KING COUNTY DEPARTMENT OF PUBLIC WORKS

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REQUIREMENTS AND GUIDELINES FOR STORM DRAINAGE CONTROL IN KING COUNTY

PREPARED BY
KING COUNTY DIVISION OF HYDRAULICS
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FOREWARD

This manual, reviewed and improved in 1976 by staff with the assistance of a committee of consulting engineers, is a professional technical guide manual for storm drainage control in King County.

It is intended to provide guidance to engineers in the preparation of drainage plans required by Ordinance 2812. It does not presume to represent the only methods acceptable to the County in resolving drainage problems. If followed, however, the user might reflect a significant saving in design costs as well as commensurate saving in time required for review by King County of such plans as may be submitted for approval.

This document will be available for purchase at cost from the Map Counter in King County Department of Public Works.

2/1/77

F I N A L
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I N D E X

INDEX (Continued)

INSTRUCTIONS
FOR
STORM DRAIN & ROAD CULVERT DESIGN

All storm waters originating on any proposed land development, roads, and all areas draining thereto shall be estimated as to rate of precipitation and to percentage of overland runoff in accordance with criteria hereinafter stated. Said estimates of precipitation and run-off shall be the basis of a drainage plan which shall be prepared by a Professional Civil Engineer and which shall be submitted to the King County Department of Public Works for review and approval. Said drainage plan shall incorporate, among other data, the best available topographical maps to clearly define: (1) the proposed development; (2) all areas, improved or unimproved, lying upstream and draining to and through the proposed development; and (3) drainage courses, natural or otherwise, to which the proposed development shall drain. Under no circumstances shall drainage be diverted in the proposed development to points of discharge other than those points receiving drainage prior to the proposed development.

Unless specifically approved otherwise by the Department of Public Works, the rate of storm water run-off from any proposed land development to any natural or manmade point of discharge downstream, such as storm sewers or ditches, shall not exceed the peak rate of runoff for the design storm occurring prior to the proposed land development, all in accordance with King County Ordinance No. 2281 as amended. In the event that waters from this development drain into a critical flood, drainage, and/or erosion problem area, the quantity of water from this site may be restricted to the existing quantity leaving this site prior to development. In the event that run-off from a proposed land development has in the past discharged directly into a relatively large body of water such as a lake, river or has or could discharge to such bodies of water via ditch or pipeline sized to accommodate anticipated increased run-off from the proposed land development, then it shall be the sole decision of the Department of Public Works to permit or not permit such increased run-off to said bodies of water from the proposed land development.

Restriction of storm water run-off from any proposed land development shall be effected by storm water holding facilities either open or closed or by introduction, on-site, of storm waters into permeable soils via an infiltration system.

The drainage plan shall incorporate all calculations for the determination of the required size of the systems. Said calculations shall be based on required criteria hereinafter stated and upon a rigid analysis of estimated run-off from areas contributing run-off to those facilities. Collection systems shall be either gravity pipe systems, open road ditches or open channels, or a combination of the three.

Open channels and gravity pipe systems across properties other than public right of way shall be treated in the drainage plan as if they were in public right of way. Construction plans shall be prepared for all storm water collection systems. Said plans shall include a plan-profile of the systems including cross sections of all open ditches and channels (profile may not be required when sufficient data is provided on the plans in a clear and concise manner). Said plans shall call out all hydraulic and physical data such as grades, bottom elevations of ditches and channels, inverts of pipes at all structures such as manholes and catch basins, size and length of all pipes, length of ditches and channels, top elevation of all catch basin covers. This includes the invert elevations of the existing or other proposed storm drainage system that the subject drainage plan proposes to tie into. Said plans shall be submitted to the Department of Public Works for review and approval. Required information to be shown on the plans and final plat such as easements, building set back lines, etc., are hereinafter specifically stated. Inspection and acceptance of the proposed storm drainage system will be done by King County in accordance with King County Ordinance 2281, as amended.

Run-off rates can be determined by the rational formula:

$$Q = C\ I\ A$$

Q = Run-off in cfs
C = Runoff coefficient
I = Rainfall intensity in inches per hour
A = Contributing area in acres

The run-off coefficient (C) should be based on Table 1. The rainfall intensity (I) will be based on the Rainfall Intensity-Duration Curves, prepared by the U. S. Weather Bureau for the area. The curve that is the closest to the plat will be used (see pages 25 to 32). Where other data of the same nature is used, the engineer should submit the curve along with the design analysis. For drainage areas less than 50 acres or producing a runoff of less than 20 cfs, a 10-year design frequency may be used. For areas greater than 50 acres or producing a run-off greater than 20 cfs, a 25-year design frequency will be used regardless of the size of the plat. The outlet flow may be further restricted if the downstream drainage basin is presently subject to serious flooding.

The time of concentration for rainfall should be computed for all ditches, channels, gutters, culverts and pipe systems. An initial collecting time of 10 minutes for unpaved areas and 5 minutes for paved areas may be taken at the most distant point of flow from a catch basin or culvert. From this point, the overland flow time to the nearest ditch, channel or gutter may be computed using Chart 1, page 20, to estimate the velocity for each significantly different slope. Once the runoff has reached a storm drainage system, the flow time through the open channel or pipe can be computed.

The following minimum roughness coefficients will be used:

n = 0.012 for concrete, clay or smooth interior metallic pipes

n = 0.021 for annular corrugated metal pipe

n = See below for helical corrugated metal pipe

PIPE DIAMETER	MANNING "h" (2-2/3" x 1/2") CORREGATIONS
12"	0.011
15"	0.013
18"	0.014
21"	0.015
24"	0.016
30"	0.018
36"	0.019
42"	0.020
48"	0.020

Storm drain pipe sizes may be selected by nomograph or calculated based on the Manning Formula. Culverts and pipes that are placed in ditches which will pass flows into the storm drainage systems may be designed from a booklet entitled Hydraulic Charts for the Selection of Highway Culverts, by the Bureau of Public Roads. Culverts should be designed to carry the design run-off with a headwater depth not greater than 2.0 times the culvert diameter for culverts 18 inches and under, or 1.5 times the culvert diameter for culverts greater than 18 inches (see pages 22-24). At all times the computed water surface must be at an elevation which will not saturate the base course under the paving.

SIMPLE RETENTION/DETENTION BASIN DESIGN
(Yrjanainen & Warren Method)

By King County Ordinance No. 2281, as amended, the peak rate of run-off from an existing site shall not be increased due to the proposed development for a given design storm. Therefore, a retention/detention facility on-site may be required. There are a number of ways to design a retention/detention facility. However, for development of 200 acres or less we recommend the Yrjanainer & Warren Method which is described in the December, 1973, issue of the Water & Sewage Works. For developments more than 200 acres in size, we recommend a more detailed method such as the Soil Conservation Service Method or the Colorado Urban Hydrograph Method.

The Yrjanainen & Warren Method for retention/detention basin design takes into consideration that the outflow is instantaneously changing as the head varies. This type of outlet can be analyzed by applying basic calculus to the controlling outflow equation. If the outflow is at a constant rate, i.e., a pump, the analysis is easier. The volume of storm water into the retention/detention basin can be determined by the rational formula. The required volume is the volume of run-off that flows into the basin minus that which flows out. Equations 1 and 2, shown below, relate volume of required storage to allowable outflow using the time for maximum storage as a parameter and the type of outlet condition.

$$V_S = \frac{BT}{T + 25} - 40\ Q_o T \quad \text{Orifice Outlet} \quad \text{Equation 1}$$

$$V_S = \frac{BT}{T + 25} - 60\ Q_o T. \quad \text{Constant Rate Outlet} \quad \text{Equation 2}$$

B is a variable depending upon the slope of the Rainfall-Intensity-Duration Curve used and for the design storm.

$$B = i\ (T + 25)$$

T is defined as the instant storage begins until the peak is attained. This can be computed by taking first derivative of the storage volume (V_S) and setting it equal to zero.

Q_o is the maximum allowable outflow per acre imperviousness

$$Q_o = \frac{\text{Allowable Outflow}}{\text{Acreage x Future Run-off Coef.}}$$

The assumptions in this method are that storm water rises in the retention/detention basin at a constant rate to fill the basin to the peak volume, and that the maximum allowable outflow is reached only at the peak volume.

A listing of the retention/detention equations for both a 10-year and 25-year frequency storm are shown in Table 2, page 15.

EXAMPLE PROBLEM

SIMPLE RETENTION/DETENTION BASIN DESIGN

Assume the example area is near Renton, Washington, (See page 8)

$$T_C = 10.0 + \frac{420 + 760}{1\ (60)} = 10.0 + 19.7 = 29.7$$

$C_{Future} - 0.40$

$C_{Existing} = 0.20$

$A_{1-8} = 15.8$ Acres

$I_{10\ Yr} = 0.83$ in/hr (Renton-Seattle Rainfall IDF Curve, pg. 26)

$$Q_{Existing} = CIA$$
$$= 0.20\ (0.83)\ (15.8)$$
$$= 2.62 \text{ cfs}$$

Since area $<$ 50 acres and flow $<$ 20 cfs use the 10-year frequency design storm

$Q_{Allowable} = 2.62$ cfs (See page 9)

Assume Retention/Detention Basin is located near CB No. 5.

$$Q_o = \frac{\text{Allowable Outflow}}{\text{Acreage x Future Runoff Coef.}}$$

$$= 2.62/15.8\ (0.4) = 0.414 \text{ cfs/Acre.C}$$

Assume orifice outlet condition exists. (See page 15)

$$T = -25 + \sqrt{1762/Q_o}$$

$$= -25 + \sqrt{1762/0.414} = 65.2 - 25 = 40.2 \text{ Min.}$$

$$V_S = \frac{2820T}{T + 25} - 40\ Q_oT$$
$$= \frac{2820\ (40.2)}{40.2 + 25} - 40\ (0.414)\ (40.2)$$
$$= 1{,}738 - 666 = 1{,}072 \text{ ft.}^3$$

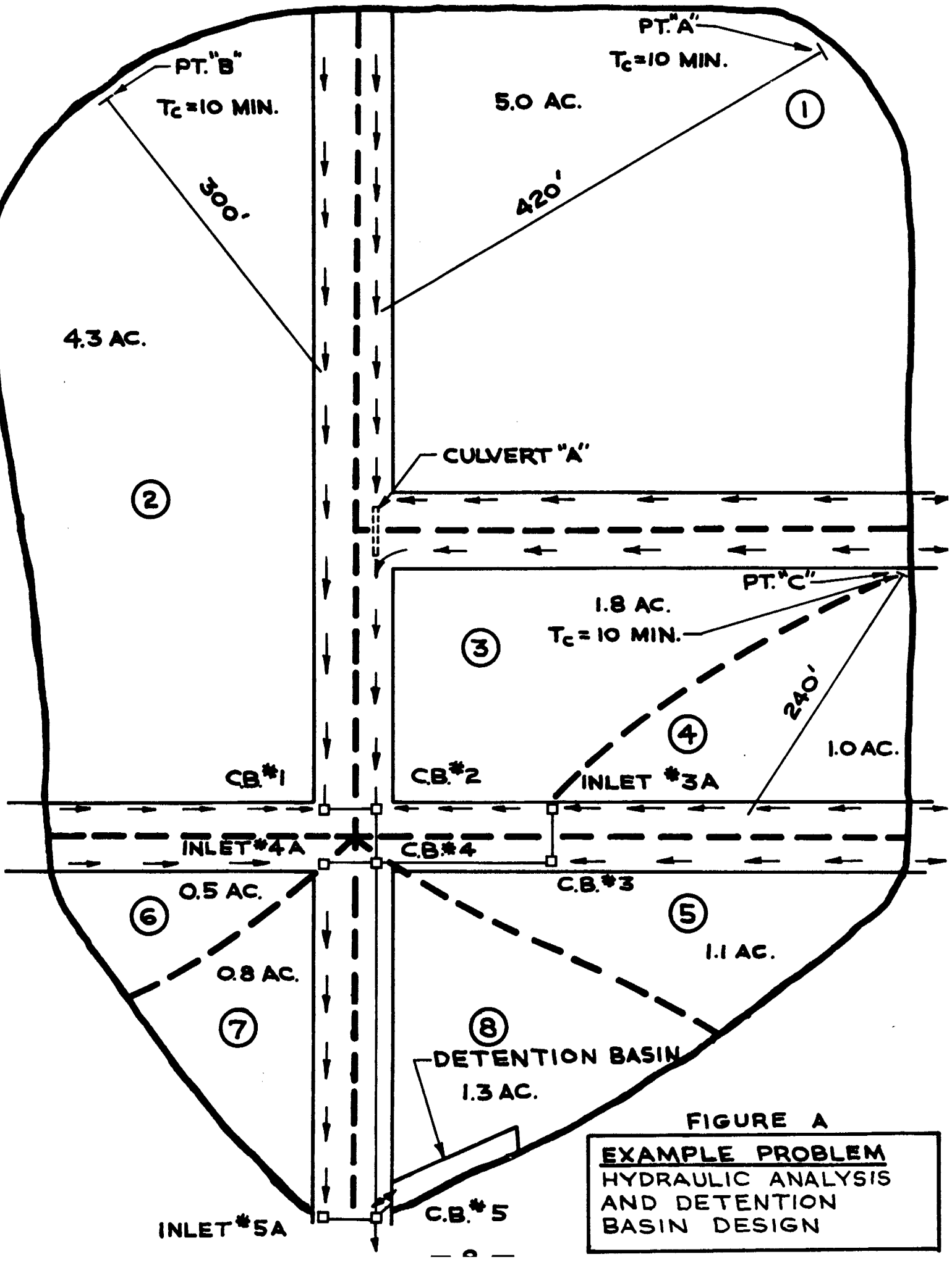


FIGURE A

EXAMPLE PROBLEM
HYDRAULIC ANALYSIS AND DETENTION BASIN DESIGN

EXAMPLE PROBLEM (Continued)

$V_{Total} = V_S \times \text{Acreage} \times \text{Run-Off Coefficient}$

$= 1{,}072\ (15.8)\ (0.40)$

$= 6{,}770\ \text{ft.}^3$

Assume the volume of runoff to be detained in an open basin with a design depth of 3 feet.

Area of Detention basin = $\frac{6{,}770}{3} = 2{,}283\ \text{ft.}^2$

Using a basin 20 feet wide

L = 2283/20 = 114.2 ft. (Say 114 ft.)

Required dimension of detention basin = 20' x 114' x 3'

Using the orifice formula, the outlet pipe can now be sized.

C = 0.62 (Sharp Edge Orifice)

$Q_{Allowable} = 0.62 \quad a \quad \sqrt{2gh}$

h = Vertical distance between the headwater surface and centerline of the orifice.

$a = \frac{Q_{Allowed}}{0.62\ \sqrt{2gh}} = 2.62/0.62 \quad \sqrt{2 \quad (32.2)(3)}$

$= 0.304\ \text{ft.}^2$

$d = \sqrt{\frac{4a}{\pi}} = \sqrt{\frac{4(0.304)}{\pi}} = 0.622\ \text{ft.} = 7.47\ \text{inches}$

Check capacity of 12" CMP:

Inlet Control Q 12" CMP = 5.1 cfs $>$ 2.62 cfs OK

Flow Full @ Q 12" CMP = 2.7 cfs $>$ 2.62 cfs OK

S = 0.02 ft/ft and V = 3.5 fps

Use 12" CMP outflow pipe with 7-1/2" hole in bottom plate at CB #5.

Also, an emergency overflow system must be included in the outlet facility.

See page 35.

EXAMPLE PROBLEM (Continued)
HYDRAULIC ANALYSIS OF INTERNAL DRAINAGE SYSTEM

Compute Flows, and Required Pipe Sizes for Areas Shown on page 8.

AREA I

Ground Cover - Short Grass-Slope of Ground = 2%

C = 0.4 A = 5.0 AC

Pt. "A" to Road Ditch 420 Ft. V = 1.0 ft/sec. (See pg. 20)

Road Ditch to Culvert "A" 165 Ft. V = 2.0 ft/sec.

$$\text{Time} = \frac{420}{(60)(1)} + \frac{165}{(60)(2)} + 10 = 7+1.4+10 = 18.4 \text{ Min.}$$

I = 1.15

Q = (.4)(5.0)(1.15) = 2.30 cfs

From Hydraulic Charts for the selection of Highway Culverts by Bureau of Public Roads:

12-inch Concrete for Q = 2.3 cfs

$\frac{HW}{D}$ = 0.95 < 2.0 OK

12-inch CMP* for Q = 2.3 cfs

$\frac{HW}{D}$ = 1.1 < 2.0 OK

Use 12-inch Concrete or CMP for Culvert "A"
*Annular CMP is used throughout example.

AREA 2

Groundcover - Short Grass-Slope of Ground = 2%

C = 0.4 A = 4.3 AC

Pt. "B" to Road Ditch 300 ft. V = 1.0 ft/sec. (See pg. 20)

Road Ditch to C.B. #1 350 ft. V = 2.0 ft/sec.

$$\text{Time} = \frac{300}{(60)(1)} \quad \frac{350}{(60)(2)} + 10 = 5+3+10 = 18 \text{ min.}$$

I = 1.15

Q = (.4)(4.3)(1.15) = 2.0 cfs

Use 12-inch Concrete or CMP (See Area 1)

C.B. #1 to C.B. #2 Slope - 1.0%

12-inch Concrete @ 0.08% = 3.8 cfs > 2.0 cfs OK

Use 12-inch Concrete @ #1.0%

EXAMPLE PROBLEM (Continued)

AREA 3

C = 0.4 A = 1.8 AC

Length = Culvert "A" to CB #2 = 260'

$$\text{Time} = 18 \text{ min.} + \frac{260}{(60)(2)} = 18 + 2 = 20 \text{ min.}$$

I = 1.05

$$Q = \underset{\text{Area 3}}{(.4)(1.8)(1.05)} + \underset{\text{Area 1}}{(.4)(5.0)(1.05)} = (.4)(6.8)(1.05) = 2.9 \text{ cfs}$$

From Hydraulic Charts for the selection of Highway Culverts by Bureau of Public Roads:

12" Conc. for Q = 2.9 cfs 12" CMP for Q = 2.9 cfs

$\frac{HW}{D} = 1.1 < 2.0$ OK $\frac{HW}{D} = 1.3 < 2.0$ OK

Use 12" Conc. or CMP for entrance pipe @ CB #2

CB #2 to CB #4 Slope = 1.5%

$$Q = \underset{\text{Area 1 \& 3}}{(.4)(6.8)(1.05)} + \underset{\text{Area 2}}{(.4)(4.3)(1.05)} = (.4)(11.1)(1.05) = 4.7 \text{ cfs}$$

12" conc. @ 1.5% = 4.8 cfs > 4.7 cfs OK

12" CMP @ 1.5% = 2.6 cfs < 4.7 cfs Try 15" CMP

15" CMP @ 1.5% = 4.9 cfs > 4.7 cfs OK

Use 12" conc. or 15" CMP @1.5%

EXAMPLE PROBLEM (Continued)

AREA 4

Groundcover - Short Grass -Slope = 2%

C = 0.4 A = 1.0 AC

Pt. "C" to Road Ditch or Gutter 240' V = 1.0 ft/sec. (See pg. 20)

Road Ditch or Gutter to Inlet 3A 180' V = 2.0 ft/sec.

$$\text{Time} = \frac{240}{(60)(1)} + \frac{180}{(60)(2)} + 10 + 4+2+10 = 16 \text{ min.}$$

I = 1.25

Q = (.4) (1.0)(1.25) = 0.5 cfs

Inlet 3A to CB #3 Slope = 1.0%

8' conc. @ 1.0% = 1.2 cfs $>$ 0.5 cfs OK

Use 8" conc. @1.0%

AREA 5

C = 0.4 A = 1.1 AC

Time = 16 min. (Same as Area 4)

Q = (.4)(1.0+1.1)(1.25) = 1.1 cfs

CB #3 to CB #4 Slope = 1.0%

12" conc. @ 1.0% = 4.0 cfs $>$ 1.1 cfs OK

12" CMP @ 1.0% = 2.3 cfs $>$ 1.1 CFS OK

Use 12" conc. or CMP @ 1.0%

EXAMPLE PROBLEM (Continued)

AREA 6

C = 0.4 A = 0.5 AC

Inlet 4A to CB #4
By inspection, use 8" conc. or CMP

CB #4 to CB #5 C = 0.4 A = 13.7 AC

Time = 20 min. (See Area 3)

Q = (.4)(13.7)(1.05) = 5.8 cfs

12" conc. @ 1.0% = 4.0 cfs $<$ 5.8 cfs Try 15" conc.

15" conc. @ 1.0% = 7.0 cfs $>$ 5.8 cfs OK

15" CMP @ 1.0% = 4.2 cfs $<$ 5.8 cfs Try 18" CMP

18" CMP @ 1.0% = 6.6 cfs $>$ 5.8 cfs OK

Use 15" conc. or 18" CMP @ 1%

AREA 7

C = 0.4 A = 0.8 AC

Inlet 5A to CB #5
By inspection, use 8" conc. or CMP

AREA 8

C = 0.4 A = 1.3 AC

Length = 300' V = 5.5 ft/sec.

