1435

HYDROLOGIC ANALYSIS

TWAIN HARTE STORM DRAINAGE SYSTEM

Prepared by: L. R. Davey RCE 19299
Sonora Ca

CONTENTS

PURPOSE

The purpose of this study is to satisfy requirements of the County of Tuolumne Transportation and Engineering Services Department that sufficient capacity exists in the "Downtown" Twain Harte drainage system for the development of the proposed Hillview Townhouses.

METHODOLOGY

The methodology used in the computation of the run-off for the area under consideration is based on practical aspects of the geography and existing land uses along with in-place facilities. Rainfall frequency curves furnished by T.E.S. and existing land use zoning maps were utilized as fixed data.

The steps to determine the time of concentration in order to use the rainfall frequency charts were as follows:

1. Assume a time of concentration for the Twain Harte Village Center and determine the flow from the site.
2. Track the run-off from the Center to the entry of the "downtown" system at Cedar Drive.
3. Compute the channel and pipe time between the Center and Cedar Drive.
4. Determine the distance from the most remote point of the basin under consideration to a defined channel. From base maps determine the slope of the land and calculate the combined run-off coefficient. From a chart of the above variables a time of concentration to a ditch was determined.
5. The ditch that the overland flow concentrated to was idealized and its length and slope determined. From this the velocity and then the time in the ditch to the Center culvert system was calculated.
6. All of the times calculated above were summed and the rainfall-frequency curve was used to determine the rainfall for that period to produce the maximum run-off for the basin under study.

METHODOLOGY (cont.)

7. The total area combined run-off coefficient was determined and all the previously obtained values were applied using the "Rational Method" for storm run-off.

8. The method was repeated for the other basin contributing to the "downtown" system.

DISCUSSION

The author of this report was instructed by Mr. Alan Roberts of the Transportation and Engineering Services Department of the County of Tuolumne (TES) to utilize all existing and furnished information for the determination of existing capacity of the storm drain system of the community of Twain Harte. This study was prompted by the application of several developers for projects that would be using capacity of the storm system.

Evidentally some suspicion prevailed at TES that the storm drain system was not sized properly due to an error that was discovered as to the size of one of the contributing drainage basins. Also another contributing area was not included as to storm run-off.

A review of the storm drain improvement plans revealed that with the inclusion of the previously existing drains in the "downtown" area the sum total capacity is indeed adequate for existing and anticipated land-use development.

The total amount of drainage exclusive of any spills from the Tuolumne Water System ditch is computed to be 154.5 cfs based upon the original design data, as to capacity.

The anticipated maximum storm run-off into the existing system is 129 cfs.

The reserve capacity for Tuolumne Water System ditch spillage is computed to be 25.5 cfs.

It must be considered that most likely the flows computed will never be achieved due to the fact that run-off coefficients are taken from tables for other types of geography and development and that the actual constructed configurations are not fully developed to equal the table value coefficient. An example of this would be the Twain Harte Elementary School which is now developed with approximately 4.5 acres of rooftop and pavement and 3.5 acres of grassed playground.

DISCUSSION (cont.)

The task as assigned required the treatment of the area as having a total area run-off coefficient of 0.80 whereas actual calculations would give a combined run-off coefficient of 0.56. This would result in a considerable reduction of run-off.

The above example is typical of the methodology problems encountered in hydrologic studies in this area. The run-off coefficients are not fixed for most of the western states and there is a reliance on textbook values derived in the eastern U.S.. In light of the above most drainage designs are extremely conservative in nature for our area.

RESULTS

Analysis and computations yield the following results:

A. The stormwater discharge for Area 1	=	74cfs
B. The stormwater discharge for Area 2	=	55cfs
C. The "downtown" storm drain system capacity	=	154.5cfs
D. Reserve capacity C - (A+B)	=	25.5cfs
E. Maximum spill of Tuolumne Water Systems ditch	=	10cfs

CONCLUSIONS

It is concluded that the "downtown" Twain Harte storm drainage system is adequate to service the existing land-use zoning at full development.

