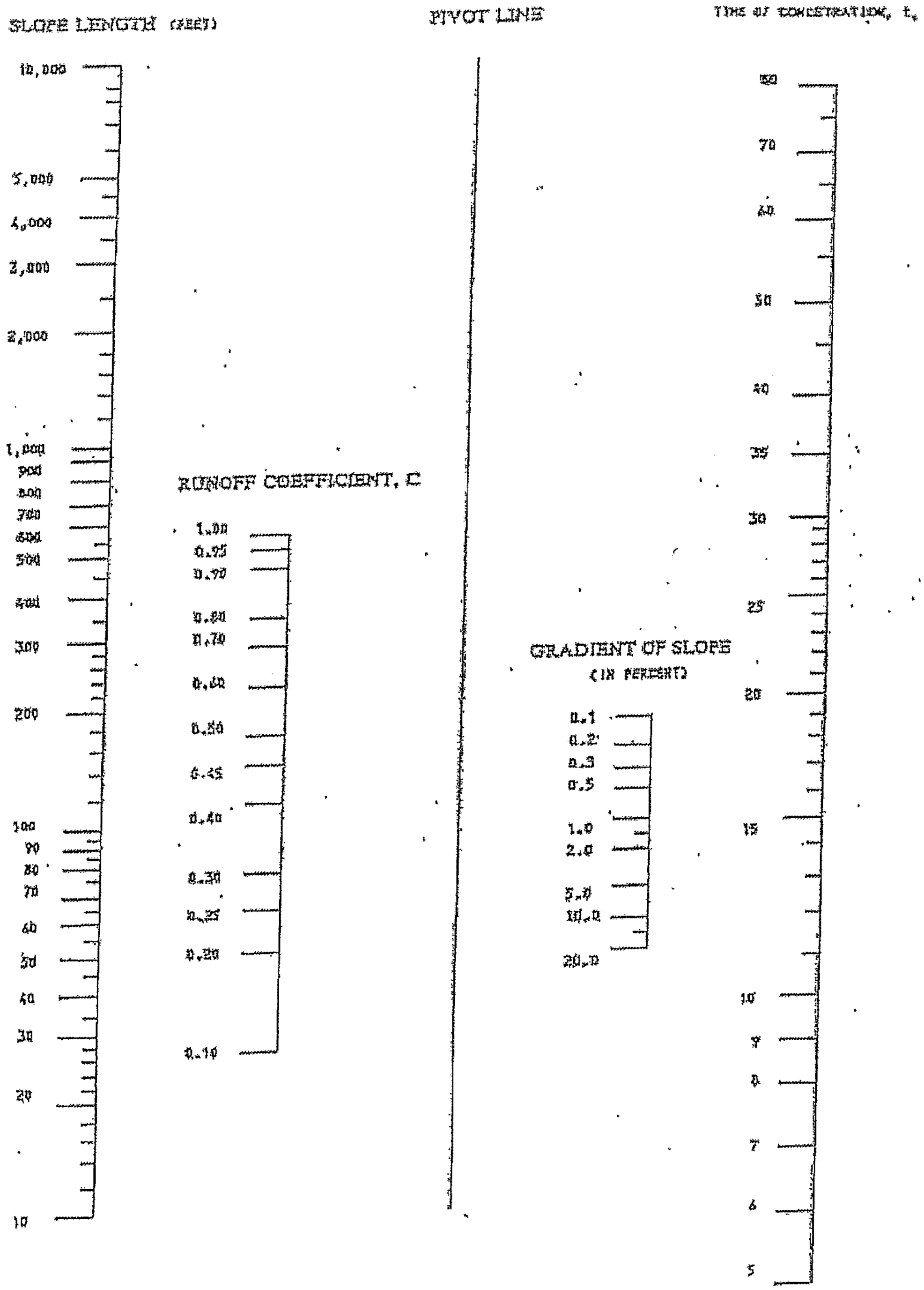
OVERLAND FLOW CHART



Worksheet 2: Runoff curve number and runoff

Project ______________________ By _______ Date _________

Location ______________________ Checked _______ Date _________

Circle one: Present Developed ______________________

1. Runoff curve number (CN)

Soil name and hydrologic group (Appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area ☐ acres ☐ mi² ☐ %	Product of CN % area
		Table 2-2	Fig. 2-3	Fig. 2-4		
				Totals =		

