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Estimating the Rainfall-Runoff Characteristics of Selected Small Utah Watersheds

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ESTIMATING THE RAINFALL-RUNOFF CHARACTERISTICS
OF SELECTED SMALL UTAH WATERSHEDS

by

Clive H. Walker

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The Intermountain Forest and Range Experiment Station made precipitation, runoff, soils and vegetation data available for the watersheds examined in this study. The Soil Conservation Service has provided personal encouragement in this endeavor. Some data was also received from the Watershed Planning Staff of the Utah State Office of the Soil Conservation Service and the Sevier River Basin Planning Party at Richfield, Utah.

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Clive H. Walker

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ABSTRACT

Estimating the Rainfall-Runoff Characteristics

of Selected Small Utah Watersheds

by

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Runoff and rainfall data have been taken from three high mountain Utah watersheds and subjected to runoff to rainfall comparisons. The resulting Q/P ratios have been compared to the average volumes of runoff curve numbers (CN) computed from this data for each watershed. Runoff curve numbers were also estimated on the basis of the soils and vegetation data available for the watersheds.

An attempt has been made to estimate the watershed lag characteristics by computing synthetic hydrographs for successively larger values of time to peak estimates until the best fit comparison was achieved between the snythetic and the actual hydrographs. Time lag estimates were also made from the Kirpich method and the Mockus method.

(128 pages)

INTRODUCTION

Much of the water supply for the intermountain west comes from small, high mountain watersheds. Most of the runoff volume comes from melting a winter snowpack and the nature of water use below these watersheds depends greatly on the reliability of this supply. However, diversion structures, storage reservoirs, and channels must allow for safe passage of high rates of runoff from high intensity summer rainfall events. The costs of failure of such structures from floods are more than the costs of the structures alone, but include the costs associated with lost water supplies until the structures are rebuilt, as well as damages to properties, crops, transportation, communication, and commerce. Some of these floods cause loss of life and livestock.

Disastrous floods occur from summer rainfall events on these watersheds. In Utah, some of the more notable of these floods have occurred on the Farmington Creek Watershed which included the Halfway Creek and Morris Creek watersheds described in this thesis, on the Pleasant Creek Watershed which is just north of Ephraim Creek, and on the Manti Creek Watershed just south of Ephraim Creek. The Alpine Meadows watershed described herein is part of the Ephraim Watershed. For descriptions of these floods see Woolley (1946), Peterson (1954), and Croft and Bailey (1964).

As potential flood plains become more intensively used, potential damages will greatly increase. New storm drainage systems and flood control structures will be constructed to reduce these damages. The U. S. Forest Service has developed watershed management and land treatment measures that have significantly reduced flood damage potential on several watersheds in the state. On several watersheds this kind of program has been combined with federally supported locally sponsored Small Watershed Protection Projects through the work of the Soil Conservation Service that include flood and debris control structures near the mouth of the mountain canyons. Local governments often find themselves in the flood control business and have constructed flood channels and control structures. Design of downstream flood control structures requires information about peak rates of flow and volumes of runoff from rainstorms from watersheds with and without upstream watershed land treatment and structural flood control measures.

Statistical and regional analysis procedures for evaluating streamflow records have been developed and are used for predicting the frequency of occurrence of specified levels of flood flow for gaged and ungaged watersheds. When this kind of analysis can be made with a reasonable degree of confidence in its accuracy it should provide the basis for hydrologic design of water control structures. This kind of procedure has serious limitations when one must: (a) predict the effect of a watershed change due to land treatment or management measures, (b) predict runoff volumes and peak rates of runoff from an ungaged watershed in an area where there are very few runoff gages, or (c) where the existing runoff gages are affected by diversions and storage to the extent they are not usable for estimating natural runoff conditions. When any of these problems must be solved, some kind of synthetic hydrograph approach must be used to develop design information.

Hydrologists in the Soil Conservation Service (SCS) have developed a synthetic unit-graph procedure to provide for safe design of water supply and flood control structures for high rates of flow. This method requires estimates of the rainfall-runoff and runoff time lag characteristics of the watersheds to which it is applied. The purpose of this study is to develop information about these characteristics for small high mountain watersheds in Utah. The watersheds have been subjected to various watershed management practices.