APPENDIX

Hydrologic Study "Downtown" Twain Harte Drainage System Capacity Analysis

L. R. Davey RCE
Sonora, Ca.

REGISTERED PROFESSIONAL ENGINEER
LESLIE RICHARD DAVEY
No. 19299
CIVIL
State of California
9/30/87

January 1987.

Hydrologic Study

Hillview Townhouses

various relationships -

time of concentration $t_c = \frac{L(ft)}{v(fpm)}$

v = velocity of runoff in assumed conveyance

areas based on TES zoning & "C" diagrams

Subarea ①-A

Area	"C"	Ac
6.94	0.30	2.082
1.49	0.30	0.447
3.80	0.30	1.14
2.06	0.30	0.618
4.91	0.45	2.21
5.95	0.45	2.678
2.89	0.45	1.301
22.07	0.25	5.52
9.71	0.25	2.428
ΣA = 59.82		ΣAc = 18.424

$C = \frac{\Sigma Ac}{\Sigma A} = \frac{18.424}{59.82} = 0.308$

∴ C = 0.31 for subarea ①-A.

Subarea ①-B

Area	"C"	Ac
11.16	0.45	5.02
14.21	0.80	11.368
12.39	0.80	9.91
1.24	0.45	0.692
20.67	0.25	5.168
1.65	0.25	0.413
ΣA = 61.32		ΣAc = 32.571

$C = \frac{\Sigma Ac}{\Sigma A} = \frac{32.571}{61.32} = 0.53$

∴ C = 0.53 for subarea ①-B

Compute anticipated time of concentration for subarea ①-B i.e. time for channel flow in 42" cmp & 42" rcp plus "ditch" flow between rcp & cmp

assume flow in cmp from t_c = 5 min (shopping center)
I_{100} from f-curve = 2.6"/hr.
area = 14.21 a Ac = 11.368   Q = AIC = 11.368 × 2.6 = 29.6 cfs

$Q = Av = \frac{1.49}{n} A r^{2/3} s^{1/2}$ s = 5% av. for pipe
n = 0.021

Hillview Ccoot

Q for full flow $Q = \frac{1.49}{0.021} \times 9.62 \times \left(\frac{3.5}{4}\right)^{2/3} \times 0.05^{1/2}$

$Q = 152.6 \times 915 = 139.6$ cfs

$q/Q = \frac{29.6}{139.6} = 0.212$

$0.337 - 0.196 = 0.141$
$0.212 - 0.196 = 0.016$
$\frac{0.016}{0.141} = 0.1135$

$\frac{v}{V} = (0.902 - 0.776)\,0.1135 + 0.776 = 0.790$

$V = \frac{Q}{A} = \frac{139.6}{9.616} = 14.52$ fps

$v = 14.52 \times 0.790 = 11.47$ fps.

time through 42" cmp $\approx \frac{700'}{11.5 \times 60} = 1$ min

42" cmp t = 1 min

time in open channel

$L = 240'$ $S = 3/240 = 0.0125$

ditch time

assume ideal section (trapezoidal) trapezoidal & uniform flow and non-erosive velocity max = 7 fps

$time = \frac{240'}{7 \times 60} = 0.57$ min

ditch = 0.57 min = t

time in 42" rcp (school)

$n = 0.012$ $S = 5\%$

$Q = \frac{1.49}{0.012} \times 9.62 \times 0.915 \times 0.223 = 243.7$ cfs

$q/Q = \frac{30}{243.7} = 0.123$

$0.196 - 0.088 = 0.108$
$0.123 - 0.088 = 0.035$
$\frac{0.035}{0.108} = 0.324$

$\frac{v}{V} = (0.776 - 0.615)\,0.324 + 0.615 = 0.667$

$V = \frac{Q}{A} = \frac{243.7}{9.62} = 25.33$ $v = 25.33 \times 0.667 = 16.9$ fps

length = 560'