Time = 20 min. + $\frac{300}{(60)(5.5)}$ = 20 + 1 = 21 min.

I = 1.01

Q = (0.4)(13.7+0.8+1.3)(1.01) = 6.4 cfs

CB #5 to Detention Basin Slope = -1.0%

Use 18" CMP @ 1.0% (Simple Detention Basin Outlet Design)

TABLE 1

RUNOFF FACTORS FOR STORM SEWERS

	FLAT 0-5%	ROLLING 5%
UNDEVELOPED LAND		
Wood & Forest	0.10	0.15
Sparse Trees & Ground Cover	0.15	0.20
Light Grass to Bare Ground	0.20	0.25
DEVELOPED AREA		
Pavement & Roofs	0.90	0.90
Gravel Roads & Parking Lots	0.75	0.80
City Business	0.85	0.90
Apartment Dwelling Areas	0.80	0.85
Industrial Areas (Heavy)	0.70	0.80
Industrial Areas (Light)	0.60	0.70
Earth Shoulder	0.50	0.50
Playground	0.25	0.30
Lawns, Meadows & Pastures	0.20	0.25
Parks & Cemetery	0.15	0.20

SINGLE FAMILY RESIDENTIAL
(Dwelling Unit/Gross Acre)

1.0-1.5 DU/GA	0.30
1.5-3.0 DU/GA	0.35
3.0-3.5 DU/GA	0.40
3.5-4.0 DU/GA	0.45
4.0-6.0 DU/GA	0.50
6.0-9.0 DU/GA	0.60
9.0-15.0 DU/GA	0.70

RETENTION/DETEN ON BASIN EQUATIONS

AREA	TYPE OF OUTLET	10 YEAR DESIGN STORM		25 YEAR DESIGN STORM	
		PEAK STORAGE TIME (MINUTES)	MAXIMUM STORAGE VOLUME (FT^3/AC)	PEAK STORAGE TIME (MINUTES)	MAXIMUM STORAGE VOLUME (FT^3/AC)
RENTON-SEATTLE	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{1762}{Q_o}}$	$V_s = \frac{2820\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{2138}{Q_o}}$	$V_s = \frac{3420\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1175}{Q_o}}$	$V_s = \frac{2820\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{1425}{Q_o}}$	$V_s = \frac{3420\ T}{T+25} - 60\ Q_oT$
TACOMA	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{1875}{Q_o}}$	$V_s = \frac{3000\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{2194}{Q_o}}$	$V_s = \frac{3510\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1250}{Q_o}}$	$V_s = \frac{3000\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{1463}{Q_o}}$	$V_s = \frac{3510\ T}{T+25} - 60\ Q_oT$
NORTH BEND	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{2255}{Q_o}}$	$V_s = \frac{3607\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{2706}{Q_o}}$	$V_s = \frac{4329\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1503}{Q_o}}$	$V_s = \frac{3607\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{1804}{Q_o}}$	$V_s = \frac{4329\ T}{T+25} - 60\ Q_oT$
SNOQUALMIE PASS	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{4076}{Q_o}}$	$V_s = \frac{6522\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{5013}{Q_o}}$	$V_s = \frac{8020\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{2718}{Q_o}}$	$V_s = \frac{6522\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{3342}{Q_o}}$	$V_s = \frac{8020\ T}{T+25} - 60\ Q_oT$
SKYKOMISH	ORIFICE WITH HEAD	$T=-25+\sqrt{\frac{2603}{Q_o}}$	$V_s = \frac{4164\ T}{T+25} - 40\ Q_oT$	$T=-25+\sqrt{\frac{3075}{Q_o}}$	$V_s = \frac{4920\ T}{T+25} - 40\ Q_oT$
	CONSTANT FLOW	$T=-25+\sqrt{\frac{1735}{Q_o}}$	$V_s = \frac{4164\ T}{T+25} - 60\ Q_oT$	$T=-25+\sqrt{\frac{2050}{Q_o}}$	$V_s = \frac{4920\ T}{T+25} - 60\ Q_oT$

TABLE 2

PIPE DIAMETER (INCHES)	MAXIMUM COVER (FEET) BY INSTALLATION DESIGN														
	PLAIN			CLASS II			CLASS III			CLASS IV			CLASS V		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
12	19	52	57	13	33	37	17	45	50	26	69	78	33	87	100
18	29	77	86	13	29	37	17	38	50	26	58	78	33	73	100
24				13	25	37	17	33	50	26	50	78	33	62	100
30				13	21	37	17	29	50	26	44	78	33	54	100
36				13	19	37	17	26	50	26	39	78	33	48	100
48				13	17	37	17	23	50	26	35	78	33	43	100
60				13	16	32	17	21	43	26	32	65	33	41	82
72				13	16	31	17	20	43	26	31	65	33	40	82
84				13	15	29	17	20	40	26	30	60	33	38	74
96				13	15	26	17	19	34	26	30	51	33	38	64
108				13	15	23	17	18	31	26	29	46	33	37	58

NOTE: 2' Min. Cover for Concrete Pipe for primaries and arterials.
1' Min. Cover for Concrete Pipe for residential roads.

CONCRETE PIPE

SCHEDULE GUIDE FOR
12" THRU 30" DIAMETER
CULVERT PIPE

TABLE 3

PIPE DIAMETER (INCHES)	MINIMUM COVER (FEET)	MAXIMUM COVER (FEET) (PLATE THICKNESS)									
		5/8" rivets or helical				3/8" rivets or helical					
		.064"		.079"		.109"		.138"		.168"	
		*C	E	C	E	C	E	C	E	C	E
36	1	82		98	44	47	69	57	72	66	76
42	1	27		30	37	36	59	42	62	48	65
48	1	24		26	33	30	52	34	54	38	57
54	1	21		23	29	26	46	28	48	31	50
60	1	19		21	26	23	41	25	43	27	45
66	1	17		20	24	22	37	23	39	25	41
72	1	16		19	22	20	34	22	36	23	38
78	1	14		19	20	20	32	21	33	21	35
84	1			18		19	29	20	31	21	32
90	1			17		19	27	19	29	20	30
96	1					18	26	19	27	19	28
102	2					18	24	18	25	19	26
108	2					18	23	18	24	18	25
114	2							18	22	18	24
120	2							18	21	18	22
		Spot welded or bolted (½" A 325 bolts)									
		or 3/8" rivets				or 7/16" rivets					
36	1	34	43	38	57	47	88	57	101	66	106
42	1	27	36	30	49	36	72	42	84	48	91
48	1	24	32	26	42	30	60	34	68	38	76
54	1	22	28	23	38	26	52	28	56	31	62
60	1	20	25	21	34	23	46	25	50	27	54
66	1	19	23	20	31	22	44	23	46	25	50
72	1	19	21	19	28	20	40	22	44	23	46
78	1	19	19	19	26	20	40	21	42	21	42
84	1			18	24	19	37	20	40	21	42
90	1			18	22	19	35	19	38	20	40
96	1					18	33	19	36	19	38
102	2					18	31	18	35	19	37
108	2					18	29	18	33	18	35
114	2							18	32	18	33
120	2							18	29	18	32

*C = Circular, E = Elongated

CORRUGATED STEEL PIPE
3"x1" Corrugations

PIPE DIAMETER (INCHES)	MINIMUM COVER (FEET)	MAXIMUM COVER (FEET) (PLATE THICKNESS)									
		.064"		.079"		.109"		.138"		.168"	
		*C	E	C	E	C	E	C	E	C	E
12	1	89		91							
15	1	67		72		93					
18	1	47	55	55	60	71	78				
24	1	29	41	33	45	40	58	47	61		
30	1	23	33	25	36	28	46	32	49	36	51
36	1	20	27	21	30	23	39	26	40	28	42
42	1	19	20	20	40	21	42	22	44	24	48
48	1	18	26	19	37	19	38	20	40	21	42
54	1			18	33	19	38	19	38	20	40
60	1					18	36	19	38	19	38
66	1					18	29	18	36	18	36
72	1							18	28	18	36
78	1									18	28
84	1									17	23

*C = Circular, E = Elongated.

CORRUGATED STEEL PIPE
2 2/3" x ½" Corrugations

PIPE DIMENSIONS SPAN - RISE (INCHES)	CORNER RADIUS (INCHES)	MINIMUM COVER (2T/ft²) (FEET)	MINIMUM THICKNESS (INCHES)	MAXIMUM COVER (FEET), for corner pressures in tons per sq. ft.	
				2 TONS	3 TONS
18 X 11	3 ½	1.5	.064"	12	19
22 X 13	4	1.5	.064"	12	18
25 X 16	4	1.5	.064"	10	16
29 X 18	4 ½	1.5	.064"	10	15
36 X 22	5	1.5	.064"	9	13
43 X 27	5 ½	1.5	.064"	8	12
50 X 31	6	1.5	.079"	7	11
58 X 36	7	1.5	.109"	8	12
65 X 40	8	1.5	.109"	8	12
72 X 44	9	1.5	.138"	8	12
79 X 49	10	1.5	.168"	8	12
85 X 54	11	1.5	.168"	8	12

CORRUGATED STEEL PIPE ARCH
2 2/3" x ½" Corrugations

PIPE DIMENSIONS SPAN - RISE (INCHES)	CORNER RADIUS (INCHES)	MINIMUM COVER (FEET)	MINIMUM THICKNESS (INCHES)	MAXIMUM COVER (FEET) for corner pressures in tons per sq ft	
				2 TONS	3 TONS
43 X 27	7 ½	1.5	.064	12	18
50 X 31	9	1.5	.064	11	17
58 X 36	10 ½	1.5	.064	12	18
65 X 40	12	1.5	.064	12	18
72 X 44	13 ½	1.5	.064	12	18
79 X 49	18	1.5	.064	16	19
87 X 54	18	1.5	.079	14	19
87 X 63	18	1.5	.079	13	18
95 X 67	18	1.5	.109	12	18
103 X 71	18	2	.109	11	17
112 X 75	18	2	.109	10	16
117 X 79	18	2	.109	10	15
128 X 83	18	2	.138	9	14

CORRUGATED STEEL PIPE ARCH
3"x1" Corrugations

TABLE 4

PIPE DIAMETER (INCHES)	MINIMUM COVER (FEET)	MAXIMUM COVER (FEET)													
		12 GAGE		10 GAGE		8 GAGE		7 GAGE		5 GAGE		3 GAGE		1 GAGE	
		* C	E	C	E	C	E	C	E	C	E	C	E	C	E
60	2	42		50	62	58	81	63	93	71	112	79	132	88	144
72	2	32	35	36	51	40	67	43	77	48	93	53	106	58	116
84	2	26	30	29	44	32	57	33	66	36	72	39	78	43	86
96	2	23	26	25	38	27	50	28	56	30	60	32	64	34	68
108	2	21	23	22	34	24	45	25	50	26	52	27	54	29	58
120	2	20	21	21	31	22	40	22	44	23	46	24	48	25	50
132	2	19		20	28	21	36	21	42	22	44	23	46	24	48
144	2	17		19	25	20	33	20	38	21	42	21	42	22	44
156	2	16		18	23	19	31	19	35	20	40	20	40	21	42
168	2	15		18	22	18	28	19	33	19	38	19	38	20	40
180	2	14		18	20	18	27	18	31	19	37	19	38	19	38
192	2			18	19	18	25	18	29	18	35	18	36	19	38
204	3			17	18	18	23	18	27	18	32	18	36	18	36
216	3					17	22	18	25	18	31	18	36	18	36
228	3					17	21	17	23	18	27	18	31	18	35
240	3							17	20	17	23	18	26	18	30
252	3									17	20	17	23	18	26

* C = Circular, E = Elongated.

CORRUGATED STEEL STRUCTURAL PLATE PIPE

6" x 2" Corrugations

PIPE DIMENSIONS SPAN - RISE (FEET & INCHES)	CORNER RADIUS (INCHES)	MINIMUM COVER 2T / ft^2 (FEET)	MINIMUM GAGE REQUIRED	MAXIMUM COVER (FEET) for corner pressures in tons per sq ft		
				2 TONS	3 TONS	4 TONS
6-1 x 4-7	18	1.5	12	16	24	32
7-0 x 5-1	18	1.5	12	14	21	28
7-11 x 5-7	18	1.5	12	12	18	25
8-10 x 6-1	18	2	12	11	16	22
9-9 x 6-7	18	2	12	10	15	20
10-11 x 7-1	18	2	12	9	13	18
11-10 x 7-7	18	2	12	8	12	16
12-10 x 8-4	18	2	12	7	11	15
14-1 x 8-9	18	2	12	7	10	14
15-4 x 9-5	18	2	10	6	9	13
15-10 x 9-10	18	2	10	6	9	12
16-7 x 10-1	18	3	10	6	9	12
13-3 x 9-4	31	2	12	12	19	19
14-2 x 9-0	31	2	12	12	18	18
15-4 x 10-4	31	2	10	11	16	18
16-3 x 10-10	31	3	10	10	15	18
17-2 x 11-4	31	3	10	10	15	18
18-1 x 11-10	31	3	8	9	14	18
19-3 x 12-4	31	3	8	8	13	17
19-11 x 12-10	31	3	8	8	12	17
20-7 x 13-2	31	3	7	8	12	16

CORRUGATED STEEL STRUCTURAL PLATE PIPE ARCH

6"x 2" Corrugations

TABLE 5

PIPE DIAMETER (INCHES)	MINIMUM COVER (FEET)	MAXIMUM COVER (FEET) (PLATE THICKNESS)															
		0.09"		0.10"		0.125"		0.15"		0.175"		0.20"		0.225"		0.25"	
		C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E
72	1	18		20		27	29	28	37	30	44	32	50	35	55	36	60
78	1	17		20		24	26	26	34	28	40	23	46	31	50	32	55
84	1	15		18		23	24	24	31	25	37	27	42	28	47	29	51
90	1	14		17		22	23	23	29	24	35	25	40	26	44	27	48
96	1	13		16		21		22	27	23	33	23	37	24	41	25	45
102	1	13		15		20		21	26	21	31	22	35	23	38	24	42
108	2	12		14		19		20	24	21	29	21	33	22	36	22	40
114	2	11		13		18		20	23	20	27	21	31	21	34	22	37
120	2			13		17		19	22	20	26	20	30	20	33	21	36
126	2			12		16		19	21	19	25	20	28	20	31	20	34
132	2			12		15		19	20	19	24	19	27	19	30	20	32
138	2					15		18	19	19	22	19	26	19	28	19	31
144	2					14		18		18	22	19	25	19	27	19	30
150	2					13		17		18	21	18	24	19	26	19	28
156	2					13		17		18	20	18	23	18	25	19	27
162	2							16		18	19	18	22	18	24	18	26
168	2							15		18		18	21	18	23	18	25
174	2									18		18	20	18	22	18	24
180	2									17		18	20	18	22	18	24

C=Circular, E=Elongated

CORRUGATED ALUMINUM STRUCTURAL PLATE PIPE

9" x 2½ Corrugations

PIPE DIAMETER (INCHES)	MINIMUM COVER (FEET)	MAXIMUM COVER (FEET) (PLATE THICKNESS)									
		.060"		.075"		.105"		.135"		.164"	
		C	E	C	E	C	E	C	E	C	E
12	1	45		45		78					
18	1	27	30	30		36	52	42	54	56	
24	1	21	22	22		25	39	27	40	37	42
30	1			18		21	31	22	32	24	33
36	1			15		19	26	20	27	21	28
42	1			18	25	18	36	19	38	19	38
48	1					18	28	18	36	18	36
54	1					17	20	18	26	18	31
60	1							17	18	17	23
66	1							16		17	
72	1									15	

NOTE: Pipes below heavy line exceed the flexibility factor limit of 76×10^{-4}.
C=Circular, E=Elongated.

CORRUGATED ALUMINUM PIPE

2 ⅔" x ½" Corrugations

PIPE DIMENSIONS SPAN-RISE (INCHES)	CORNER RADIUS (INCHES)	MINIMUM COVER (2T/ft²) (FEET)	MINIMUM THICKNESS (INCHES)	MAXIMUM COVER (FEET) for corner pressure in Tons per sq. ft.	
				2 TONS	3 TONS
18 X 11	4 5/16	1.5	.060	17	26
22 X 13	4 5/16	1.5	.060	14	21
25 X 16	4 7/8	1.5	.060	12	18
29 X 18	4 1/2	1.5	.060	10	15
36 X 22	5	1.5	.060	9	13
43 X 27	5 1/2	1.5	.075	8	12
50 X 31	6	1.5	.105	7	11
58 X 36	7	1.5	.135	8	12
65 X 40	8	1.5	.135	8	12
72 X 44	9	1.5	.164	8	12

NOTE: Pipe arches below heavy line exceed the flexibility factor of 76×10^{-4}.

CORRUGATED ALUMINUM PIPE ARCH

2 ⅔" x ½" Corrugations

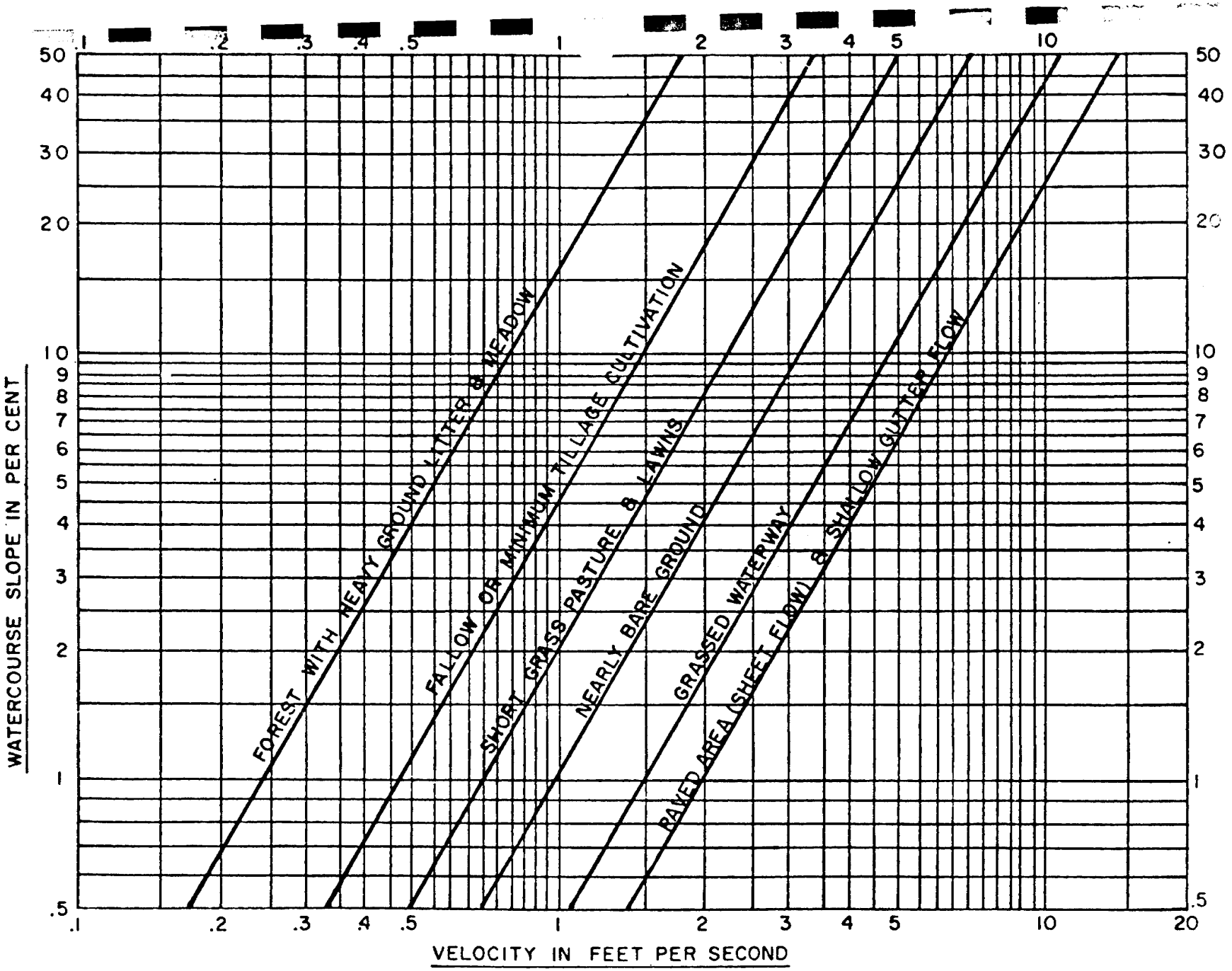
PIPE DIMENSIONS SPAN-RISE (INCHES)	MINIMUM COVER (2T/ft²) (FEET)	MINIMUM THICKNESS (INCHES)	MAXIMUM COVER (FEET) for corner pressure in Tons per sq. ft.	
			2 TONS	3 TONS
17-11 X 13-1	1	.125	26	27
21-5 X 16-4	1	.125	22	23
24-7 X 18-5	2	.125	19	20
28-2 X 21-1	2	.125	17	18
35-4 X 26-3	2	.15	15	9
42-1 X 31-6	2	.15	13	8
49-0 X 36-0	2	.15	12	8
53-1 X 39-5	2	.175	11	17
60-3 X 44-10	2	.175	10	16
67-3 X 49-4	2	.20	10	15
74-2 X 53-9	2	.225	9	14
81-11 X 58-1	2	.25	9	13