Morgan and Johnson (1962) tested four synthetic unit-graph methods against actual hydrographs from watersheds in Illinois. Serious deficiencies were found in each method, but the method proposed by the Soil Conservation Service was found to be one of the two better methods. Hydrologists in the Soil Conservation Service use this method throughout the United States. Hydrologists in the Forest Service use this method as part of their standard procedures. Other federal agencies sometimes use this method to obtain information about small watersheds. The Soil Conservation Service method is most recently described in the SCS National Engineering Handbook, Section 4 (Soil Conservation Service, 1964) in an SCS technical paper, SCS-TP-149 (Kent, 1968), and in a handbook edited by Chow (1964). Forest Service procedures for this method are found in a Forest Service handbook (Forest Service, 1959), and in some unpublished information obtained from the regional hydrologist in Ogden, Utah, reproduced in this paper in Table 5. The parts of this method adopted by the Bureau of Reclamation are published in another handbook (Bureau of Reclamation, 1960).

Some of the data originally used to develop the Soil Conservation

Service method are included in publications of the Agricultural Research Service (1959, 1960). Other data that was used remains largely in unpublished form except as included in reports prepared for other purposes by various persons and agencies, as in Croft and Bailey (1964). Research is continuing in projects administered by both the Agricultural Research Service and the Forest Service on several small watersheds throughout the nation. Reports of these studies may be easily found by reference to one of many recently published bibliographies of hydrology and water resources research.

The primary data obtained for this study are contained in unpublished material located in offices of the U. S. Forest Service Intermountain Forest and Range Experiment Station in Logan and Ephraim, Utah. Some soils and vegetation information was obtained from the office of the Sevier River Investigation Staff of the Soil Conservation Service in Richfield, Utah.

OBJECTIVES AND SCOPE OF THIS STUDY

Objectives

There is some rainfall and runoff data available for summer rainstorm events from a few instrumented small high mountain Utah watersheds. This data will be used to estimate summertime rainfall-runoff characteristics of some of these watersheds. To do this requires reducing the primary stage hydrograph traces into direct runoff volume estimates. Records from recording rain gages must be adjusted to estimates of average rainfall over the watersheds for the same events. Soils and vegetation information must also be obtained to estimate the soil and land use effects of the rainfall-runoff characteristics of the watersheds. The soil and land use effects will be represented by rainfall-runoff curve numbers (CN) to be developed with procedures used by the Soil Conservation Service (1964) as described in Appendix A. If rainfall and runoff events are sufficiently large, CN may also be computed directly from rainfall and runoff data. If the CN obtained by these two methods do not agree or do not describe the rainfall-runoff volume characteristics of the watersheds with accuracy, an alternate method should be presented to represent these characteristics. An attempt will be made to approximate actual runoff hydrographs from rainfall data using the Soil Conservation Service snythetic unit-graph method. This will provide information about the time lag characteristics of the watershed.

Scope

This study is limited to a few selected high mountain watersheds in Utah and to measured runoff events that have occurred during the summer rainfall season. The data for this study were obtained in 1966 and 1967 and do not include events more recent than 1965. The watersheds used for this study have been visited and the gaging sites examined. The only field work done was to obtain an estimate of general watershed soils classification where a soil survey was not available and a general familiarization with vegetation types and watershed topography. All quantitative information about precipitation, runoff, and watershed properties has been taken from records developed by the Forest Service, the U. S. Geological Survey, the U. S. Weather Bureau, and the Soil Conservation Service.

There are almost 100 small watersheds in Utah with drainage area smaller than 400 square miles that have some gaged runoff records. Approximately one-fourth of these have drainage areas under 12 square miles, are located in mountains and might have been suitable for this study. Most of these have not been included in this study because there is not a rain gage on or very close to the watershed. Another reason is that runoff records are very short and do not include significant summer runoff events. Many of these watersheds have very limited information about soils and vegetation.