$t = \frac{560}{16.9 \times 60} = 0.55$ min

42" rcp t = 0.55 min

$\Sigma = 1 + 0.57 + 0.55 = 2.12$ min

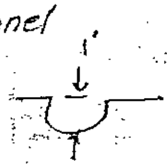
now determine time of overland flow from upper-most reach of drainage basin

path length = 1000'
slope from map = $\frac{240'}{1000}$ = 0.24

C = 0.30
by chart for L = 1000', S = 0.24, C = 0.30

t_c = 22 min

time in gulley channel

assume ½ circle  flowing full

n = 0.15 (rough, stoney & weedy)

$S = \frac{220}{1100} = 0.20$ $r = \frac{d}{4} = \frac{2}{4} = 0.5$ $r^{2/3} = 0.5^{2/3} = 0.671$

$V = \frac{1.49}{n} r^{2/3} s^{1/2} = \frac{1.49}{0.15} \times 0.5^{2/3} \times 0.20^{1/2} = 2.80$ fps

$t = \frac{L}{V60} = \frac{1100}{2.8 \times 60} = 6.55$ min

gulley time = 6.55 min

total time to funnel of area ①
t_c = 6.55 + 22 + 0.55 + 0.57 + 1 = 30.67 min

by f-chart for 30 min rainfall I_{100} = 1.4 "/hr

C for total basin = $\frac{\Sigma AC}{\Sigma A} = \frac{18.424 + 32.571}{59.82 + 61.32}$ = 0.421

C = 0.42

$Q_{100} = C I_{100} A = 0.42 \times 1.4 \times 125.94 = 74.05 \approx 74$ cfs

Area ① Q_{100} = 74 cfs

now check basin ③ to determine characteristics and run-off

Area	c	Ac
14.71	0.45	6.62
12.98	0.30	3.89
52.89	0.45	23.80
1.15	0.25	0.29
2.48	0.25	0.62
4.79	0.80	3.83

$c = \frac{\Sigma Ac}{\Sigma A} = \frac{39.05}{89} = 0.439$

$c = 0.44$

$\Sigma A = 89$ $\quad\Sigma Ac = 39.05$

by assumptions made for area ①

distance to defined channel = 900'

$S = \frac{320}{900} = 0.36$

$c = 0.45$

by chart for $S = 0.36$ $c = 0.45$ $L = 900$

$t_c = 17$ min

circular gulley time

$S = 400/2700 = 0.15$ $\quad S^{1/2} = 0.39$

$L = 2700$

$V = \frac{1.49}{0.15} \times 0.671 \times 0.39 = 2.6$ fps

$t = \frac{L}{v60} = \frac{2700}{2.6 \times 60} = 17.31$ min

gulley $t = 17.3$ min

total $t_c = 17 + 17.3 = 34.3$ min

by f-chart

$I_{100} = 1.35$ "/hr

∴ approx same as area ①

use total $I_{100} = 1.4$ "/hr.