CORRUGATED ALUMINUM STRUCTURAL PLATE PIPE AR

9" x 2½" Corrugations

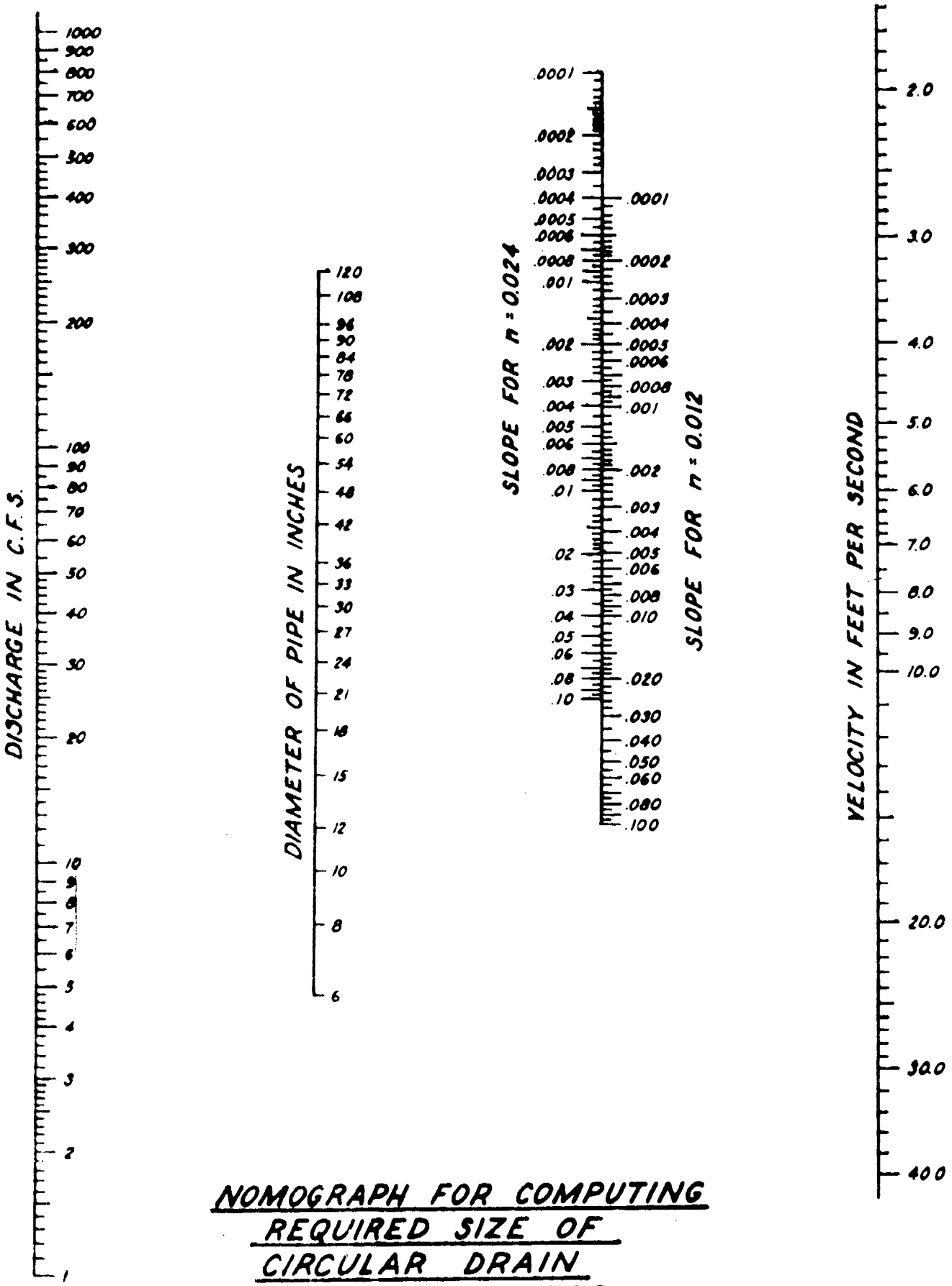
TABLE 6

CHART 1



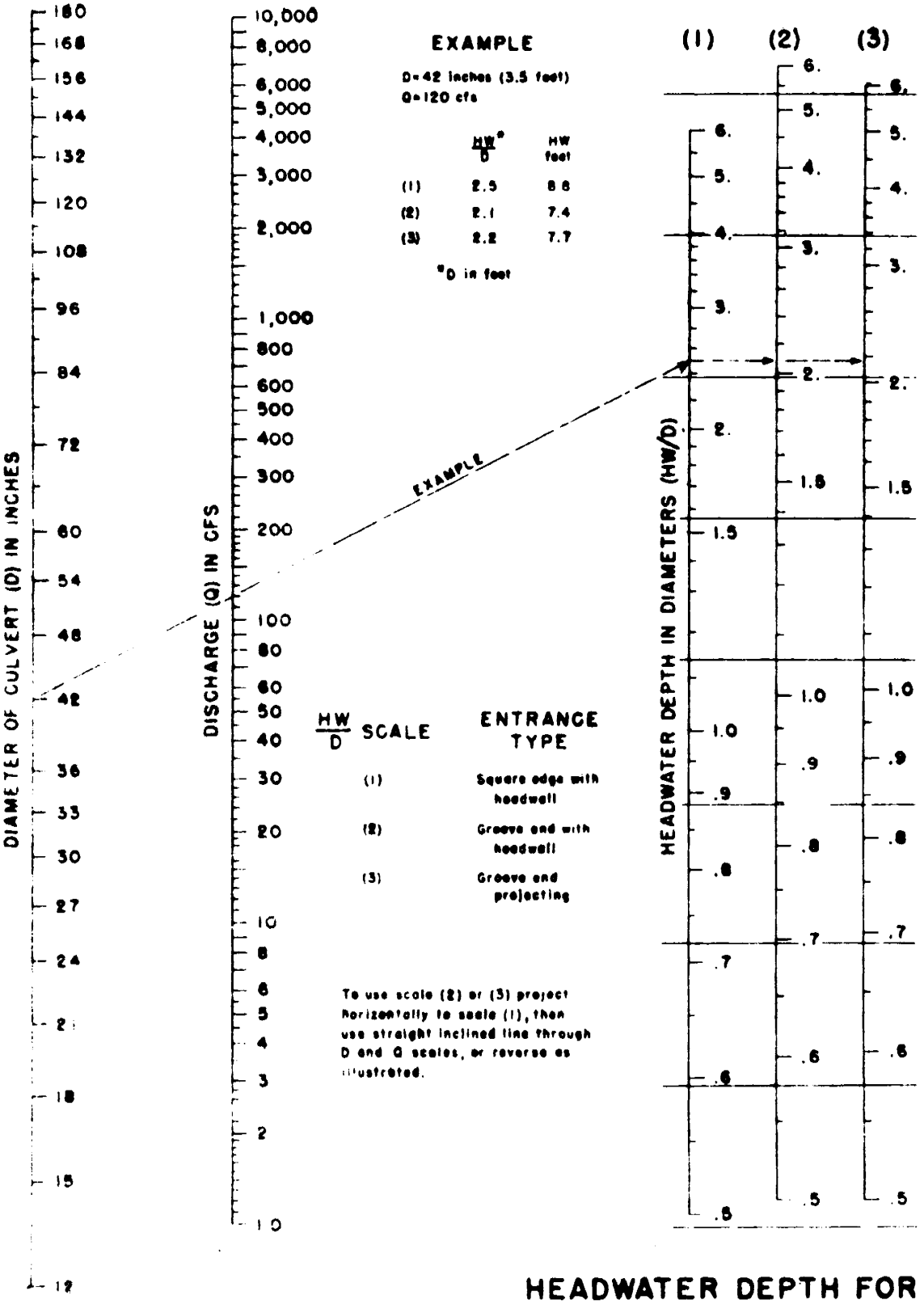
AVERAGE VELOCITIES FOR ESTIMATING TRAVEL TIME FOR OVERLAND FLOW

SOIL CONSERVATION SERVICE
TECHNICAL RELEASE NO. 55
JANUARY 1975



NOMOGRAPH FOR COMPUTING REQUIRED SIZE OF CIRCULAR DRAIN FLOWING FULL FOR n = 0.012 OR n = 0.024

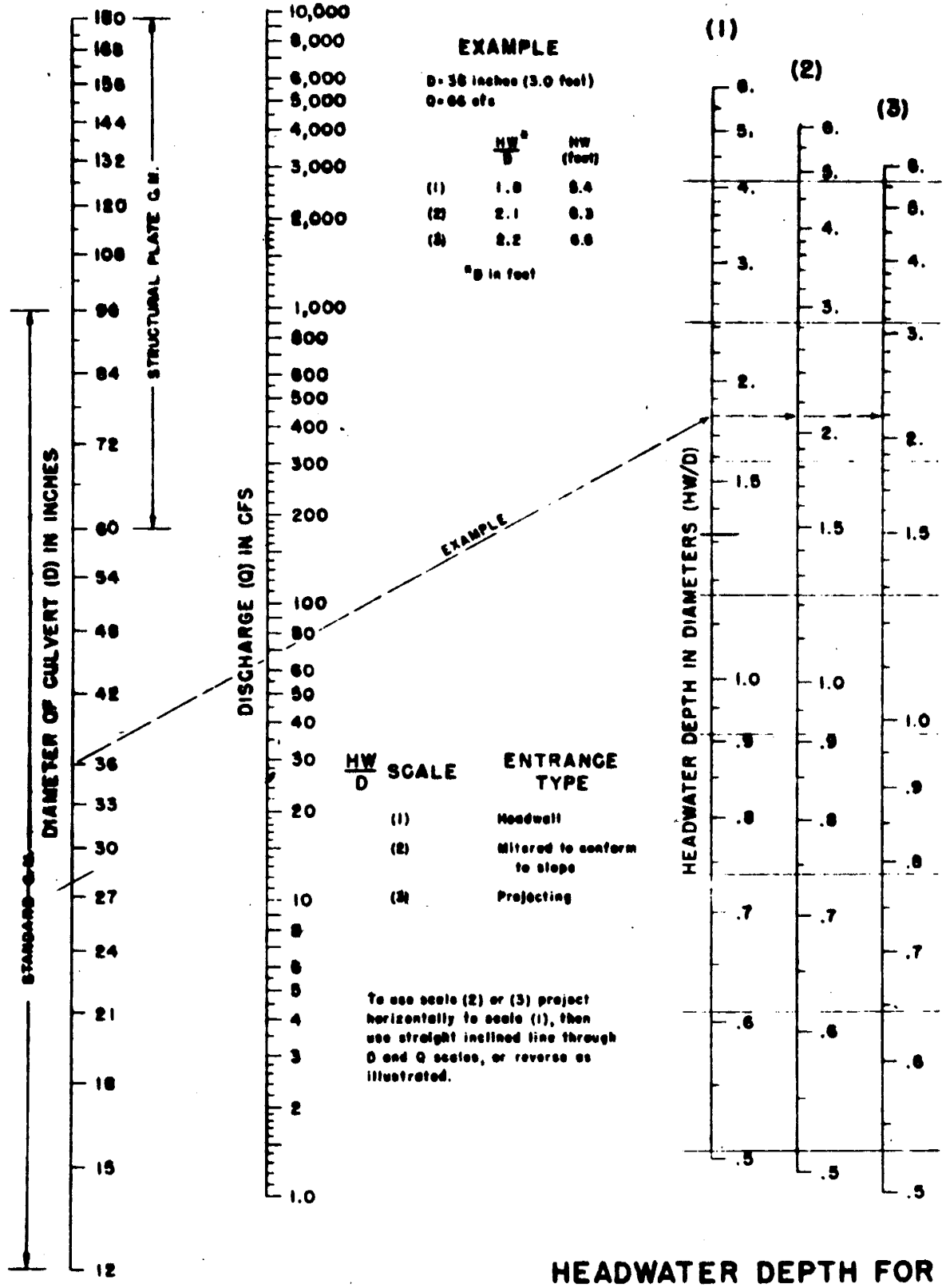
CHART 2



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN 1963

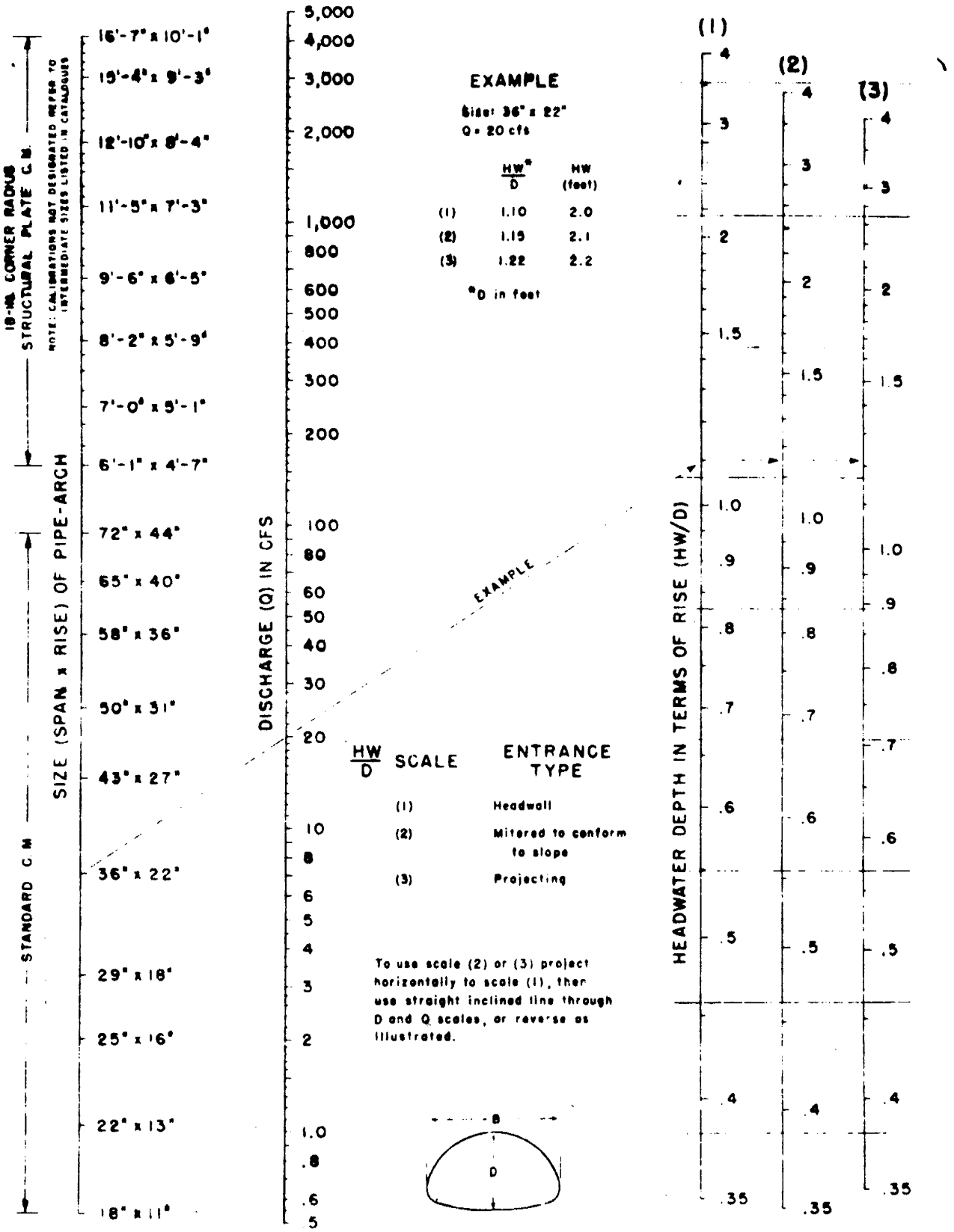
CHART - 3



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

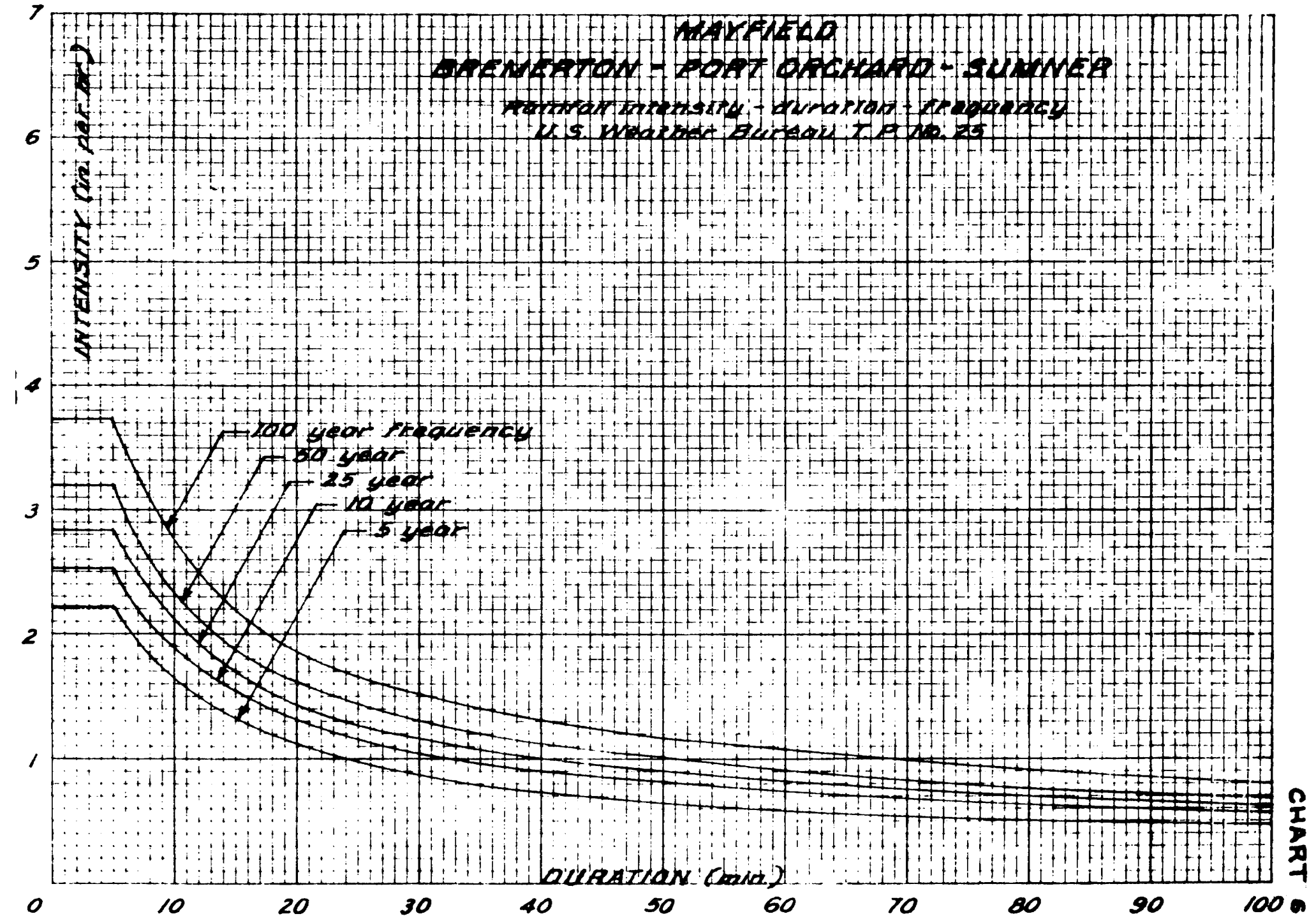
CHART 4

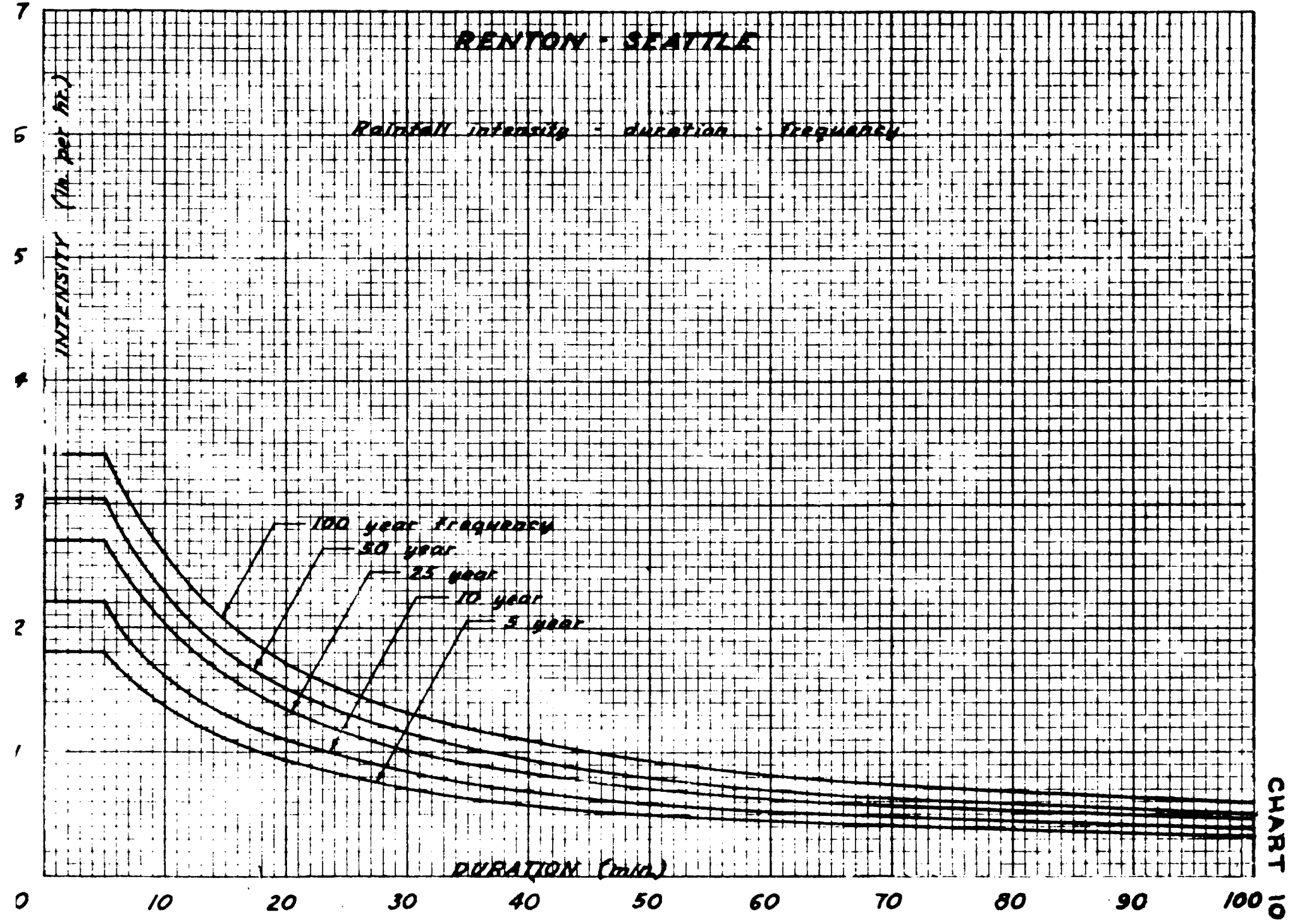


HEADWATER DEPTH FOR C. M. PIPE-ARCH CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN 1963