1/ Use only one CN source per line

CN (weighted) = total product/total area = ——— = _______; Use CN = [ ]

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency..........yr			
Rainfall, P (24-hour)..........in			
Runoff, Q..........in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)			

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project ______________________ By ______ Date ______

Location ______________________ Checked ______ Date ______

Circle one: Present Developed ______________________

Circle one: T_c T_t ______________________

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

		Unit	Segment 1		Segment 2		Total
<u>Sheet flow</u> (applicable to T_c only)	Segment ID						
1.	Surface description (table 3-1)						
2.	Manning's roughness coeff., n (table 3-1)..........						
3.	Flow length, L (total L ≤ 300 ft)......................	ft					
4.	Two-yr 24-hr rainfall, P_2..................................	in					
5.	Land slope, s	ft/ft					
6.	$T_t = 0.007(nL)^{0.8}/P_2^{0.5}s^{0.4}$ Compute T_t ...	hr		+		=	
<u>Shallow concentrated flow</u>	Segment ID						
7.	Surface description. (paved or unpaved)						
8.	Flow length, L	ft					
9.	Watercourse slope, s	ft/ft					
10.	Average velocity V (figure 3-1)	ft/s					
11.	$T_t = L/360V$ Compute T_t.........	hr		+		=	
<u>Channel flow</u>	Segment ID						
12.	Cross sectional flow area, a	ft^2					
13.	Wetter perimeter, P_w	ft					
14.	Hydraulic radius, $r = a/P_w$ Compute r	ft					
15.	Channel slope, s	ft/ft					
16.	Manning's roughness coeff., n						
17.	$V = 1.49\, r^{2/3}\, s^{1/2}/n$ Compute V ..	ft/s					
18.	Flow length, L	ft					
19.	$T_t = L/3600V$ Compute T_t	hr		+		=	
20.	Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19)	hr					

Worksheet 4: Graphical Peak Discharge method

Project ______________________ By ________ Date ________

Location ______________________ Checked ________ Date ________

Circle one: Present Developed ______________________

1. Data:

Drainage area .... A_m = __________ mi^2 (acres/640)

Runoff curve number .... CN = __________ (From worksheet 2)

Time of concentration .... T_c = __________ hr (From worksheet 3)

Rainfall distribution type = __________ (I, II, III)

Pond and swamp areas spread throughout watershed........... = __________ percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr			
3. Rainfall, P (24-hour)	in			
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in			
5. Compute I_a/P				
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4 - ___)	csm/in			
7. Runoff, Q .... (From worksheet 2).	in			
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)				
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs			

Worksheet 5a: Basic watershed data

Project ______________ Location ______________ By ______________ Date ______

Circle one: Present Developed ______________ Frequency (yr) ______ Checked ______ Date ______

Subarea name	Drainage area A_m (mi^2)	Time of concen-tration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet $\sum T_t$ (hr)	24 -hr Rain-fall P (in)	Runoff curve number CN	Run-off Q (in)	$A_m Q$ (mi^2 - in)	Initial abstraction I_a (in)	I_a/P

↑↑↑↑↑↑↑↑↑↑↑↑↑↑ From worksheet 3 (Time of concentration, Travel time through subarea)

↑↑↑↑↑↑↑↑↑↑↑↑↑ From worksheet 2 (Runoff curve number, Runoff)

↑↑↑↑↑↑↑↑ From table 5-1 (Initial abstraction)

Worksheet 5b: Tabular hydrograph discharge summary

Project ______________________ Location ______________________ By ____________ Date ________

Circle one: Present Developed ______________________ Frequency (yr) ________ Checked ____________ Date ________

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours form exhibit 5- 2/											
	Sub-area T_c (hr)	$\sum T_t$ to outlet (hr)	I_a/P	A_mQ (mi^2-in)												
					Discharges at selected hydrograph times 3/ (cfs)											
Composite hydrograph at outlet																

1/ Worksheet 5a. Rounded as needed for use with exhibit 5.

2/ Enter rainfall distribution type used.