The selected watersheds are experimental watersheds administered by the Forest Service. Each has at least one recording rain gage on or very near the watershed. Some soils and vegetation information has been developed by qualified surveyors for each of them. However, because there is not sufficiently detailed or accurate data, no attempt has been made to probe deeply into the mechanics of the hydrologic cycle on these watersheds.

METHODS OF PROCEDURE

Obtaining basic data

The physical data of shape, size and slope of the three watersheds have been taken from topographic maps published by the U. S. Geological Survey. The watershed boundaries have been defined as the topographic divide above the runoff gaging sites. Watershed areas have been measured by planimetry of these boundaries. The average watershed slope has been computed by the equation

$$S = 100MN / A \tag{1}$$

where S is the slope in per cent, M is the total length of the contour lines in feet, N is the chosen contour interval in feet and A is the total area of the watershed in square feet. Stream lengths and profiles have also been obtained from the topographic maps. This information is given in Appendix B.

Soils information is very sketchy for these watersheds. There is a generalized soils map for the Alpine Meadows Watershed that may be obtained from the Soil Conservation Service. The only soils information found for the Farmington Canyon watersheds was contained in vegetation surveys. These surveys include qualitative estimates of runoff and erosion potential of the soil based primarily on the surface evidence of runoff or erosion occurring before the time of the survey. A field reconnaissance was performed to obtain general estimates of soil textures. These are explained in the descriptions of the individual watersheds in Appendix B. Aerial photographs were used as an aid in defining hydrologic soil group boundaries on the Halfway Creek Watershed.

Morris Creek and Alpine Meadows watersheds were assigned one hydrologic soil group for each watershed except for rocky areas. The watershed soils were classified into hydrologic soil groups according to the criteria explained in Appendix A.

Vegetative cover data for the Farmington Canyon watersheds was obtained from surveys made for the Forest Service. The basic data is in unpublished field survey sheets in the possession of the Intermountain Forest and Range Experiment Station. This data has been interpreted and summarized in Appendix B. There is a general range survey available in Forest Service offices that includes the Alpine Meadows Watershed area. This survey identifies important grazing and browse plants, but provides little information about plant cover density. Density has been estimated from a few unrecorded visual observations of different parts of the watershed. Measurements of watershed areas by major vegetative types on the Alpine Meadows Watershed has been taken from aerial photograph interpretation. These data are also summarized in Appendix B.

An estimate of the ability of the soils and vegetal cover of the watersheds to intercept and abstract moisture from rainfall has been obtained using the procedure developed by the Soil Conservation Service and briefly outlined in Appendix A. The estimate is presented in the form of runoff curve number (CN) for each watershed. The CN developed for Halfway Creek Watershed is 50, for Morris Creek is 34, and for Alpine Meadows Watershed is 60. The tabular computations of these CN are in Appendix B.

The runoff data for the summertime rainfall produced runoff events was obtained through a search of existing stage trace hydrographs from water stage recorders. The more significant runoff events were chosen from the trace. All three watersheds have perennial streams. Personal judgment was used to estimate the beginning of the rise of the hydrograph and the effective end of direct runoff for the event. Recorded stage information was converted to flow estimates using the weir or flume rating tables provided by the agency responsible for the operation of the runoff gaging sites. A computer program was written and used to compute the volume of direct runoff for each hydrograph. Base flow was estimated as a straight line from the beginning of rise to the end of direct runoff. This estimate was subtracted from the recorded total flow at each time-flow coordinate chosen to describe the hydrograph. The differences are adjusted direct flows. These flows were used to compute the mass curve of the volume of runoff in inches for each event.

The rainfall data was obtained from recording rain gage records provided by the Forest Service. These records were searched to find the rainstorm events which most likely caused the runoff events studied. The rainfall and runoff data have been punched on computer cards and are available as computer printout. The rain gage and watershed locations were plotted on map overlays. Storm depths were plotted on these overlays and isohyetal lines were estimated. The average watershed storm rainfall was estimated from these charts. The base maps of watershed and rain gage locations are in Appendix B.