CHART 5


MAYFIELD
BRENNATON - PORT ORCHARD - SUMNER
Rainfall intensity - duration - frequency
U.S. Weather Bureau T.P. No. 25
INTENSITY (in. per hr.)
100 year frequency
50 year
25 year
10 year
5 year
DURATION (min.)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
CHART 6


RENTON - SEATTLE
Rainfall intensity - duration - frequency
INTENSITY (in. per hr.)
100 year frequency
50 year
25 year
10 year
5 year
DURATION (min.)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
CHART 10

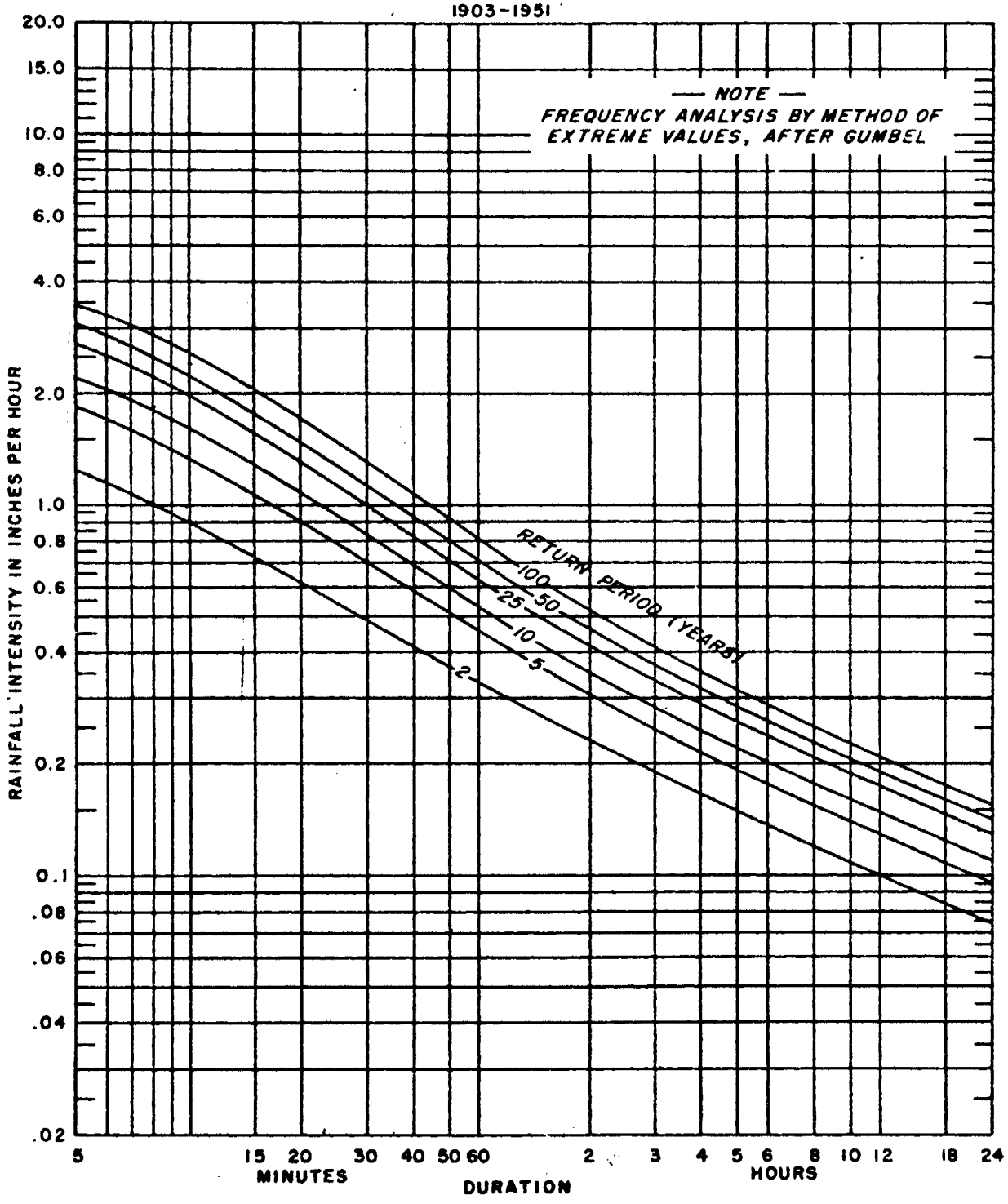
PRECIPITATION

GRAPH B

RAINFALL INTENSITY - DURATION - FREQUENCY CURVES

SEATTLE, WASHINGTON

1903-1951



This graph is for use in estimating runoff and the frequency of various rainfall intensities in the Seattle area. For example: Rain lasting 5 hours at the average rate of 0.2 inch per hour can be expected about once in 7 years, while about once in 25 years a rain of intensity 1.0 inch per hour can be expected to last for 30 minutes.

Source: Weather Bureau Technical Paper No.25.
Rainfall Intensity-Duration-Frequency Curves.December 1955
(Hydrologic Services Division)

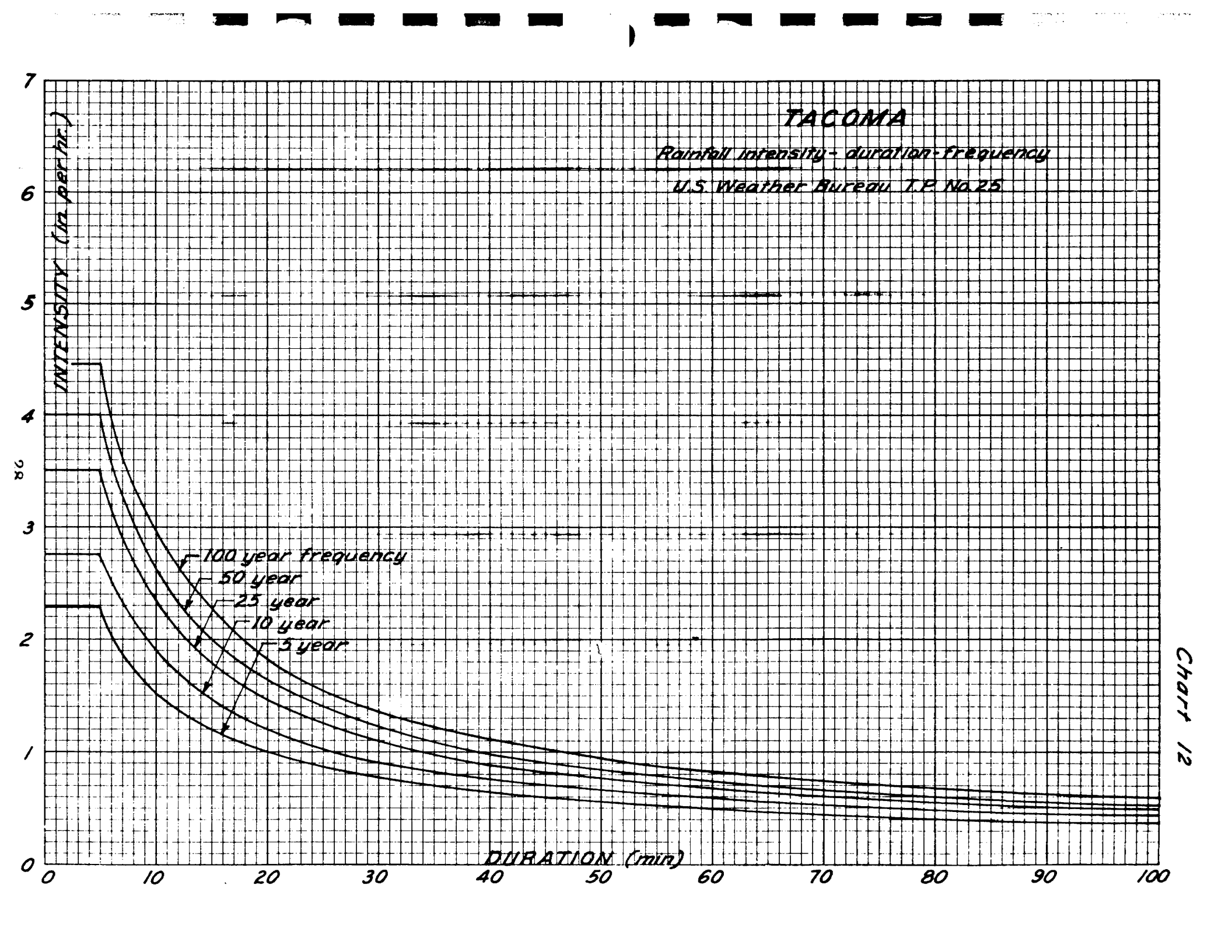

TACOMA
Rainfall intensity - duration - frequency
U.S. Weather Bureau T.P. No. 25
INTENSITY (in. per hr.)
DURATION (min)
100 year frequency
50 year
25 year
10 year
5 year
0
1
2
3
4
5
6
7
0
10
20
30
40
50
60
70
80
90
100

Chart 12

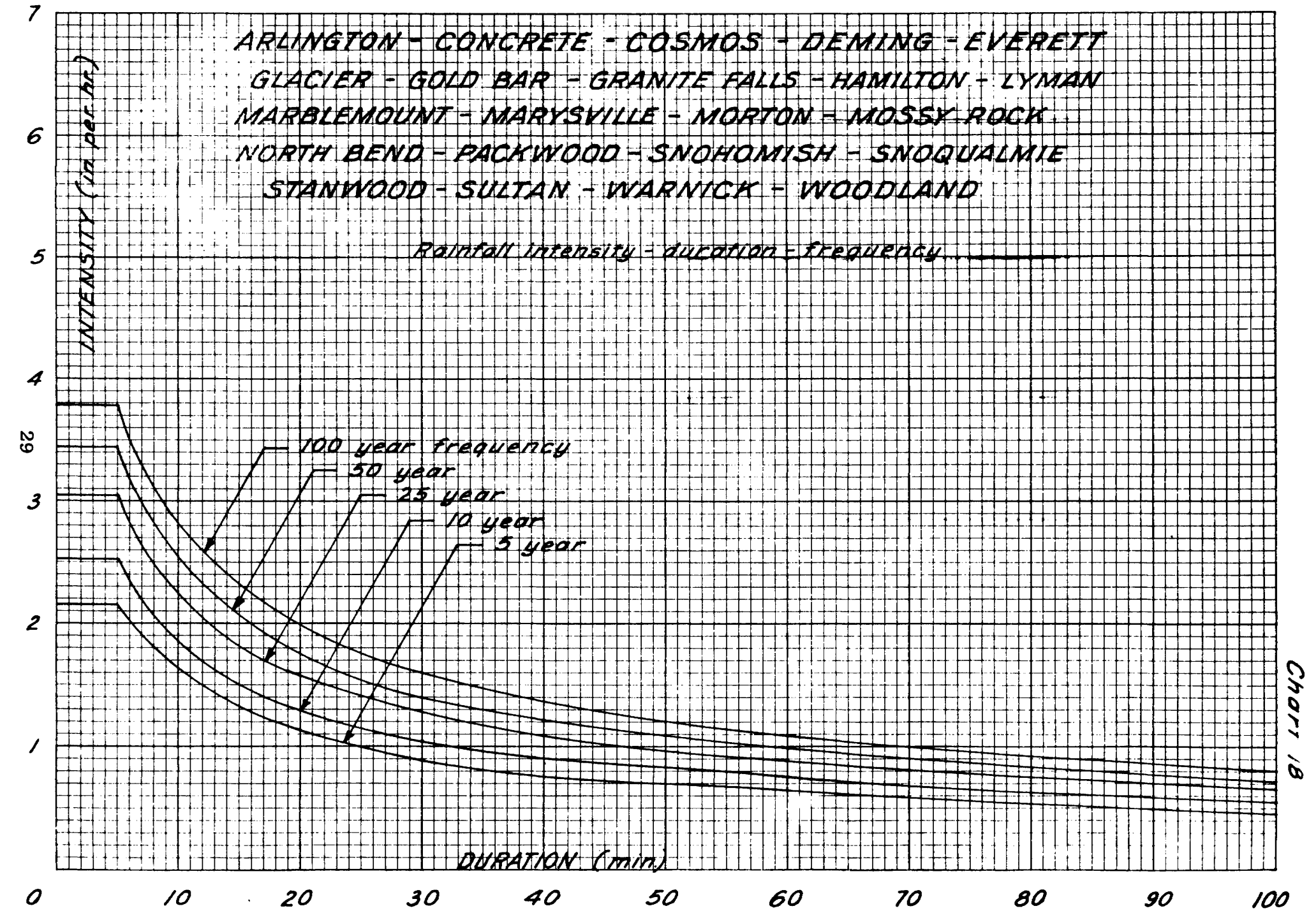

ARLINGTON - CONCRETE - COSMOS - DEMING - EVERETT
GLACIER - GOLD BAR - GRANITE FALLS - HAMILTON - LYMAN
MARBLEMOUNT - MARYSVILLE - MORTON - MOSSY ROCK
NORTH BEND - PACKWOOD - SNOHOMISH - SNOQUALMIE
STANWOOD - SULTAN - WARNICK - WOODLAND
Rainfall intensity - ducation - frequency
INTENSITY (in per hr)
100 year frequency
50 year
25 year
10 year
5 year
DURATION (min)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7