area ③ $Q_{100} = CIA = 0.44 \times 1.4 \times 89 = 54.82$ cfs

$Q_{100} = 55$ cfs

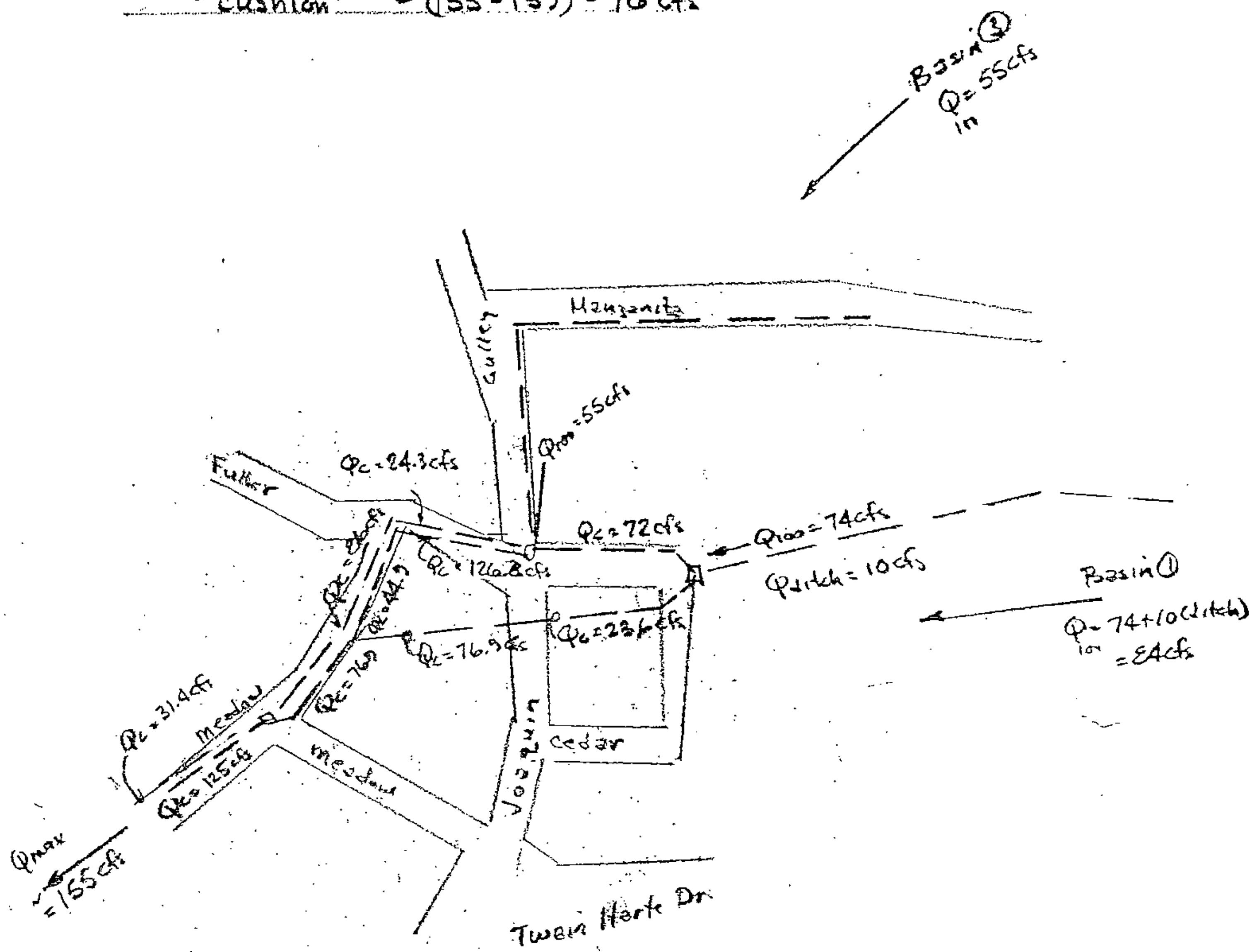
total for "downtown" system

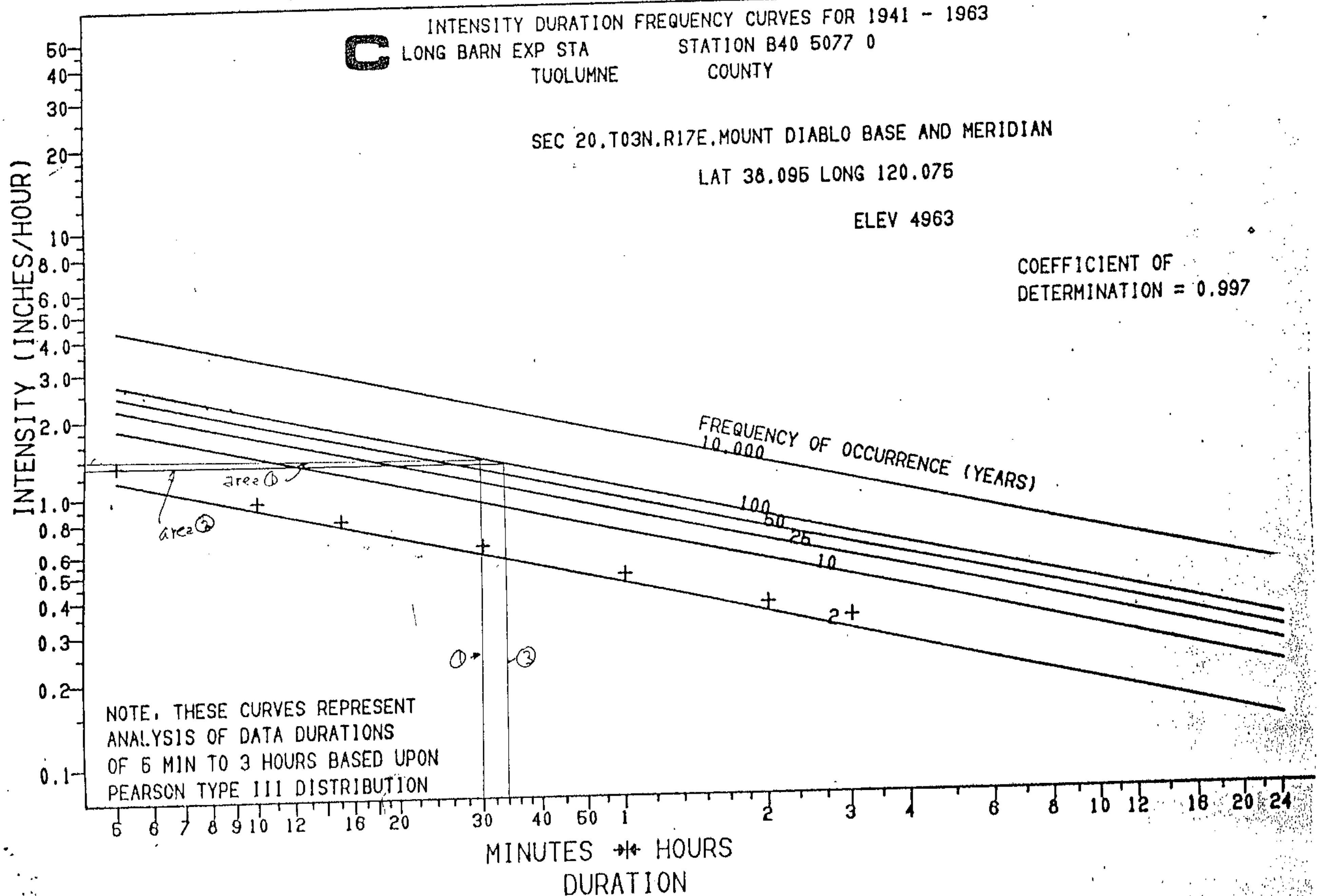
$Q_{①} + Q_{③} = 74 + 55 = 129$ cfs

Hillview (cont.)

Area ① Q_{100} = 74 cfs [RVA = 76 cfs (inc. ditch)]
Area ③ Q_{100} = 55 cfs [RVA = 47.4 cfs]
ΣQ_{100} = 129 cfs
ditch = 10 cfs
Total Max Q = 139 cfs [RVA 123.4 cfs]

System Capacity ≈ 155 cfs
"cushion" = (155 - 139) = 16 cfs




INTENSITY DURATION FREQUENCY CURVES FOR 1941 - 1963
LONG BARN EXP STA
STATION B40 5077 0
TUOLUMNE
COUNTY
SEC 20,T03N,R17E,MOUNT DIABLO BASE AND MERIDIAN
LAT 38.095 LONG 120.075
ELEV 4963
COEFFICIENT OF
DETERMINATION = 0.997
FREQUENCY OF OCCURRENCE (YEARS)
10,000
100
50
25
10
2
area ①
area ②
① →
③
NOTE, THESE CURVES REPRESENT
ANALYSIS OF DATA DURATIONS
OF 6 MIN TO 3 HOURS BASED UPON
PEARSON TYPE III DISTRIBUTION
INTENSITY (INCHES/HOUR)
50
40
30
20
10
8.0
6.0
5.0
4.0
3.0
2.0
1.0
0.8
0.6
0.5
0.4
0.3
0.2
0.1
5
6
7
8
9
10
12
16
20
30
40
50
1
2
3
4
6
8
10
12
16
20
24
MINUTES HOURS
DURATION