Comparison of rain and runoff-- Linear base

The first set of rainfall to runoff comparisons is on the basis of volume with straight line plots. These comparisons are given in

Table 1 and in Figures 1, 2 and 3. The computed CN shown in the table and figures were obtained from the equation

$$Q = (P + 2 - 200 / CN)^2 / (P - 8 + 800 / CN) \qquad (2)$$

with repetitive 'cut and try' estimates of CN. The minimum possible value of CN for each rainfall-runoff event was found from the equation

$$CN = 200 / (P + 2) \qquad (3)$$

This CN was then repeatedly incremented by a value of 2 until the computed Q was equal to or greater than the actual runoff volume for the event. These CN estimates were summed and averaged for the events studied for each watershed. The computed average CN has been reduced one value to improve the estimate.

Simple linear regression analysis has been performed for the rainfall-runoff data. The resulting equations of best fit straight lines and the computed correlation coefficients for these lines are presented in Table 1. The Q intercepts for Halfway Creek and Morris Creek watersheds are so near zero that the lines obtained from plotting the average Q/P ratios as shown on Figures 1 and 2 are felt to be representative of the rainfall-runoff relationships for these watersheds for the low values of Q encountered. The best fit straight line is retained for the Alpine Meadows Watershed. The line obtained from plotting the average Q/P ratio is also shown in Figure 3 for this watershed. The CN estimated from soils and vegetation data are also shown in the figures combined with runoff values computed for each value of P from the average Q/P ratios. Refer to Appendix B for the development of runoff curve numbers (CN) from soils and vegetation information.

Table 1. Rainfall-runoff comparisons

Halfway Creek Watershed

Event Number	Date	Rain Inches	Runoff Inches	Computed CN	
1	7/1/1940	1.50	.0192	65	63.25
2	7/12/1942	1.00	.0105	73	71.66
3	8/19/1945	1.33	.0216	68	66.85
4	7/12/1951	.50	.0036	84	82.92
5	8/1/1952	.80	.0105	77	76.48
6	7/26/1953	.30	.0073	91	90.54
7	8/4/1954	1.31	.0088	66	64.19
8	8/19/1959	.50	.0036	84	82.92
9	7/13/1962	1.09	.0147	71	70.55
10	9/13/1963	1.00	.0035	71	69.58
11	9/13/1963	.44	.0030	86	84.58
12	7/18/1965	1.50	.0186	65	63.25
13	8/12/1965	.44	.0042	86	85.04
14	8/21/1965	.58	.0067	84	81.52

The average runoff to rain Q/P ratio is .011.

The equation for the best fit straight line is $Q = -.0012 + .0124\,P$.

The correlation coefficient for this line is .82.

The average computed CN for this watershed is 75.

The CN estimated from soil and vegetation data was 49.

Table 1. Continued

Morris Creek Watershed

Event Number	Date	Rain Inches	Runoff Inches	Computed CN
15	7/1/1940	1.50	.0050	61
16	9/12/1942	1.00	.0022	71
17	8/3/1945	.77	.0032	76
18	8/19/1945	1.36	.0029	64
19	8/13/1946	.30	.0011	89
20	8/10/1947	.76	.0041	76
21	7/27/1951	.50	.0007	82
22	8/4/1951	.76	.0020	76
23	8/19/1951	.95	.0028	72
24	8/1/1952	.70	.0027	78
25	7/26/1953	.40	.0010	85
26	8/4/1954	1.35	.0036	64
27	7/11/1956	.35	.0005	87
28	7/28/1956	.35	.0008	87
29	8/21/1957	.90	.0072	75
30	8/19/1959	.80	.0011	73
31	7/18/1965	1.20	.0017	64

The average runoff to rain Q/P ratio is .0031.

The equation for the best fit straight line is $Q = .0003 + .0027\ P$.

The correlation coefficient for this line is .58.

The average computed CN for this watershed is 74.

The CN estimated from soil and vegetation data was 34.