Chart 18

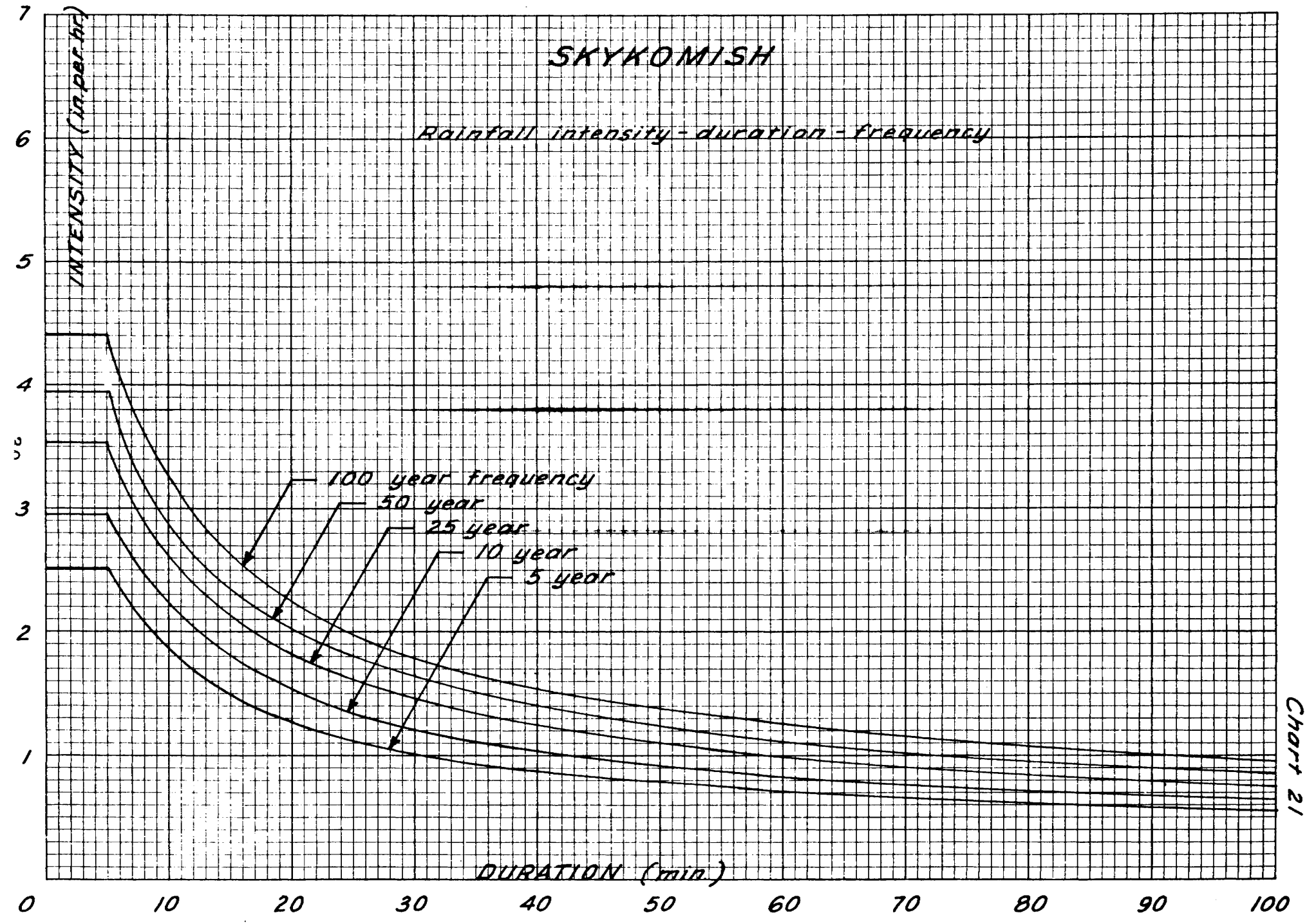
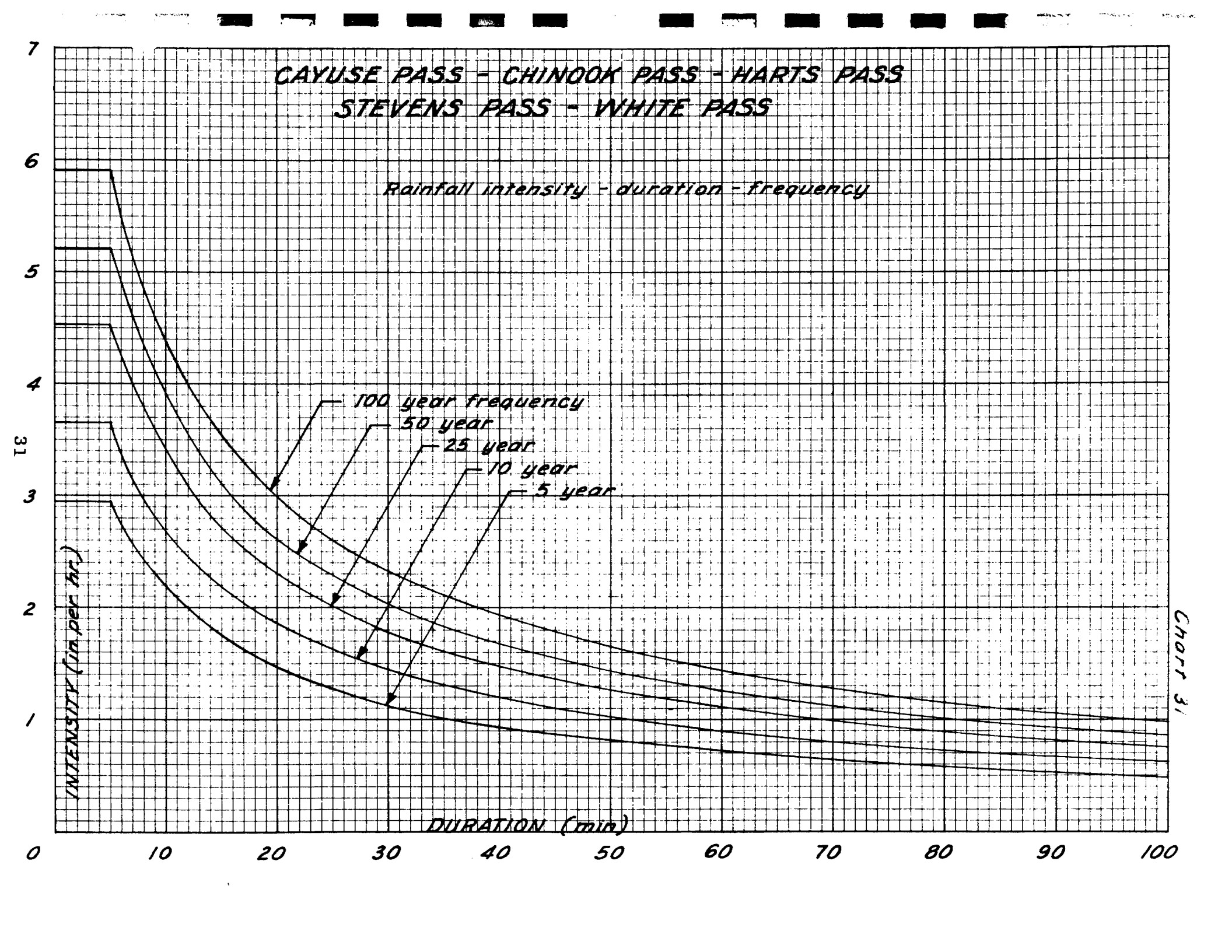
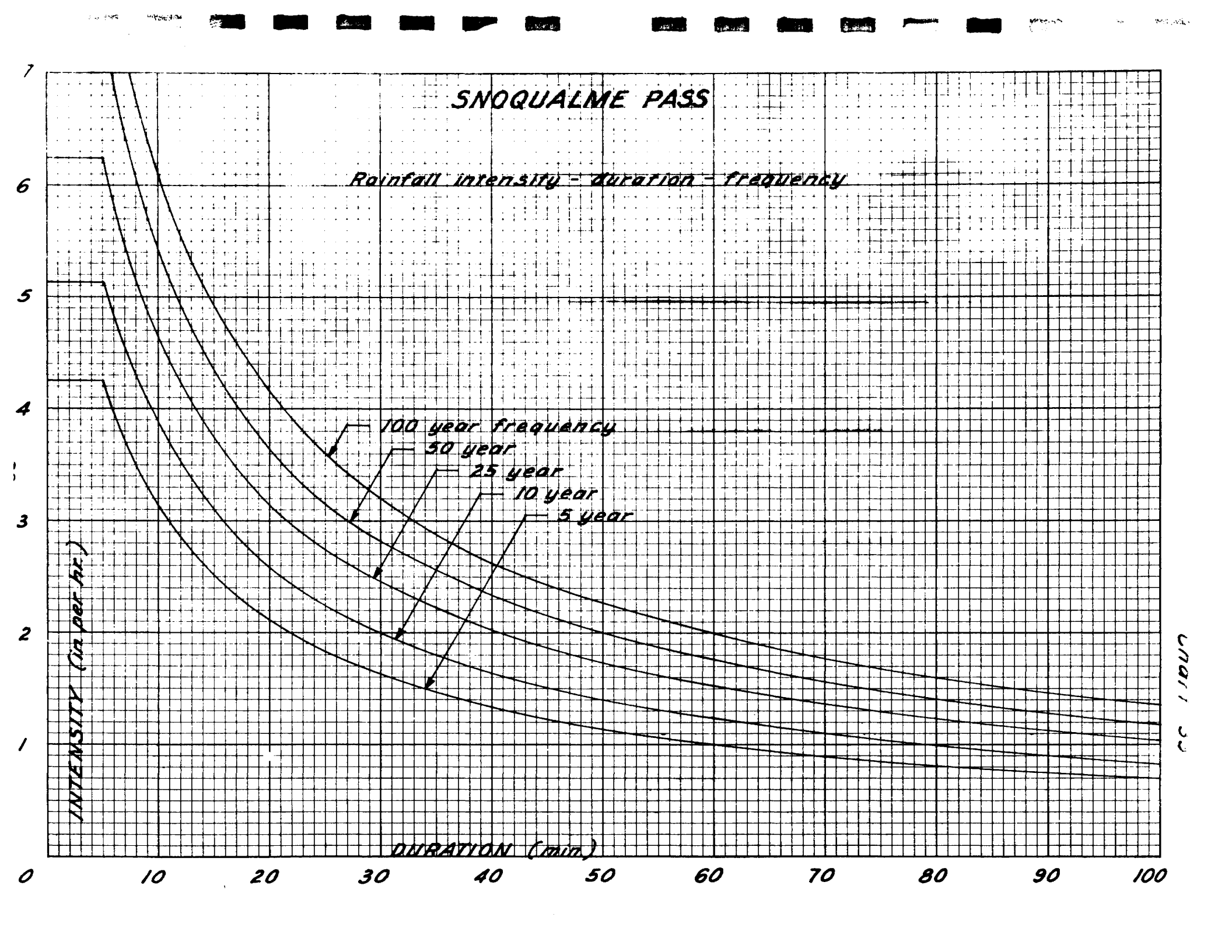

SKYKOMISH
Rainfall intensity - duration - frequency
INTENSITY (in. per hr.)
100 year frequency
50 year
25 year
10 year
5 year
DURATION (min.)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7

Chart 21


CAYUSE PASS - CHINOOK PASS - HARTS PASS
STEVENS PASS - WHITE PASS
Rainfall intensity - duration - frequency
100 year frequency
50 year
25 year
10 year
5 year
INTENSITY (in per hr.)
DURATION (min)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7
Chart 31
31


SNOQUALME PASS
Rainfall intensity - duration - frequency
100 year frequency
50 year
25 year
10 year
5 year
INTENSITY (in per hr.)
DURATION (min.)
0
10
20
30
40
50
60
70
80
90
100
1
2
3
4
5
6
7

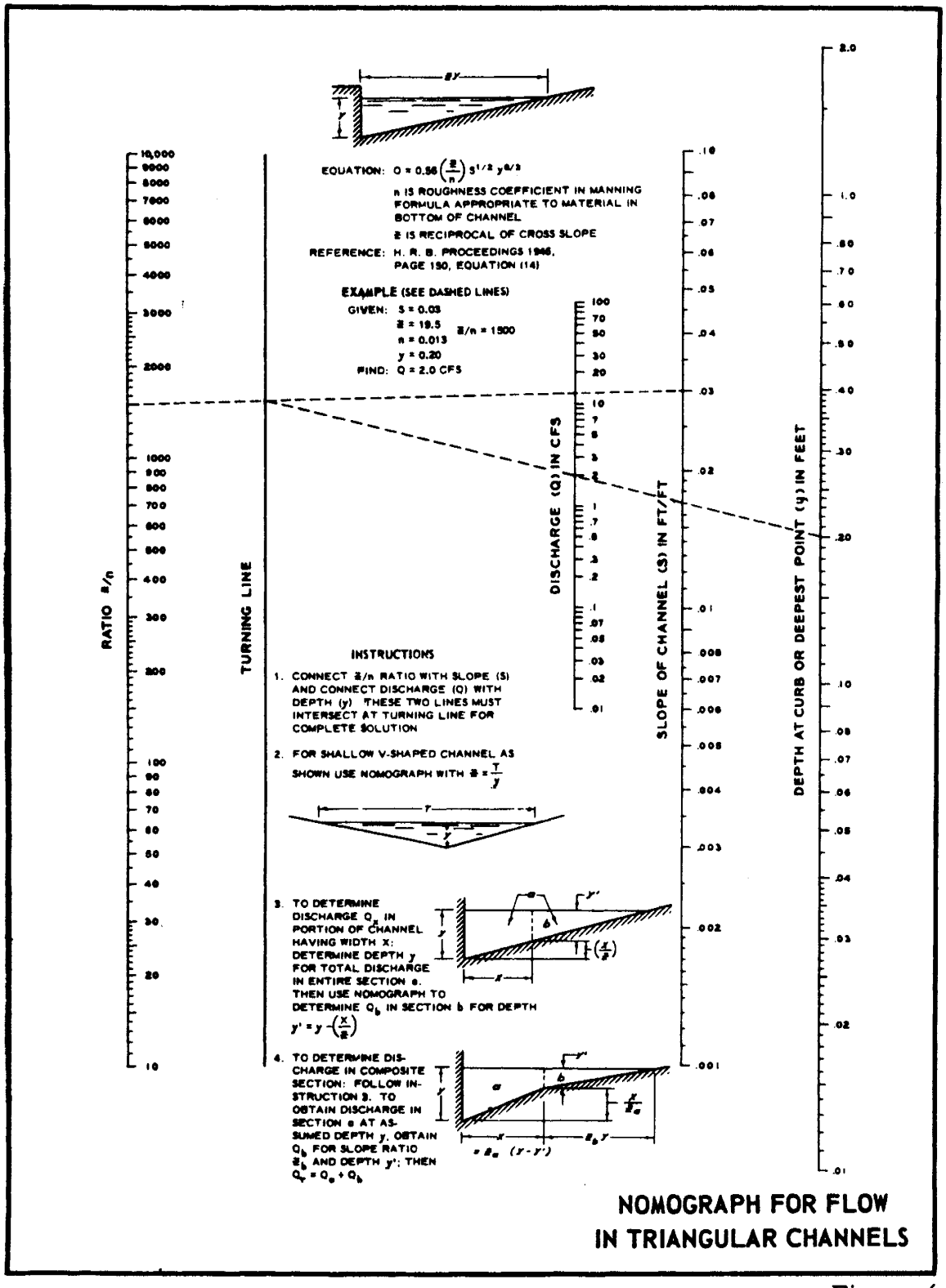
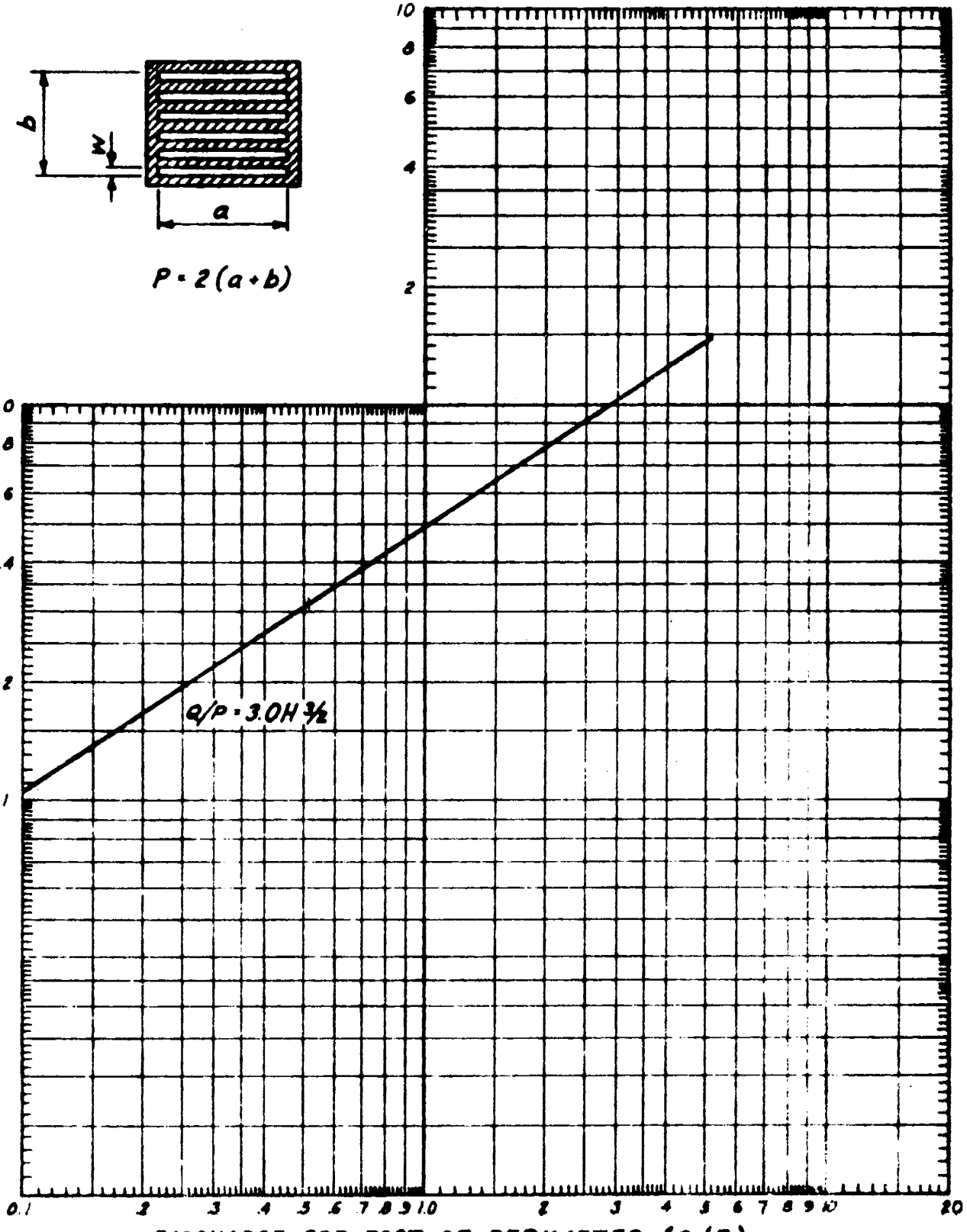
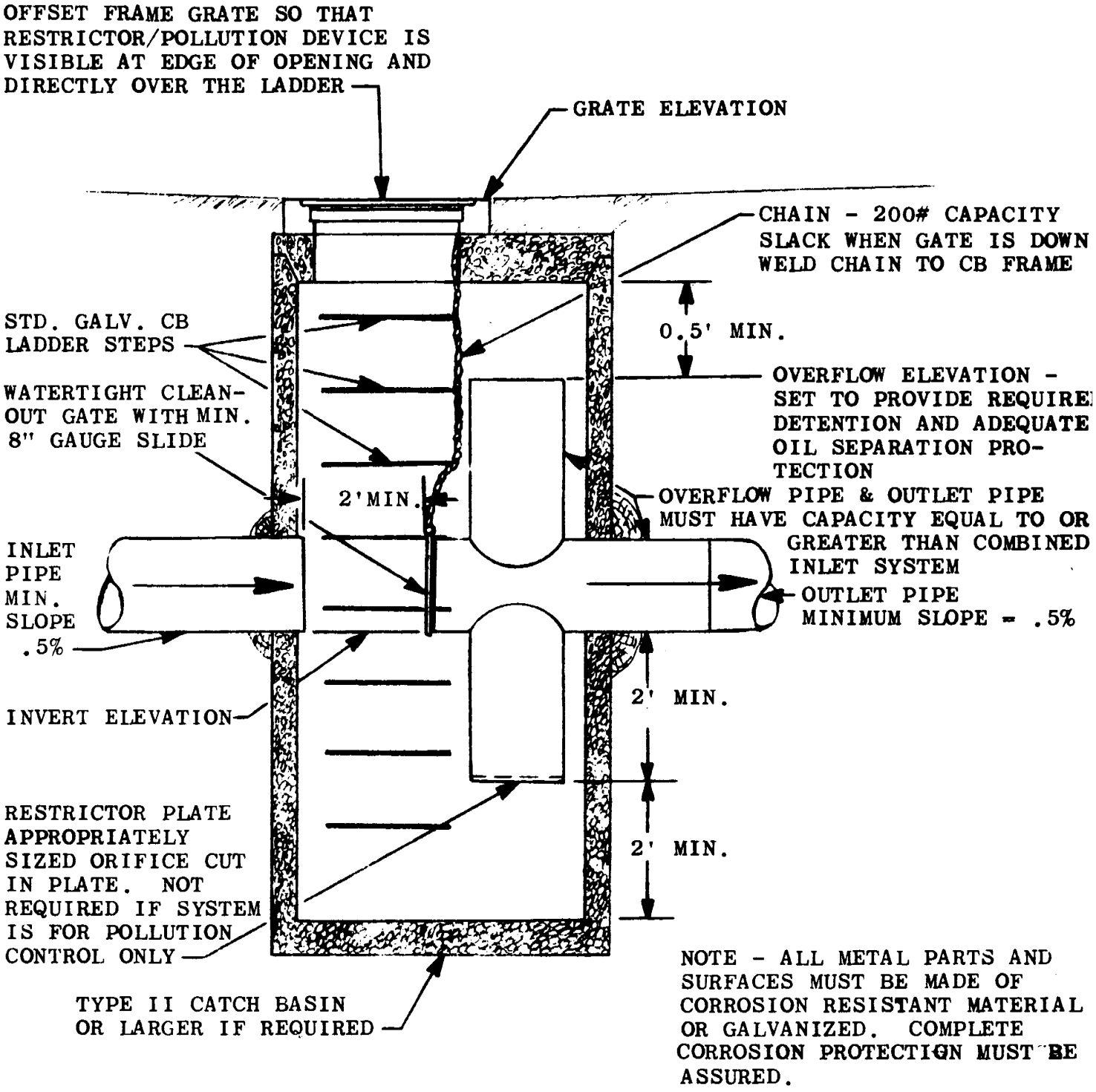

EQUATION: $Q = 0.56\left(\frac{z}{n}\right) s^{1/2} y^{8/3}$
n IS ROUGHNESS COEFFICIENT IN MANNING FORMULA APPROPRIATE TO MATERIAL IN BOTTOM OF CHANNEL
z IS RECIPROCAL OF CROSS SLOPE
REFERENCE: H. R. B. PROCEEDINGS 1946, PAGE 150, EQUATION (14)
EXAMPLE (SEE DASHED LINES)
GIVEN: S = 0.03
z = 19.5
n = 0.013
z/n = 1500
y = 0.20
FIND: Q = 2.0 CFS
RATIO z/n
TURNING LINE
DISCHARGE (Q) IN CFS
SLOPE OF CHANNEL (S) IN FT/FT
DEPTH AT CURB OR DEEPEST POINT (y) IN FEET
INSTRUCTIONS
1. CONNECT z/n RATIO WITH SLOPE (S) AND CONNECT DISCHARGE (Q) WITH DEPTH (y) THESE TWO LINES MUST INTERSECT AT TURNING LINE FOR COMPLETE SOLUTION
2. FOR SHALLOW V-SHAPED CHANNEL AS SHOWN USE NOMOGRAPH WITH $z = \frac{T}{y}$
3. TO DETERMINE DISCHARGE Q_a IN PORTION OF CHANNEL HAVING WIDTH X: DETERMINE DEPTH y FOR TOTAL DISCHARGE IN ENTIRE SECTION a. THEN USE NOMOGRAPH TO DETERMINE Q_b IN SECTION b FOR DEPTH $y' = y - \left(\frac{x}{z}\right)$
4. TO DETERMINE DISCHARGE IN COMPOSITE SECTION: FOLLOW INSTRUCTION 3. TO OBTAIN DISCHARGE IN SECTION a AT ASSUMED DEPTH y, OBTAIN Q_b FOR SLOPE RATIO z_b AND DEPTH y'; THEN $Q_t = Q_a + Q_b$
NOMOGRAPH FOR FLOW IN TRIANGULAR CHANNELS