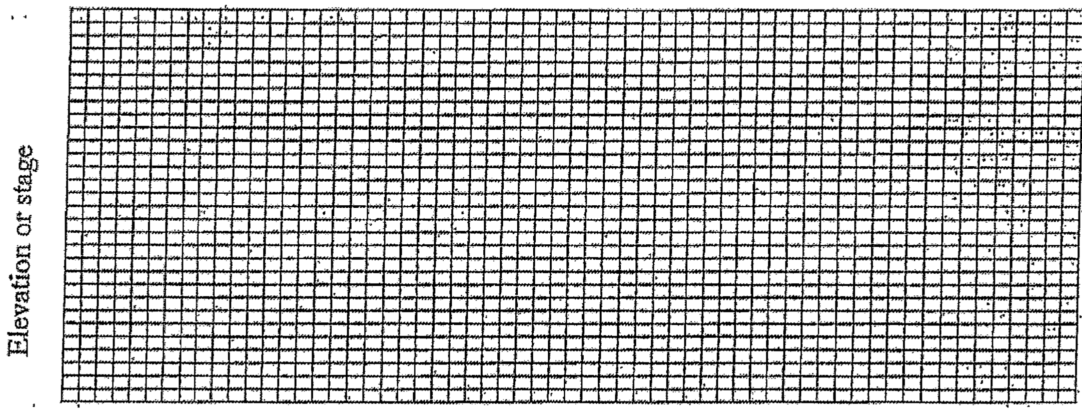
3/ Hydrograph discharge for selected times in A_mQ multiplied by tabular discharge from appropriate exhibit 5.

Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project ______________________ By ______________ Date ________

Location ______________________ Checked ______________ Date ________

Circle one: Present Developed ______________________________



Detention basin storage

1. Data:
   Drainage area .... A_m = ________ mi^2
   Rainfall distribution Type (I, IA, II, III) = ________

	1st stage	2nd stage
2. Frequency..................yr		
3. Peak inflow discharge q_i ....cfs (from worksheet 4 or 5b)		
4. Peak outflow discharge, q_o ....cfs 1/		
5. Compute q_o / q_i		

6. V_s/V_r.................................. (Use q_o/q_i with figure 6-1)			
7. Runoff, Q .... (From worksheet 2)	in		
8. Runoff volume, V_r .... ($V_r = QA_m53.33$)	ac-ft		
9. Storage volume, V_s .... ($V_s = V_r (V_s/V_r)$)	ac-ft		
10. Maximum stage, (From plot)	E_{max}		

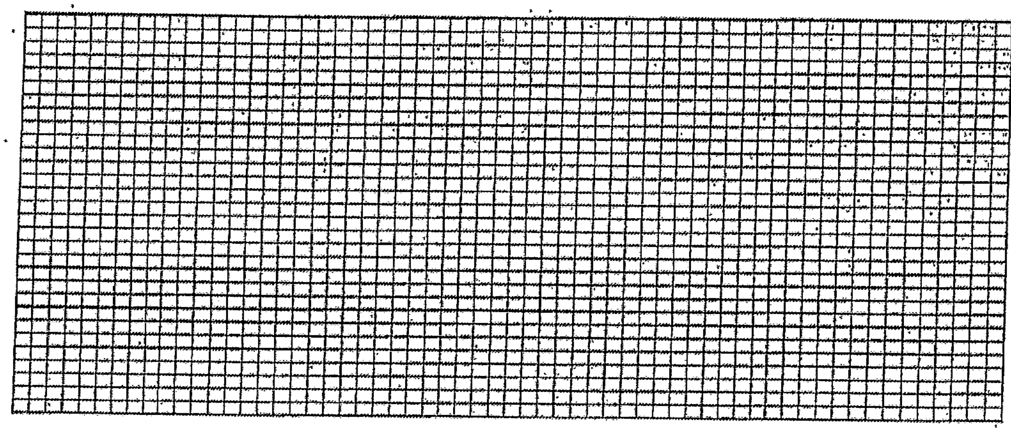
1/ 2nd stage q_o includes 1st stage q_o

Worksheet 6b: Detention basin, peak outflow, storage volume (V_s) known

Project ______________________ By ______________ Date __________

Location ______________________ Checked ______________ Date __________

Circle one: Present Developed ______________________________



1. Data:
   - Drainage area .... A_m = ________ mi²
   - Rainfall distribution type (I, IA, II, III) = ________

	1st stage	2nd stage
2. Frequency .... yr		
3. Storage volume, V_s .... ac ft		
4. Runoff, Q .... in (From worksheet 2)		
5. Runoff volume, V_r .... ac ft ($V_r = QA_m 53.33$)		
6. Compute V_s/V_r		
7. q_o/q_i .... in (Use V_s/V_r and figure 6-1)		
8. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)		
9. Peak outflow discharge, q_o .... cfs ($q_o = q_i\,(q_o/q_i)$)		1/
10. Maximum stage, (From plot) E_{max}		