Table 1. Continued

Alpine Meadows Watershed

Event Number	Date	Rain Inches	Runoff Inches	Computed CN
32	7/16/1951	.40	.0027	87
33	8/3/1951	.30	.0044	91
34	7/28/1952	1.10	.0969	81
35	7/30/1952	.20	.0119	95
36	7/10/1953	.60	.0345	87
37	7/28/1953	.47	.0406	91
38	8/31/1953	.79	.0761	86
39	8/16/1955	.61	.0279	85
40	8/3/1961	.77	.0486	84
41	8/7/1961	.38	.0246	92

The average runoff to rain Q/P ratio is .066.

The equation for the best fit straight line is $Q = -.0216 + .1039\ P$.

The correlation coefficient for this line is .92.

The average computed CN for this watershed is 87.

The CN estimated from soil and vegetation data was 60.

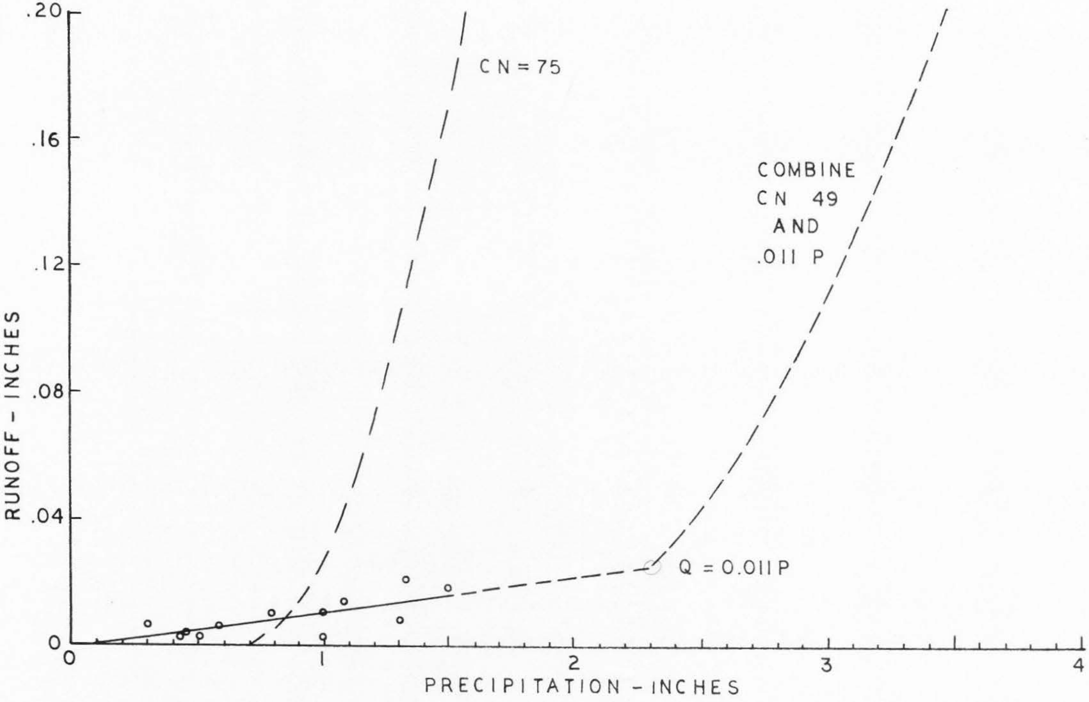

Figure 1. Estimated rainfall-runoff curve for Halfway Creek Watershed--Linear analysis.