Figure 6



BUREAU OF PUBLIC ROADS

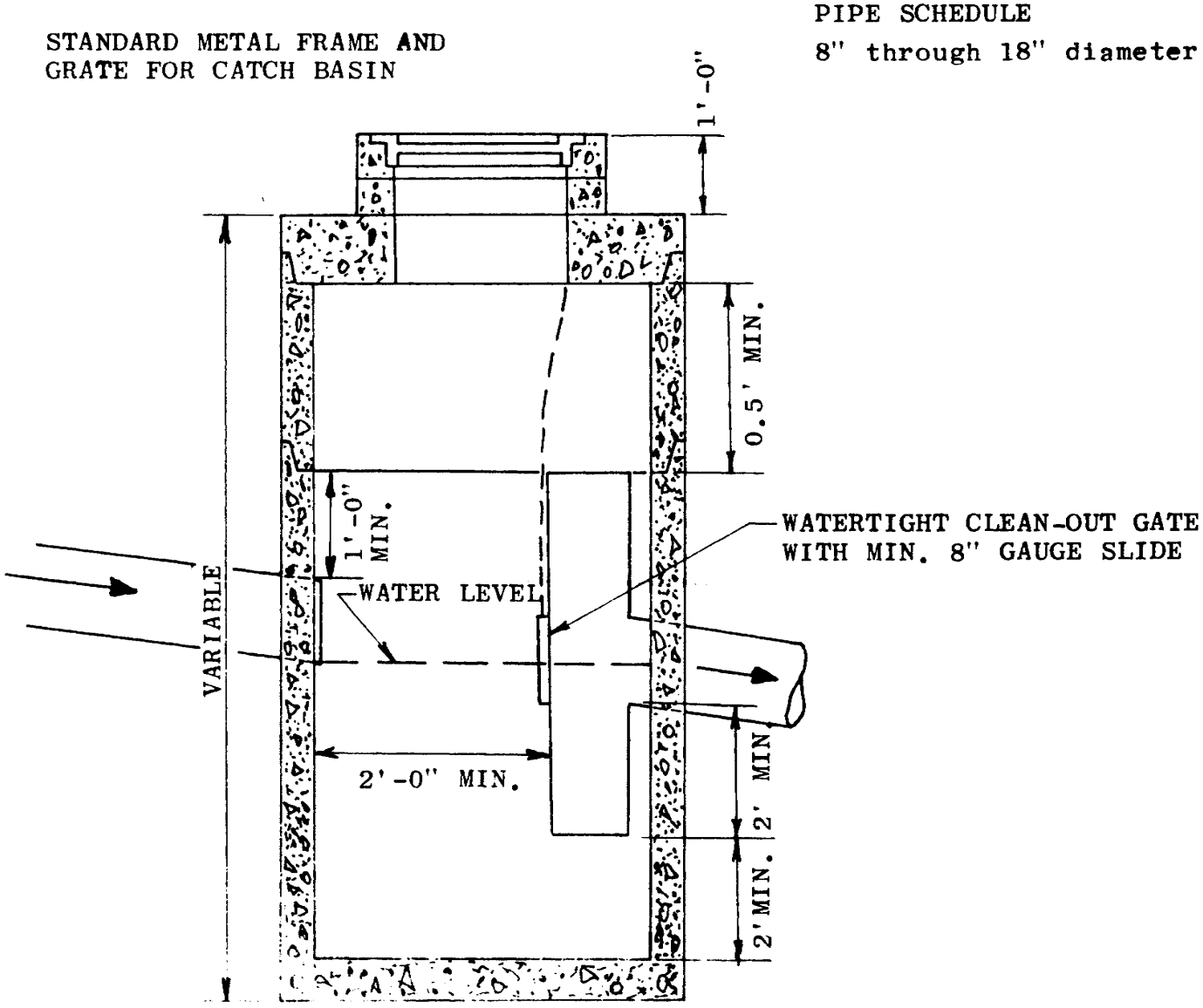
CAPACITY OF GRATE INLET IN SUMP



FLOW RESTRICTOR/OIL POLLUTION

CONTROL DEVICE/CATCH BASIN

Figure 1



GREASE TRAP SEPARATOR

Figure 2

TEMPORARY EROSION / SEDIMENTATION CONTROL PLAN NOTES:

1. WHERE POSSIBLE, MAINTAIN NATURAL VEGETATION FOR SILT CONTROL.
2. TEMPORARY SILTATION AND DETENTION PONDS TO BE CONSTRUCTED BY PLACING STRAW BALES ACROSS SWALES
3. ALL TEMPORARY SILTATION AND DETENTION PONDS SHALL BE MAINTAINED IN A SATISFACTORY CONDITION UNTIL SUCH TIME THAT CLEARING AND/OR CONSTRUCTION IS COMPLETED AND THE PERMANENT DRAINAGE FACILITIES ARE OPERATIONAL.
4. RETURN SILTATION CONTROL AREAS TO ORIGINAL GROUND CONDITIONS
5. RIP-RAP BASE (BOTH SIDES) OF BALES FOR EROSION CONTROL, AS REQUIRED.
6. APPROVAL OF THIS PLAN DOES NOT CONSTITUTE AN APPROVAL OF DESIGN, SIZE NOR LOCATION OF PIPES, RESTRICTORS, CHANNELS OR RETENTION FACILITIES; BUT IS AN APPROVAL OF TEMPORARY SEDIMENTATION CONTROL PLAN ONLY.

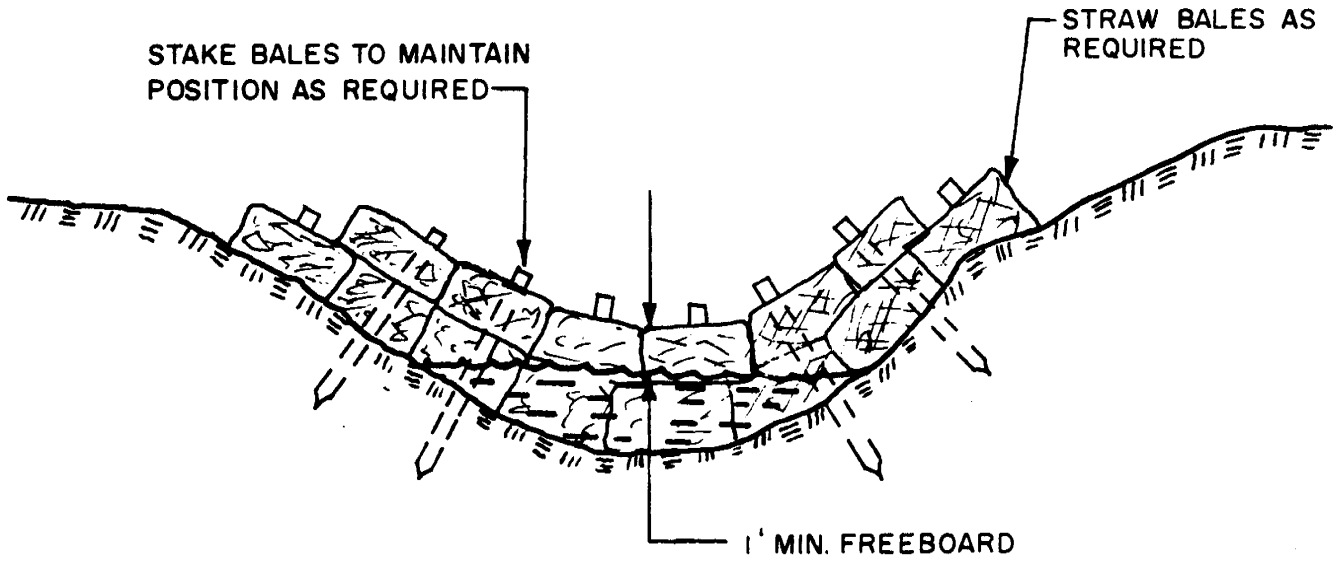
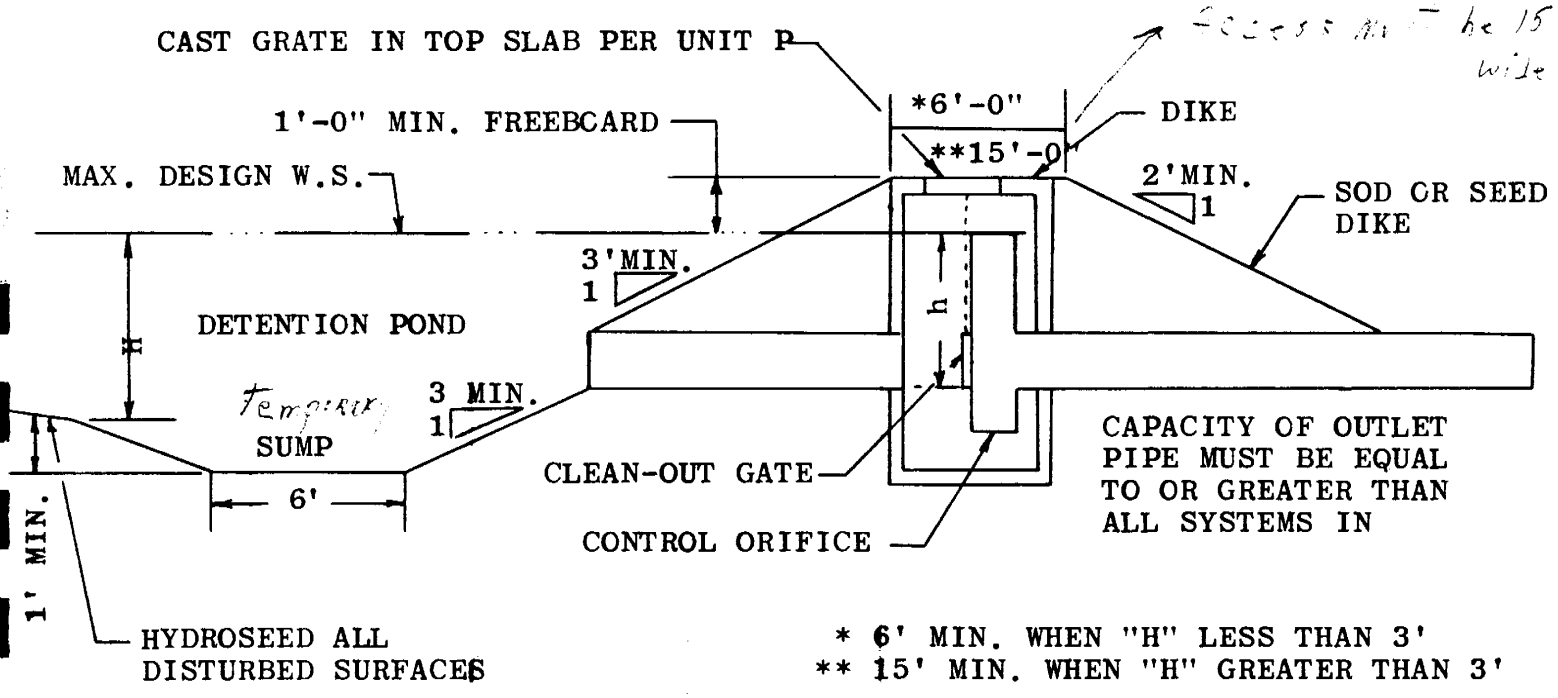
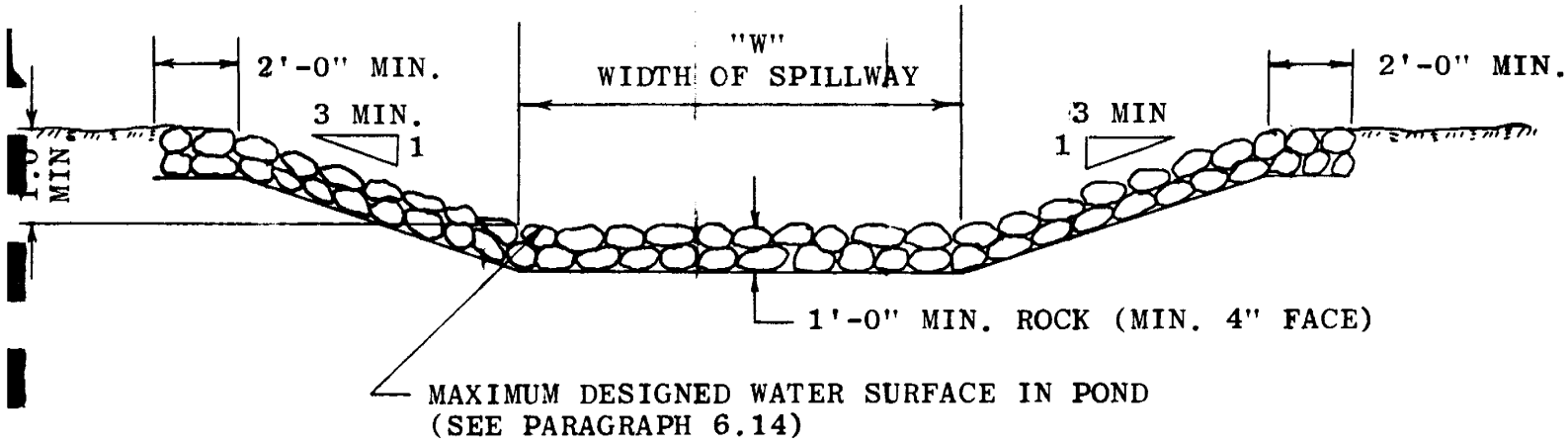