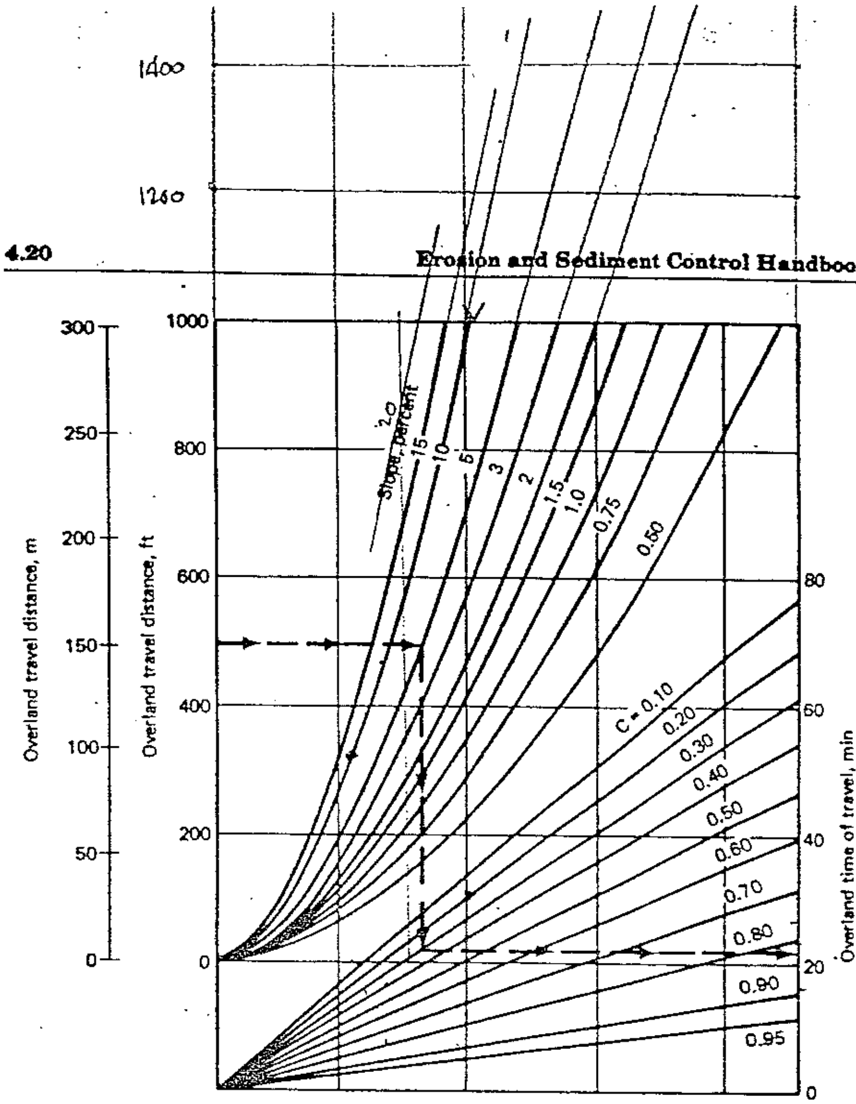


Fig. 4.5 A nomograph of overland flow time. (10) Enter left margin with slope length; move right to slope curve and down to C value; and find overland travel time on right margin.

- Calculate the average slope by computing the difference in altitude between the highest and lowest points of the flow path and dividing by the distance between those points.
- Find or compute the C value.
- Enter the graph on the left margin with the overland travel distance; move to the right to the correct slope curve; move down to the C value; and then move over to the right margin.
- Read the overland flow time from the right-hand scale.

EXAMPLE 4.5

Given: A site 500 ft (152 m) long with 5 percent average slope and a C value of 0.30.

Find: Overland flow time.

Solution: From Fig. 4.5, the estimated flow time is 22 min.