1/ 2nd stage q_o includes 1st stage q_o

DETENTION BASIN STORAGE DESIGN

I Calculate the peak flow in cfs due to the one (1) year frequency storm under predeveloped conditions.

q_1 = A*C*i (allowable detention basin outflow release rate – stage one)

Area, "A" = [________] acres

Runoff Coefficient, "C" = [________]

Intensity, "i" = a/(t_c+ b) = [________] in/hr

Where: a = 80 (Table IV)

b = 14 (Table IV)

t_c = time of concentration (minutes) as determined from Appendix C – Exhibit 1

q_1 = A [______]* C [______] * i [______] = [_______] cfs

II Calculation for the one (1) year frequency storm under postdevelopment conditions.

Q_1 = A*C*i

Area, "A" = [________] acres

Runoff Coefficient, "C" = [________]

Intensity, "i" = a/(t_c+ b) = [________] in/hr

Where: a = 80

b = 14

t_c = time of concentration (minutes)

Q_1 = A [______]* C [______] * i [______] = [_______] cfs

III Critical Storm Calculation.

$[(Q_1/q_1) - 1.0]*100 = PC$ PC = [_______] (See Table II on Page 34 for Critical Storm Frequency)

Critical Storm Frequency = [________]

IV Calculate maximum storm duration, T_{ccr}, for the critical storm frequency (in minutes).

$$T_{ccr} = \left(\frac{(A * C * a * b)}{(2 * q_1/3) - [(q_1^2 * t_c) / (6 * C * A * a)]} \right)^{1/2} - b$$

Where: a = determined from Table IV (for critical storm frequency)

b = determined from Table IV (for critical storm frequency)

C = the one year postdeveloped weighted runoff coefficient

A = area in acres

T_{ccr} = [_______] minutes

V Calculate I_{cr}:

I_{cr} = [a / (T_{ccr} + b)] = [_______] in/hr

VI Calculate Q_{cr}, flow at maximum duration for the critical storm frequency:

Q_{cr} = A [_____]* C [______] * I_{cr} [______] = [_______] cfs

VII Calculate the required storage volume due to critical storm criteria, SV_{cr}:

$$SV_{cr} = [(60 * Q_{cr} * T_{ccr})] - \{ [2 * q_1 * (T_{ccr} + t_c) * 60] / 3\} + [(q_1^2 * t_c * 60) / (6 * Q_{cr})]$$

SV_{cr} = [__________] ft^3

VIII Calculate the peak flow in cfs due to the one-hundred (100) year frequency storm under predeveloped conditions.

q_{100} = A*C*i (allowable detention basin outflow release rate – stages one + two)

Area, "A" = [________] acres

Runoff Coefficient, "C" = [________]

Intensity, "i" = a/(t_c+ b) = [________] in/hr

Where: a = 290 (Table IV)

b = 31(Table IV)

t_c = time of concentration (minutes) as determined from Appendix C – Exhibit 1, for predeveloped

q_{100} = A [_____]* C [______] * i [_____] = [_______] cfs

IX Calculate maximum storm duration T_{c100}, for the one-hundred year frequency (in minutes) storm under postdeveloped conditions.

$$T_{ccr} = \left[\frac{(A * C * a * b)}{(2 * q_{100}/3) - [(q_{100}^{2} * t_c) / (6 * C * A * a)]} \right]^{1/2} - b$$

Where: a = 290

b = 31

C = the one-hundred year <u>post</u>developed weighted runoff coefficient

A = area in acres

Tc_{100}= [______] minutes

X Calculate I_{100}:

I_{100} = [a / (Tc_{100}+ b)] = [______] in/hr

XI Calculate Q_{100}, flow at maximum duration for the critical storm frequency:

Q_{100} = A [______]* C [______] * I_{100} [______] = [______] cfs

XII Calculate the required storage volume due to critical storm criteria, SV_{cr}:

$$SV_{100} = [(60 * Q_{100} * Tc_{100})] - \{ [2 * q_1 * (Tc_{100} + t_c) * 60] / 3\} + [(q_{100}^{2} * t_c * 60) / (6 * Q_{100})]$$

