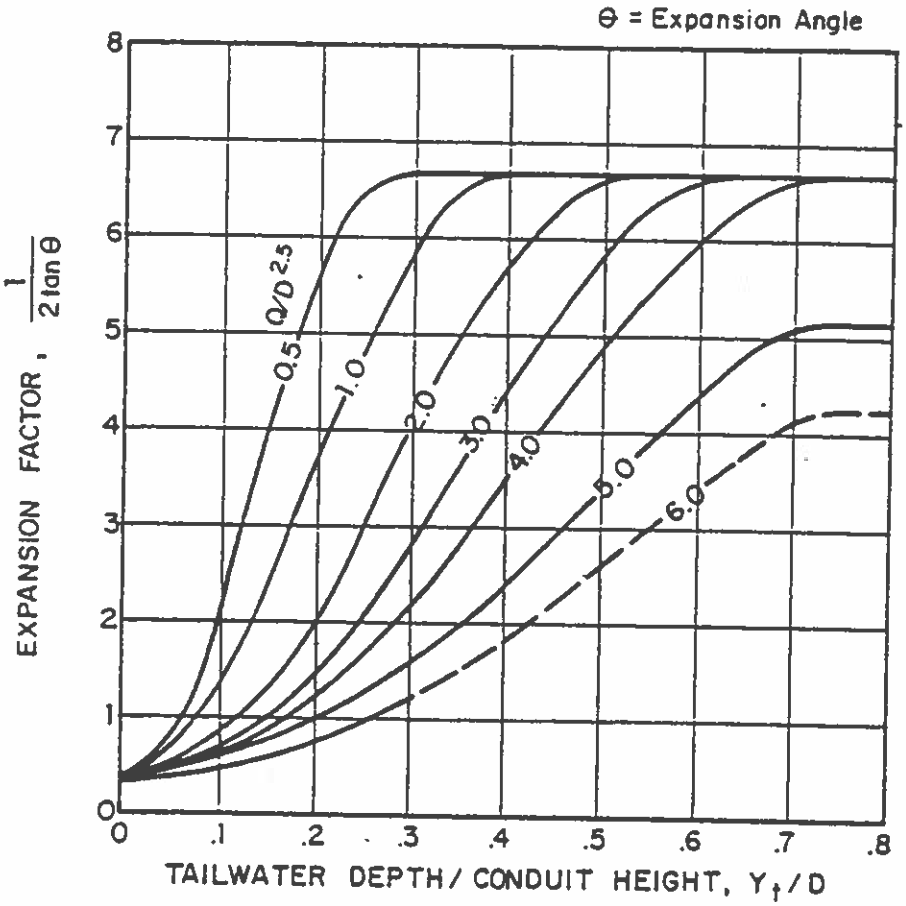


FIGURE 5-9. EXPANSION FACTOR FOR CIRCULAR CONDUITS