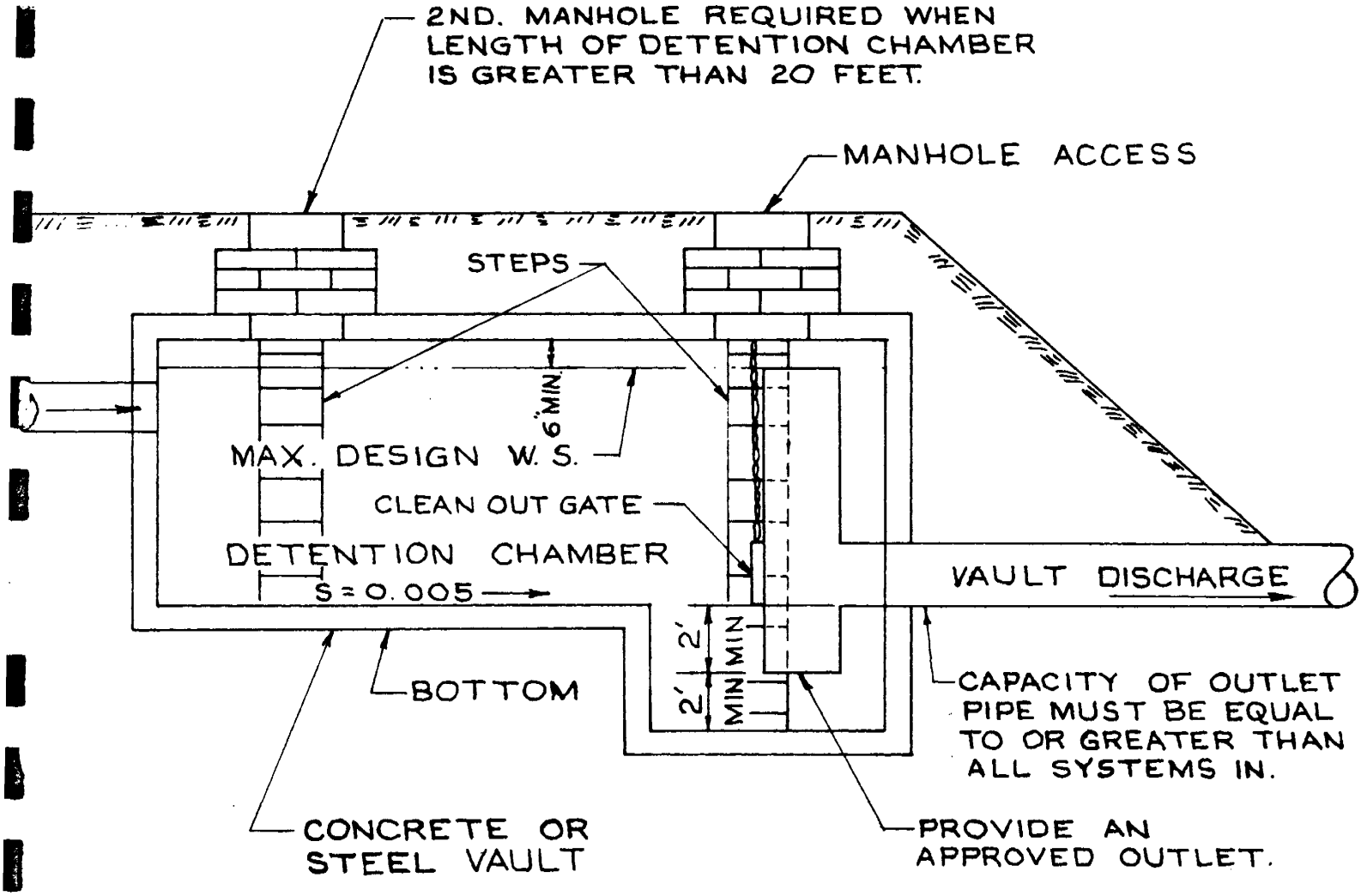
Figure 3



TYPICAL DETENTION POND OUTLET
Figure 4

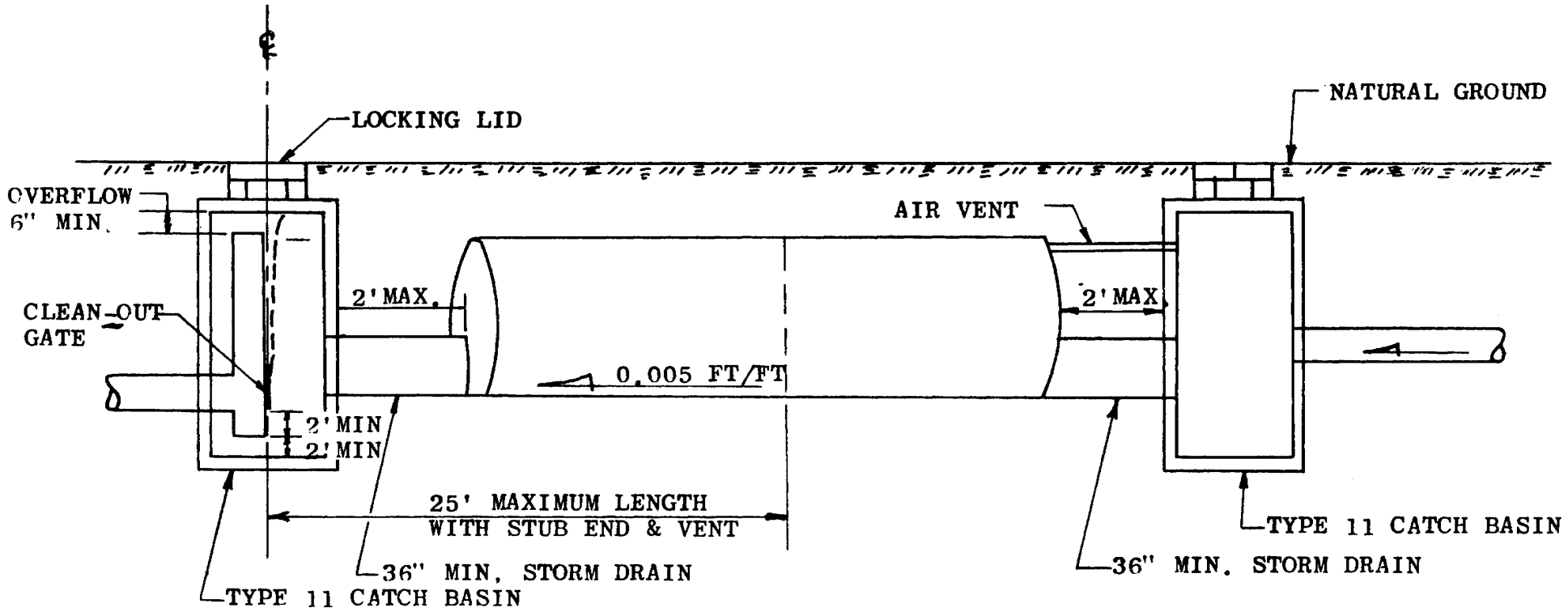


TYPICAL POND OVERFLOW SPILLWAY
Figure 5



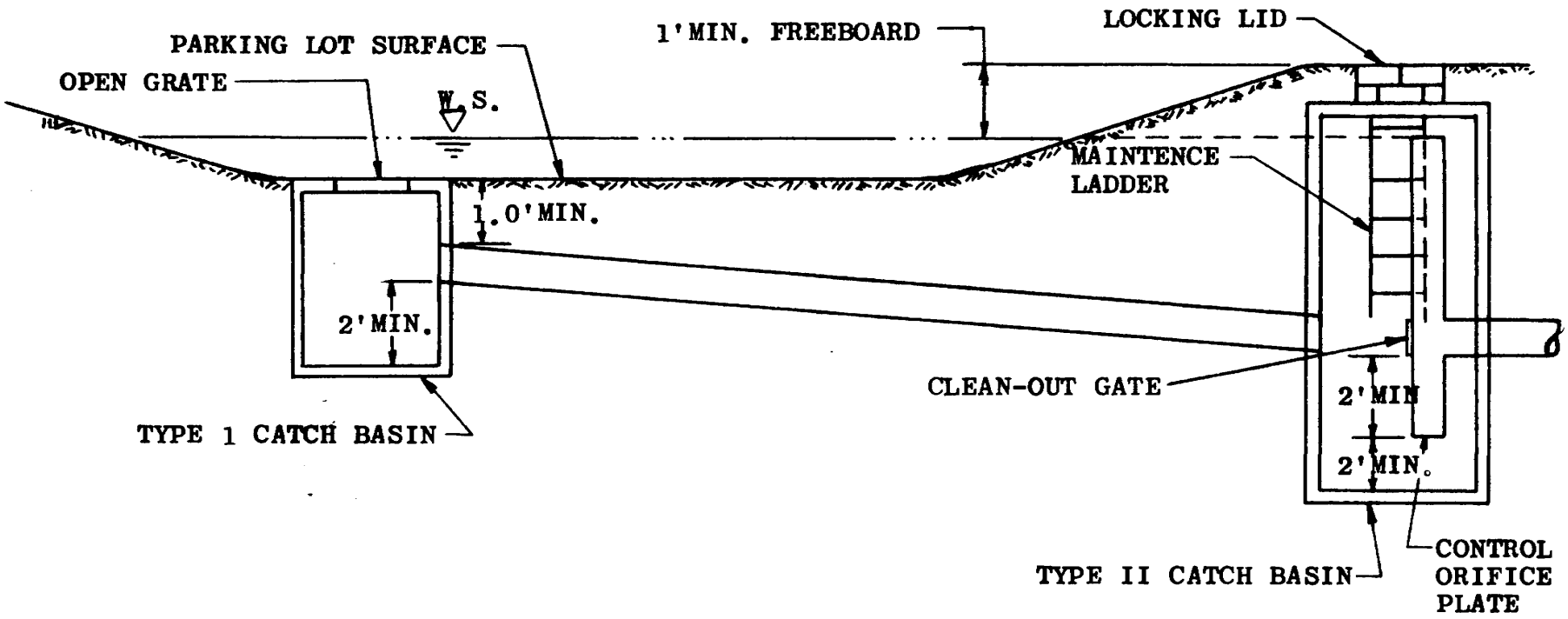
TYPICAL CLOSED DETENTION VAULT

Figure 6



TYPICAL CLOSED DETENTION PIPE

FIGURE 7



TYPICAL PARKING LOT PONDING

FIGURE 8

Calculated by _____ Date _____ Checked by _____ Date _____

STORM SEWER DESIGN CALCULATIONS

S.H. No. 1 Project Westside Storm Sewer
Sheet No. 1 of 1 sheets

LOCATION			DISCHARGE											SEWER DESIGN				SEWER PROFILE						REMARKS
Sewer Located on	From Station	To Station	Source of Drainage	Increment of Area A Acres	Run-off Factor I	AI	ΣAI	Time of Concentration to Sta (Col 2 + Col 3) min	Time of Flow in Pipe Col 3 ÷ 180 min	Total Time to Sta (Col 3 + 10) min	Rainfall Intensity (I) in/hr	Runoff ΣAIR cfs	Discharge from Lat. cfs	Total Discharge (13+14) cfs	Pipe Diameter in	Slope of Pipe ft/ft	Pipe Capacity cfs	Velocity Flowing Full ft per sec	Length ft	Fall in Sewer ft	Ground Elev. At Sta in Col 2	Ground Elev. At Sta in Col 3	Invert Elev At Sta in Col 2	Invert Elev At Sta in Col 3	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
LAT-A	0+00L	0+00R	Pvmt	0.58	0.90	052	052	5.0	0	5.0	220	114	-	1.14	12	0.0400	7.70	9.70	50	2.00	1040	1040	1037.00	1035.00	
	0+00R	2+70R	Pvmt	0.20	0.90	0.18																			
			Grass	0.35	0.35	012	082	5.0	0.6	5.6	220	181	-	181	12	0.0250	6.10	7.70	270	6.75	1040.45	1034.15	1035.00	1028.25	
	2+70L	2+70R	Pvmt	0.20	0.90	0.18	0.18	5.0	0	5.0	220	040	-	0.40	12	0.0400	7.70	9.70	50	2.00	1034.30	1034.15	1030.25	1028.25	
	2+70R	100+00	Pvmt	0.20	0.90	0.18																			
			Grass	0.25	0.35	009	127	5.6	0.8	6.4	210	266		2.66	2'	0.0250	6.10	7.60	300	7.50	1034.15	1026.05	1028.25	1020.75	
	5+40 L	100+00	Pvmt	0.20	0.90	0.18	0.18	5.0	0	5.0	220	0.40	-	0.40	12	0.0450	8.20	10.40	65	2.93	1027.10	1026.05	1023.67	1020.75	
	100+00	104+00	Pvmt	0.65	0.90	0.59																			
			P Grass	2.15	0.20	043	247	6.4	1.2	7.6	2.50	6.25	-	6.25	15	0.0095	6.80	5.50	400	3.80	1026.05	1022.50	1020.50	1016.70	
	0+00	2+00	Pvmt	0.10	0.90	0.09																			
			Grass	0.95	0.40	0.38	0.47	9.0	0.5	9.5	1.70	0.80	-	0.80	12	0.0180	5.20	6.50	200	3.60	1030.00	1027.00	1026.85	1023.25	
	2+00	104+00	Pvmt	0.30	0.90	0.27																			
			Grass	0.20	0.50	0.10																			
			P Grass	1.48	0.25	0.37	1.21	9.5	0.9	10.4	1.60	1.94		1.94	12	0.0180	5.20	6.50	350	6.30	1027.00	1022.50	1023.25	1016.94	
	104+00	105+50	Pvmt	0.35	0.90	0.32																			
			G Grass	0.85	0.65	0.55	4.55	10.4	0.4	10.8	1.95	8.90	-	8.90	18	0.0095	11.0	6.40	150	1.42	1022.50	1020.25	1016.45	1015.03	
	105+50	107+50	Pvmt	0.15	0.90	0.14	4.69	10.8	0.5	11.3	1.90	8.90		8.90	18	0.0100	11.50	6.40	200	2.00	1020.25	1015.60	1005.80	1003.80	Drop MH
	107+50	110+50	P Grass	2.05	0.20	4.10	8.79	24.0	0.8	24.8	1.20	10.50		10.50	18	0.0100	11.50	6.40	300	3.00	1015.60	1008.32	1003.80	1000.80	Long T_c
	110+50	Outfall	-	-	-	-	8.79	24.8	-	-	1.15	10.10	-	10.10	21	0.0060	13.20	5.40	300	1.80	1008.32	1001.50	1000.55	999.75	

ORDINANCE NO. 2281

(As amended by K.C. Ordinance No. 2812)

AN ORDINANCE to establish a surface water runoff policy in King County and requiring the submission of drainage plans in conjunction with land development proposals.

BE IT ORDAINED BY THE COUNCIL OF KING COUNTY:

SECTION 1. PURPOSES. The Council finds that this Ordinance is necessary in order to minimize water quality degredation by preventing the siltation of the county's creeks, streams, rivers, lakes and other water bodies; to protect property owners adjacent to developing land from increased runoff rates which could cause erosion of abutting property; to promote sound development policies which respect and preserve the county's water courses; to insure the safety of county roads and rights of way; and to decrease surface water damage to public and private property.

SECTION 2. DEFINITIONS.

(a) "Computations" shall mean calculations, including coefficients and other pertinent data, made to determine the drainage plan with flow or rates of water given in cubic feet per second (cfs).

(b) "Department" shall mean the Department of Public Works and Transporation.

(c) "Developmental coverage" shall mean all developed surface areas within the subject property including, but not limited to, rooftops, driveways, carports, accessory buildings, and parking areas.

(d) "Director" shall mean the director of the Department of Public Works and Transportation.

(e) "Drainage area" shall mean the watershed (acreage) contributing surface water runoff to and including the subject property.

(f) "Drainage plan" shall mean a plan for receiving, handling, and transporting surface water within the subject property.

(g) "Peak discharge" shall mean the maximum surface water runoff rate (cfs) determined for the design storm frequency.

(h) "Receiving bodies of water" shall mean creeks, streams, rivers, lakes and other bodies of water into which surface waters are directed, either naturally or in manmade ditches or open systems.

(i) "Retention/detention facilities" shall mean facilities designed either to hold runoff for a short period of time and then releasing it to the natural watercourse or to hold water for a considerable length of time and then consuming it by evaporation, plants, or infiltration into the ground.

(j) "Subject property" shall mean the tract of land which is the subject of the permit and/or approval action.

SECTION 3. SUBMISSION OF A DRAINAGE PLAN.

(a) All persons applying for any of the following permits and/or approvals shall submit for approval a drainage plan with their application and/or request:

(1) Grading permit
(2) Substantial development permit
(3) Flood Control zone permit
(4) Subdivision approval
(5) Unclassified use permits
(6) Conditional use permits

(7) Building permits where the permit relates to 5,000 or more square feet of development coverage within the property.

(8) Plan Unit Development

(b) Drainage plans will be required for those short plat applications which present adverse drainage impacts as defined by administrative guidelines to be developed by the Department and the Division of Building and Land Development and approved by the County Council. *

(c) The plan submitted during one permit/approval process may be subsequently submitted with further required applications. The plan shall be supplemented with additional information at the request of the Department of Public Works and Transportation.

The plan requirement established in this section will not apply when the department determines that the proposed permit and/or activity:

(1) Will not seriously and adversely impact the water quality conditions of any affected receiving bodies of water, and/or

(2) will not alter the drainage patterns, increase the peak discharge, and cause any other adverse effects in the drainage area.

SECTION 4. CONTENTS OF A DRAINAGE PLAN. All persons applying for any of the permits and/or approvals contained in Section 3 of this ordinance shall provide a drainage plan for surface water flows entering, flowing within, and leaving the subject property. The detailed form and contents of the drainage plan shall be described in procedures provided by the department. The procedures will set forth the manner of presenting the following required information:

(a) Background computations for sizing drainage facilities:

(1) Depiction of the drainage area on a topographical map, with acreage indicated.

(2) Indication of the peak discharge and amount of surface water currently entering and leaving the subject property.

(3) Indication of the peak discharge and amount of runoff which will be generated within the subject property if development is allowed to proceed.

(4) Determination of the peak discharge and amount of water that will be generated by the design storm frequencies as specified by the department at various points on the subject property.

(b) Proposed improvements for handling the computed runoff.

SECTION 5. MANDATORY REQUIREMENTS FOR ALL DRAINAGE IMPROVEMENTS. (1) Surface water entering the subject property shall be received at the naturally occurring location and surface water exiting the subject property shall be discharged at the natural location with adequate energy dissipators to minimize downstream damage and with no diversion at any of these points; and (2) The peak discharge from the subject property may not be increased due to the proposed development; and (3) Retention/detention facilities must be provided in order to handle all surface water in excess of the peak discharge; and (4) Where open ditch construction is used to handle drainage within the tract, a minimum of 15 feet will be provided between any structures and the top of the bank of the defined channel.

(a) In open channel work the water surface elevation will be indicated on the plan and profile drawings. The configuration of the finished grades constituting the banks of the open channel will also be shown on the drawings.

(b) Proposed cross-section of channel will be shown with stable side slopes. Side slopes will be 3:1 maximum unless paved or stablized in some other manner approved by the Department.

* King County Motion No. 2604 (see pg. 5)

(c) The water surface elevation of the design flow will be indicated on the cross-section.

(5) Where a closed system is used to handle drainage within the tracts, all structures will be a minimum of 10 feet from the closed system.

Variances from any or all of the foregoing requirements may be permitted only after a determination by the Department employing the following criteria:

(a) Capacity of downstream facilities;
(b) Acceptablity of receiving bodies of water;
(c) Possibility of adverse effects of retention;
(d) Utility of regional retention facilities; and
(e) Capability of maintaining the system.

SECTION 6. DEVELOPMENT IN CRITICAL FLOOD, DRAINAGE, AND/OR EROSION AREAS. Development which would increase the volume of discharge from the subject property shall not be permitted in areas where existing flooding, drainage, and/or erosion conditions present an imminent likelihood of harm to the welfare and safety of the surrounding community, until such a time as the community hazard is alleviated, where applications of the provisions of this section will deny all reasonable uses of the property, the restriction on development contained in this section may be waived for the subject property, provided that the resulting development shall be subject to all of the remaining terms and conditions of this ordinance.

SECTION 7. REVIEW AND APPROVAL OF THE PLAN. All storm drainage plans prepared in connection with any of the permits and/or approvals listed in Section 3 shall be submitted for review and approval to the Department of Public Works and Transportation, Division of Hydraulics.

SECTION 8. BONDS AND LIABILITY INSURANCE REQUIRED. The Department of Public Works and Transportation is authorized to require all persons constructing retention/detention facilities to post with the director of the department surety and cash bonds. Where such persons have previously posted, or are required to post, other such bonds with the director, either on the facility itself or on other construction related to the facility, such person may, with the permission of the director and to the extent allowable by law, combine all such bonds into a single bond, provided that at no time shall the amount thus bonded by less than the total amount which would have been required in the form of separate bonds, and provided further that such a bond shall on its face clearly delineate those separate bonds which it is intended to replace.

(1) CONSTRUCTION BOND. Prior to commencing construction, the person constructing the facility shall post a construction bond in an amount sufficient to cover the cost of conforming said construction with the approved drainage plans. After determination by the department that all facilities are constructed in compliance with the approved plans, the construction bond shall be released.

(2) MAINTENANCE BOND. After satisfactory completion of the facilities and release of the construction bond by the county, the person constructing the facility shall commence a one year period of satisfactory maintenance of the facility. A cash bond to be used at the discretion of the director to correct deficiencies in said mantenance affecting public health, safety and welfare must be posted and maintained throughout the one year maintenance period. The amount of the cash bond shall be determined by the director, but shall not be in excess of one thousand dollars. In addition, a surety bond or cash bond to cover the cost of defects or failures of the facilities shall also be posted and maintained throughout the one year maintenance period.

(3) The person constructing the facility shall maintain a liability policy in the amount of one hundred thousand dollars per individual, three hundred thousand dollars per occurrence and fifty thousand dollars property damage, which shall name King County as an additional insured and which shall protect King County from any liability up to those amounts for any accident, negligence, failure of the facility, or any other liability whatsoever, relating to the construction or maintenance of the facility. Said liability policy shall be maintained for the duration of the facility by the owner of the facility, Provided that in the case of facilities assumed by King County for maintenance pursuant to Section 9 of this ordinance, said liability policy shall be terminated when said county maintenance responsibility commences.

SECTION 9. COUNTY ASSUMPTION OF MAINTENANCE. King County is authorized to assume the maintenance of retention/detention facilities after the expiration of the one year maintenance period in connections with the subdivision of land if:

(1) All of the requirements of Section 7 have been fully complied with;

(2) The facilities have been inspected and approved by the department after their first year of operation;

(3) The surety bond required in Section 8 herein, has been extended for one year, covering the county's first year of maintenance.

(4) All necessary easements entitling the county to properly maintain the facility have been conveyed to the county.

SECTION 10. RETROACTIVITY RELATING TO COUNTY MAINTENANCE OF SUBDIVISION FACILITIES. If any person constructing retention/detention facilities and/or receiving approval of drainage plans prior to the effective date of this ordinance re-assesses the facilities and/or plans so constructed and/or approved and demonstrates, to the director's satisfaction, total compliance with the requirements of this ordinance, the county may, after inspection, approval, and acknowledgement of the proper posting of the required bonds as specified in Section 8 assume maintenance of the faciliities.

SECTION 11. APPLICABILITY TO GOVERNMENTAL ENTITIES. All municipal corporations and governmental entities shall be required to submit a drainage plan and comply with the terms of this ordinance when developing and/or improving land including but not limited to, road building and widening, within the unincorporated areas of King County.

SECTION 12. EFFECTIVE DATE. The effective date of this ordinance shall be ten days after its enactment. The requirements of this ordinance shall apply to all roads commencing construction and/or widening subsequent to December 31, 1975. Further, all plats receiving preliminary approval subsequent to the effective date of this ordinance must comply with the terms of the ordinance. In the case of all additional actions enumerated in Section 3, the terms of this ordinance will apply where final action by the county has not been taken prior to the effective date of the ordinance.

SECTION 13. SEVERABILITY. If any provision of this ordinance or its application to any person or property is held invalid the remainder of the ordinance or the application of the provision to other persons or circumstances shall not be affected.

"SECTION 12. KING COUNTY ORDINANCE NO. 2812" Resolution 36230 is hereby repealed."

Ordinance No. 2281 was passed and approved January 14, 1975.
Ordinance No. 2812 was passed and approved July 26, 1976.
The codified version of these ordinances will be found in King County Code 20.50.

MOTION NO. 2604

A MOTION establishing administrative guidelines for determining the need for drainage plans in conjunction with short plat applications in accordance with Ordinance No. 2281 and K.C.C. 20.50 as amended.

WHEREAS, Ordinance No. 2281 and K.C.C. 20.50 have been revised by the County Council, and

WHEREAS, the revised ordinance which has been adopted by the Council states that "Drainage plans will be required for those short plat applications which present adverse drainage impacts as defined by administrative guidelines to be developed by the Department and the Division of Building and Land Development and approved by the County Council," and

WHEREAS, The Department of Public Works and the Department of Planning and Community Development have developed guidelines delineating which short plat applications shall be required to include drainage plans for review by the Division of Hydraulics,

NOW THEREFORE, BE IT MOVED by the Council of King County:

1. Any short plat which meets one or more of the following criteria shall include a drainage plan which shall be submitted to the Division of Hydraulics for review and approval:
   1) Two or more vacant or undeveloped lots are created where the average density is less than 35,000 square feet.
   2) Natural drainage swales and/or natural retention areas are located within the short plat and exceed one foot in depth. These shall be identified by the applicant on the short plat.
   3) The short plat lies within a designated critical area as defined by Ordinance No. 2281 as amended.
   4) The short plat is located within or adjacent to the flood plain for a river or stream.
2. Drainage improvements for short plats shall comply with all applicable criteria set forth in K.C.C. 20.50.
3. If any provision of this motion is found to be inconsistent with the County's short plat ordinance (K.C.C. 19.26), revisions shall be made to insure consistency.

Motion No. 2604 was passed and approved July 26, 1976.

KING COUNTY DEPARTMENT OF PUBLIC WORKS

DRAINAGE POLICIES AND/OR RECOMMENDATIONS

TABLE OF CONTENTS

SECTION 1 - GENERAL REQUIREMENTS

1.1 The temporary erosion/sedimentation control facility shall be constructed prior to any grading or extensive land clearing in accordance with the approved temporary erosion/sedimentation control plan. These facilities must be satisfactorily maintained until construction and landscaping is completed and the potential for on-site erosion has passed. (Add this note on temporary erosion/sedimentation control and final drainage plans).

1.2 All required storm water retention/detention facilities must be constructed and in operation prior to paving and building construction unless otherwise approved by the Department of Public Works. (Add this note on final drainage plan.)

1.3 In those cases where no runoff leaves the site for a storm greater than a 100 year frequency, the engineer is required to design the development to retain the 100 year frequency storm with no runoff. The overflow after the 100 year frequency storm must be situated where it would have overflowed under the existing condition.

1.4 The capacity of the downstream drainage course may be required to be evaluated for a minimum distance of 1/4 mile from the point of discharge of the development. This system would be shown on the drainage layout and related drawings, in detail.

1.5 Construction details must be provided on drawings for all drainage systems. These drawings must show plan, profiles and cross sectional views.

1.6 When calculating required storage capacity of the retention/detention facilities, use only the expected runoff of the design storm for the total area of the development site, unless otherwise required by the Department of Public Works.

1.7 A simple retention/detention design method, such as the "Yrjanainen and Warren Method," may be used for areas less than 200 acres. For areas exceeding 200 acres, the Soil Conservation Service's Method or similar type analysis must be used.

1.8 The size of the controlled outlet shall be calculated for the total drainage basin when the total runoff from both off-site and on-site are combined.

1.9 All structures shall be located no closer than 10 feet from the spring line of any culvert and 15 feet from the top of any channel bank. These setbacks must be shown on the plans. (See Figure 1)

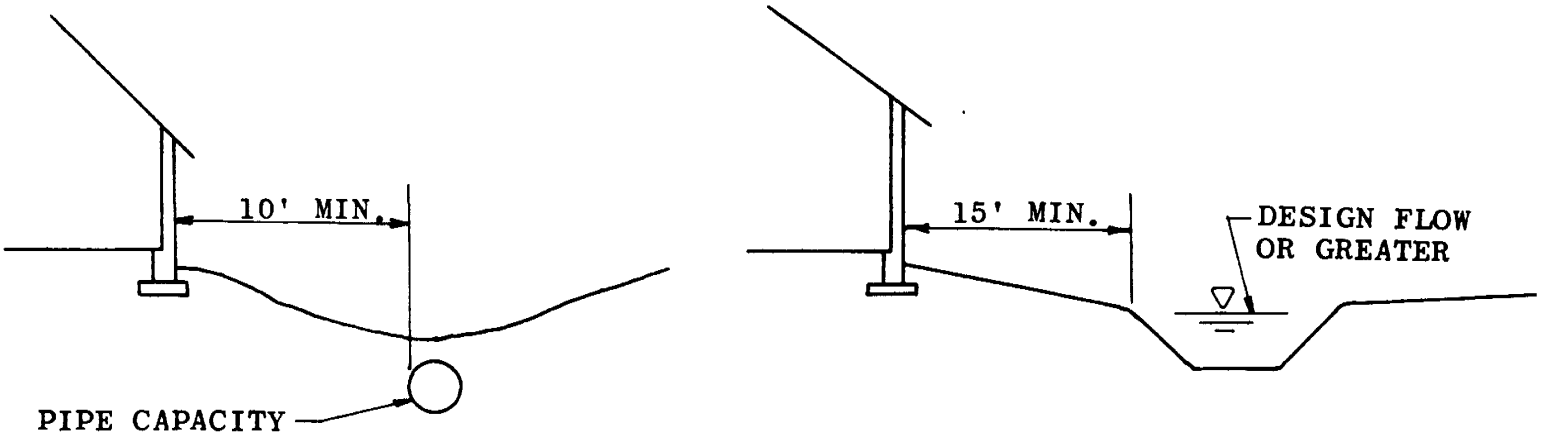


FIGURE 1

1.10 Permanent bridges that provide minor stream crossings for residential access streets shall be designed to accommodate the 25 year frequency flood with a minimum of 2 feet of clearance between the maximum design water surface and the lowest portion of the bridge span. A minimum clearance of 6 feet above the 100 year frequency maximum water surface must be provided for any major stream or river unless otherwise approved by the Department of Public Works.