SV_{100} = [________] ft^3

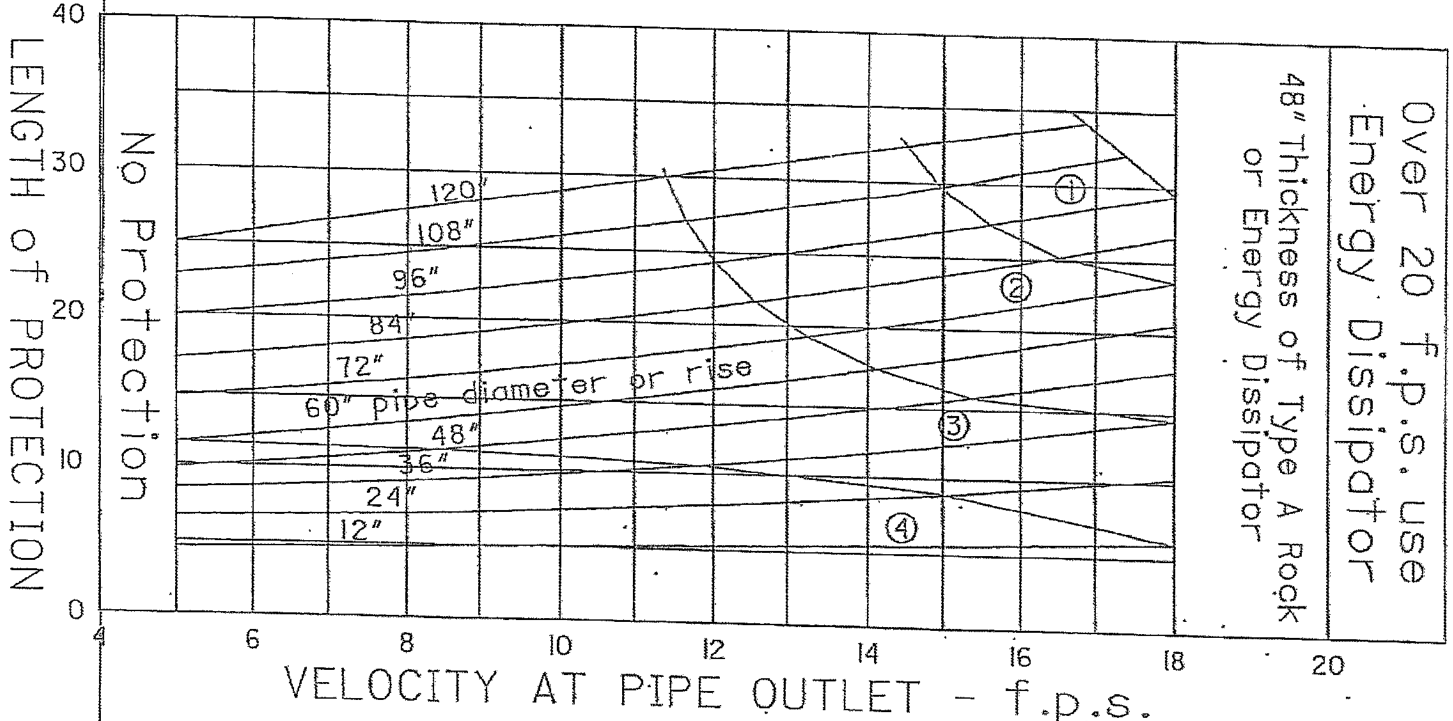
XIII Design Notes:

1. Design as a two stage outlet
    a. An iterative process is required since the change in elevation head will cause an increase in the outflow of the stage one opening.
    b. Two detention areas can be used to eliminate the iterative two stage outlet design process.
2. Emergency overflow must be accounted for via a spillway or other means.

General Notes:

1. The formulas used in calculations III through VII assume an orifice controlled outflow.
2. Reference pages 98 and 99, <u>Water and Wastes Engineering</u>, "Estimate Detention and Reservoir Storage". By A.S. Paital, P.E., Ph.D.

ROCK CHANNEL PROTECTION AT CULVERT AND STORM SEWER OUTLETS



NOTES

Rock size (6", 12", 18") indicates the square opening on which 85% of the material, by weight, will be retained.

The width of protection shall be the width of the headwall, with 4' being the minimum.

(Where a stream bed will withstand the calculated velocity without erosion, no rock channel protection will be required.)

LEGEND	ROCK TYPE
① 48" of 18" rock	A
② 36" of 18" rock	A
③ 30" of 12" rock	B
④ 18" of 6" rock	C