1.11 An emergency overflow system is required for all retention/detention facilities.

1.12 Open retention/detention ponds and infiltration facilities shall not be located in dedicated public road right of way areas.

1.13 Sharp edge circular orifices may be used for discharge restriction where $Q = Ac\sqrt{2gh}$ and "C" = 0.62. "h" shall be the vertical distance between maximum water surface and centerline of the orifice for other than submerged outlets. See Handbook of Hydraulics, Fifth Edition, by King and Brater for other acceptable types of orifices.

1.14 Where a natural ground depression occurs in the drainage course of an area to be considered in contributing runoff in the natural state to a proposed retention/detention facility, consideration shall be given to past detention capability of that natural depression which has caused an increase in Time of Concentration. The following procedure may be followed in determining the time of flow in the depression: From a topographical map of the depression determine the mean depth and width and calculate the area. Determine the rate of runoff in the natural state to the depression and the corresponding time of concentration from Q=AV, calculated the mean velocity through the depression. Determine the length of depression and calculated time of flow. Add this time of flow to time of concentration at head of the depression to determine time of concentration at the downstream end thereof. Also, the existing retention/detention capacity of the natural depression must be analyzed in calculating the allowable rate of runoff from the subject property.

1.15 Where the drainage area upstream of a proposed retention/detention facility exceeds 200 acres, determine Time of Concentration to the detention facility for the immediate upstream 200 acres of the drainage area, including the development, contributing runoff to the detention pond and calculate runoff using the Rational Formula, Q=ACI. Then, determine time of concentration for entire drainage basin upstream of the detention pond and calculate runoff to the pond using Rational Formula. Use the greater of the two calculated runoff in determining the runoff to the pond in the natural state. Follow the same procedure for designing the most upstream culvert receiving runoff from the upstream basin.

1.16 The limits of the 25 or 100 year frequency flood plains (25 Stream)(100 River) may be required to be deliniated on the face of the Final Plat, as well as the engineering drawings for plat construction.

1.17 Arrows indicating drainage direction in all public and private property shall be shown on the Construction Drawings for all hydraulic conveyance systems.

1.18 A soils report prepared by an engineer may be required when a proposed development is adjacent to a steep unstable hillside.

1.19 A topography map, at least 1" = 100', shall be used to indicate drainage areas contributing runoff within the proposed development.

1.20 The best topographical map sufficient in area to show all areas draining onto the proposed land development must be submitted and show enough of abutting downstream properties to indicate natural or man-made drainage course into which the proposed land development is to drain. This map shall have indicated thereon direction of flow, acreage of areas contributing drainage to the development, the outline of the development, the length of travel and grade of the mean drainage course in upstream areas from the farthest upstream point in the upstream area to the farthest upstream end of a proposed storm sewer or ditch in the development and to any proposed storm water retention/detention facility. Said map shall have references shown thereon for use and reference in the expository part of drainage plan.

1.21 Pipe anchors may be required when pipe slopes exceed 15% or when constructed in unstable soils regardless of whether it is a buried or above ground installation unless proven stable by a soils analysis.

SECTION 2 - DEFINITIONS & TERMS

2.1 Design storm is the rain storm of a chosen intensity and duration selected for a storm drainage analysis and system design, and can be expressed as having a statistical probability of recurrence, i.e. once in every 5, 10, 25, or 100 years.

2.2 Drainage area is the area that contributes runoff to the point under design.

2.3 Embankment (or fill) is a bank of earth, rock or other material constructed above the natural ground surface.

2.4 Flowline or Invert means that part of a pipe or culvert below the spring line - generally the lowest point of the internal cross section.

2.5 Height of Cover (hc) is the distance from the crown of a culvert or conduit to the finished ground or road surface.

2.6 Impervious means impenetrable. Completely resisting the entrance of liquids.

2.7 Intercepting Drain is a ditch or trench filled with pervious filter material around a subdrainage pipe.

2.8 Revetment is a wall or a facing of stone placed on stream banks to prevent erosion.

2.9 Right Bank is that bank of a stream which is on the right when one looks downstream.

2.10 Spring Line (or springing line) is the line of intersection between the intrados and the supports of an arch. Also the maximum horizontal dimension of a culvert or conduit.

2.11 Subdrain (underdrain) means a pervious backfilled trench containing a pipe with perforations or open joints for the purposes intercepting ground water or seepage.

2.12 Top of Bank shall mean a major topographic break as approved by the Department of Public Works.

SECTION 3 - TEMPORARY EROSION/SEDIMENTATION CONTROL

3.1 An Temporary Erosion/Sedimentation Control plan is required unless otherwise approved by the Department of Public Works.

3.2 Prior to the initial clearing and grading of any land development, provisions shall be made for the interception of all potential silt-laden runoff that could result from said clearing and grading. Said interception shall preclude any silt-laden runoff from discharging from the proposed land development to downstream properties unless approved as hereinafter described. Said interception shall cause all silt-laden runoff to be conveyed by open ditch or other means to whatever temporary facility is necessary to remove silt from said silt-laden runoff prior to discharge to downstream properties.

3.3 Details of the siltation ponds and channels must be submitted. The location and profiles of the interim drainage channels may be shown by a typical cross-section and flow direction arrows.

3.4 The maximum velocities and channel slopes must be shown on the Temporary Erosion/Sedimentation Control plan.

3.5 Construction such as right of way clearing, grading and underground utilities may commence upon approval of the Temporary Erosion/Sedimentation Control Plan.

3.6 Check dams shall be employed or some other acceptable method to limit ditch velocities to 5-foot per second unless rocked. "V" ditches may be used with side slopes no steeper than 2 horizontal to 1 vertical.

3.7 A desiltation facility or siltation pond shall provide a minimum of one-foot below the lowest point of the pond discharge for storage. The volume of the pond above the 1.0 foot storage shall be a minimum of 150 cubic feet per acre contributing runoff to the pond.

3.8 Discharge from a siltation pond shall be directed through straw bales or some other acceptable filtering system before leaving the proposed development.

3.9 Excavated sides of siltation ponds shall be no steeper than three horizontal to 1 vertical. A minimum of 1 foot of freeboard shall be provided for all siltation ponds.

3.10 It is recommended wherever possible to locate intercepting ditches across future building sites to preserve natural vegetation. Intercepting ditches outside of future building sites should meander to avoid trees.

3.11 Cut-off trenches are recommended to dissipate drainage into the natural on-site vegetation. However, drainage from disturbed areas must be directed into a siltation pond prior to leaving the site unless otherwise approved by the Department of Public Works.

SECTION 4 - NATURAL & CONSTRUCTED CHANNELS -- REQUIREMENTS

4.1 Bank stabilization is required when the design flow velocities of constructed channels exceed 5 feet per second (5 fps).

4.2 Unstable river and major stream banks in proposed subdivisions shall be stabilized to the satisfaction of Department of Public Works.

4.3 Show design velocities in computations for all constructed drainage ditches.

4.4 All road ditches shall be as shown on King County Standard Road Section for Open Ditch Construction. All other ditches or channels shall have maximum side slopes of 3 horizontal to 1 vertical unless approved by the Dept. of Public Works. Ditches may be "V" shaped or trapezoidal.

4.5 Capacity of ditches and channels shall be determined by the Manning Formula. The value for "n" shall be 0.030 for natural earth-lined ditches. The value for "n" shall be 0.035 for ditches with rock-lined bottoms. Minimum velocity for ditch at design flow shall be 2.0 feet per second unless approved otherwise by the Department of Public Works.

4.6 Ditches shall have rock-lined bottoms and side slopes at discharge point of storm sewers or culverts. The rock shall extend for a minimum of 8 feet downstream from the end of the storm sewer or culvert.

4.7 All ditch sides and bottoms shall be seeded except, of course, rock-lined channels and roadside ditches.

4.8 Points of discharge from culverts and storm sewers into ditches 15% or greater in grade shall be rock-lined with boulders with one face a minimum of 24" in dimension. Said rock lining shall extend for a distance of 10 feet minimum from the point of culvert or storm sewer discharge and shall have a width 3 feet in excess of the diameter of the culvert or storm sewer. Also, a special outlet structure serving as an energy dissipator may be required.

4.9 For normal rock lined ditches with design velocities less than 8 feet per second, quarry spalls should be used as defined in Section 9.13.1 of Washington State Highway Standard Specifications. Also, the minimum rock thickness shall be 12 inches.

4.10 Where velocity of flow in road ditches exceeds 5.0 feet per second the two sides of the "V" ditch shall be lined with rock as specified in (4.9) above to a minimum depth of 12". Top of rock lining shall extend to the bottom of the shoulder crushed rock.

4.11 Ditches and channels in property other than public property shall be provided with a drainage easement sufficient in width to accommodate a 15 foot wide access along each side of the channel when the channel top width exceeds 30 feet. When the channel top width is 30 feet or less, a 15 foot wide strip for an access road maybe required on only one side.

SECTION 5 - CLOSED SYSTEMS & STRUCTURES -- REQUIREMENTS

5.1 The maximum allowable velocity in concrete pipe is thirty (30) feet per second.

5.2 A minimum velocity in any pipe or culvert carrying the design storm flow shall be two (2) feet per second. EXCEPTIONS: Culvert installed as "equalizers" and those culverts and piping that are a direct part of the retention/detention system.

5.3 Show design velocities in computations for all storm water culverts.

5.4 Debris barriers shall be required at the inlets of all culverts larger than 24". Debris barriers may be required for culverts less than 24".

5.5 Match crowns of culverts or use the 0.8 rule at all catch basins and manholes, except for drop manholes, or unless otherwise approved by the Department of Public Works. The 0.8 rule matches 0.8 the diameter of the culverts instead of culvert crowns as measured from their respective inverts.

5.6 Downsizing of culverts within a closed system with culverts less than 18 inches in diameter is not permitted. Culverts larger than 18 inches in diameter may be downsized 3 inches, if the culvert capacity is adequate and a minimum 100 foot run of pipe is proposed to be downsized.

5.7 Storm water entering a closed storm drainage systems shall be via catch basins as shown on King County Standards for debris and silt removal.

5.8 A 8-inch pipe laid with a minimum velocity of 2 fps may be used to connect a curb inlet to a catch basin if the length of the pipe does not exceed 44 feet. If a longer pipe is required to connect a curb inlet to a catch basin, a catch basin shall be used in lieu of the curb inlet and a 12" pipe shall be used with a minimum velocity of 2.0 fps at design flow.

5.9 Any closed storm sewer system collecting runoff from paved areas in public or private property shall provide for oil separation prior to discharge of the system to any offsite hydraulic conveyance system unless otherwise approved by the Department of Public Works.

5.10 Type II catch basins shall be required to accommodate all pipe greater than 18" in diameter.

5.11 No storm sewer between catch basins or manholes shall be less than 12" in diameter.

5.12 Where any pipe discharges onto an area at a point other than a natural defined drainage course, the discharge shall be dispersed over an area sufficiant to approximate the predeveloped condition.

5.13 No storm sewer pipe in a drainage easement shall have its centerline closer to a private rear or side property line than 5'.

SECTION 6 - OPEN RETENTION/DETENTION PONDS - REQUIREMENTS

6.1 Side slopes for earth lined retention/detention ponds shall be no steeper than 3 horizontal to 1 vertical unless approved by the Department of Public Works. Flatter slopes are encouraged.

6.2 The access road grade into the proposed retention/detention pond must be no steeper than 5 horizontal to 1 vertical.

6.3 All retention/detention ponds not abutting a public right of way shall be accessible to King County Work Forces for maintenance and operation. Access shall be provided in access easements and shall accommodate vehicular traffic. Access shall be surfaced with a 15-foot wide gravel, Class "B" or equal lane laid at a minimum depth of 6". Well graded quarry rock may be used with 6" maximum, 1-1/2" minimum aggregate. Access surfacing must accommodate traffic loading of 10 cubic yard dump truck and 3 cubic yard front end loader.

6.4 A vehicular access road must be provided to the bottom of the retention/detention pond when the bottom width of the pond is 20 feet, or greater, and the road shall be surfaced with quarry rock to a minimum depth of 6". Gravel base, class "B" may be required pending soil conditions. The access road shall be able to support maintenance vehicles and equipment such as a 10 cubic yard dump truck and 3 cubic yard front end loader.

6.5 All retention/detention ponds shall have a minimum of one foot of freeboard above the maximum design water surface.

6.6 Any embankment for a retention/detention pond in excess of 4 feet must be approved by a qualified engineer and the Department of Public Works. The minimum top width of this berm shall be 15 feet with a key section, unless otherwise approved by a qualified engineer and the Department of Public Works.

6.7 Any embankment less than 4 feet including 1 foot of freeboard in depth forming one or more sides of a retention/detention pond shall have a minimum 6 foot wide berm with back slope not to exceed 2 horizontal to 1 vertical.

6.8 All constructed and graded retention/detention ponds shall be sloped no flatter than 0.005 ft./ft. (1/2%) towards the outlet, for drainage.

EXCEPTION: This requirement need not apply to natural ponds, which exist, and are utilized for storm water detention.

6.9 All berms or embankments constructed for retention/detention ponds in excess of 2 feet in height shall be compacted to at least 95 percent of the maximum relative density as determined by Section 2-03.3(14)D of the Washington State Highway Department 1976 Standard Specifications. Those berms 2 feet in height and less shall be compacted as stated above or compacted by a dozer or similar type piece of equipment in lifts not to exceed 6 inches of compactable soil.

6.10 The back slopes for all earth berms shall be no steeper than 2 horizontal 1 vertical.

6.11 Backup retention/detention facilities and the preservation of natural drainage ponds are encouraged. See figure 2 below.

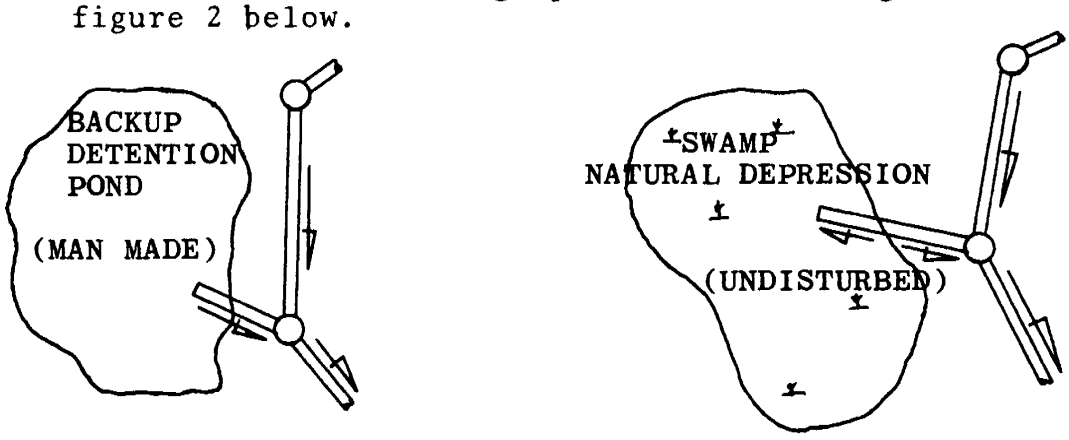


FIGURE 2

6.12 All detention ponds shall have a spillway whose top elevation shall equal or be greater than the maximum design water surface elevation.

6.13 Spillway surfacing may be rock spalls or crushed rock having one face with a minimum dimension of 4 inches. Spalls or crushed rock shall be laid in two or more layers to a minimum depth of 12 inches. Spillway shall have side slopes at the ends not to exceed a slope of 3 horizontal to 1 vertical.

6.14 Spillways for retention/detention ponds shall be designed as suppressed sharp-crested weirs so long as maximum depth of flow over weir does not exceed 0.33 feet (4").

6.15 Storm retention/detention ponds may be utilized as Interim Drainage Facilities if approved by the Department of Public Works.

6.16 The use of a private parking lot to act as a retention/detention facility is permissable provided the surface storage portion of the facility is located entirely within the parking portion of the lot. The access and service roads shall not be utilized for surface storage.

6.17 A fence may be required around a retention/detention pond where the pond side slopes are steeper than 3 horizontal to 1 vertical.

SECTION 7 - CLOSED DETENTION SYSTEMS

7.1 A standard manhole or Type II catch basin is required when the depth exceeds 5 feet from the flowline (invert) of a culvert to the top of grate. A ladder or steps are required when the depth exceeds 3 feet from the flowline (invert) to the top of grate excluding Type 1B catch basin.

7.2 Adequate access to detention facilities shall be required, i.e. a manhole at each end of a closed, underground facility. See figures 6 and 7.

7.3 All metal tanks, culverts, pipes and other metal parts of any storm water detention facility shall be protected with asphalt, galvanization or other adequate protective covering and structurally sound to the satisfaction of the Department of Public Works.

SECTION 8 - INFILTRATION SYSTEMS

8.1 If an infiltration system is used, runoff is required to flow through an oil separator and a filtering system prior to entering the infiltration system unless otherwise approved by the Department of Public Works.

8.2 No soils infiltration shall be assumed in detention ponds or channels, unless otherwise approved by the Department of Public Works.

8.3 French drains and dry wells generally are not recommended as a means of disposing of surface water, except for small areas and areas that have a high infiltration rate. Also, they will only be approved when the engineer shows that an adequate filtering device is to be provided giving special note to the capacity of the filtering device to pass water into the French drain or drywell.

8.4 If an infiltration system is used, a percolation test or tests must be provided.

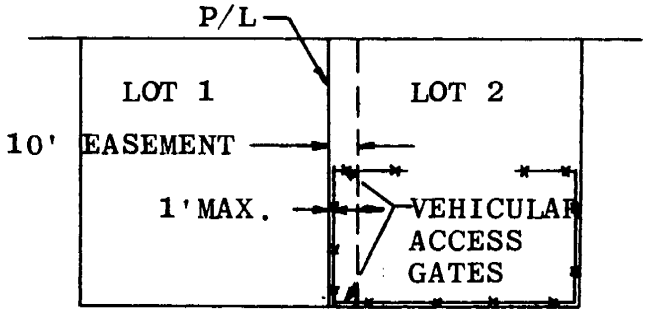
SECTION 9 - RIGHTS OF WAY & EASEMENTS -- REQUIREMENTS

9.1 All retention/detention ponds required pursuant to Ordinance No. 2281 (as amended) may be required to be located in separate tracts with a drainage easement for maintenance. If the tract is not adjacent to a roadway, a fourteen (14) foot wide roadway, surfaced with at least 6 inches of Class "B" gravel or equal will be required within an easement for unobstructed ingress and egress between the tract and the public roadway.

9.2 When platting or developing an area adjacent to a river, the applicant shall provide a 30 foot wide Flood Control Maintenance Easement to King County Department of Public Works. This easement is measured landward from the top of the river bank. See paragraph 2.12.

9.3 The written restriction shall be added to the final plat drawing that "Prior approval must be obtained from the Department of Public Works before any structures, fill or obstructions, including fences, are located within any drainage easement or delineated flood plain area."

An example of an acceptable fencing plan is shown below:



9.4 An access gate for access roads is required and shall be structurally and aesthetically acceptable for the use and location proposed or an acceptable alternative to control traffic.

9.5 An access road must be provided to the bottom of a retention/detention pond or a 14 foot wide access road around it. Either of these alternatives must be included in described tracts or drainage easements unless otherwise approved by the Department of Public Works. We recommend that existing trees be preserved where possible.

9.6 A minimum 15 foot wide drainage easement is required for all closed storm drainage systems that contain storm drains having a diameter of five (5) feet, or more.

9.7 All public and maintained storm water drainage systems including collection, conveyance and restrictions shall be located in drainage easements to King County Department of Public Works except commercial developments. All drainage easements shall be shown on the Construction Plans and Final Plat.

9.8 Permanent access and drainage easements shall be granted to King County for any storm water retention/detention facility and an access road to that facility where such facility and access road are located on property other than the proposed land development but serve the development. The owner in fee simple and the contract purchaser of the property upon which the access road and facility are to be located shall execute the said easement. King County shall have the option to record the easement or delay its recording for any length of time it deems justifiable, depending upon any extenuating circumstances.

SECTION 10 - STANDARDS FOR PLAT SUBMITTALS

10.1 All plans and computations must be checked, initialed and sealed by the engineer.

10.2 An overall storm drainage plan must be shown on a single sheet when the storm drainage plan and profile sheets exceed 3.

10.3 When plans are returned to the consultant for corrections, any changes by the consultant must be marked on a print in color and returned. The date of these changes must be indicated and the color used for marking changes cannot be red or yellow.

10.4 To help expedite the review of a development, the applicant or his engineer may request a special meeting with the Department of Public Works following his receipt of our initial comments. However, before this meeting, the applicant and his engineer should review all initial comments and have a solution to propose. This meeting will be used to review the overall concept of the plan and any modification and not computations.

10.5 The engineer must demonstrate to the satisfaction of the Department of Public Works any deviation from the design criteria discussed in this handbook.