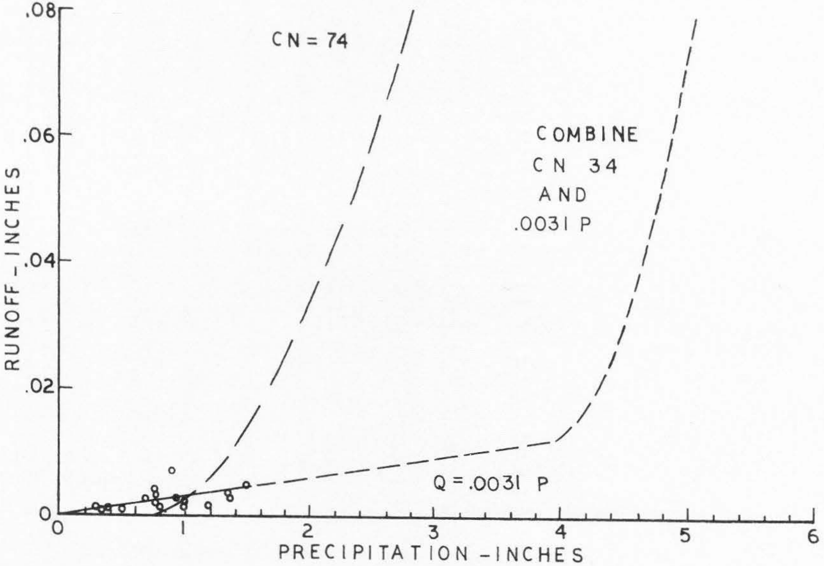

Figure 2. Estimated rainfall-runoff curve for Morris Creek Watershed--Linear analysis.

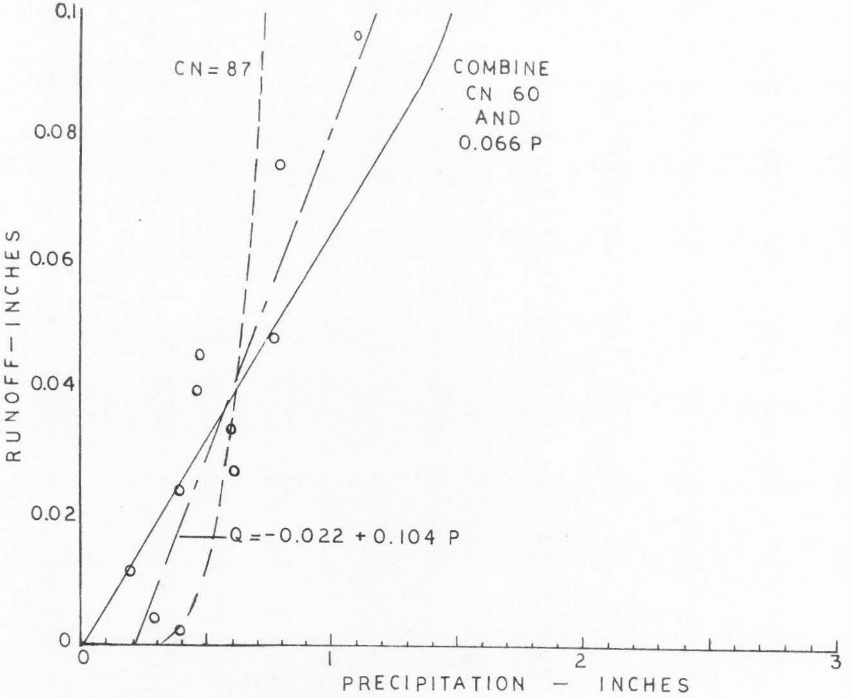

Figure 3. Estimated rainfall-runoff curve for Alpine Meadows Watershed--Linear analysis.

Comparison of rain and runoff--
Logarithmic base

The rainfall and runoff volume data may also be analyzed through logarithmic transformation. The resulting rainfall-runoff relationship is of the form

$$Q = a\ P^{b} \tag{4}$$

If three events on Halfway Creek Watershed, July 26, 1953, August 4, 1954, and September 13, 1963, are designated mavericks and neglected, the best fit curve has the formula

$$Q = 0.012\ P^{1.48} \tag{5}$$

with a correlation coefficient of the logarithms of the volumes of 0.98. The best fit curve for the Morris Creek Watershed with no mavericks excluded is

$$Q = 0.0028\ P^{1.12} \tag{6}$$

and for Alpine Meadows Watershed with the event for July 16, 1961, excluded is

$$Q = 0.081\ P^{1.52} \tag{7}$$

If the exponent of P is held constant at 1.48 and the coefficients (a) chosen so that the curves pass through a mean logarithm of the runoff volumes, the resulting formulas for the best fit curves are

$$Q = 0.012\ P^{1.48} \tag{8}$$

$$Q = 0.003\ P^{1.48} \tag{9}$$

$$Q = 0.079\ P^{1.48} \tag{10}$$

for the three watersheds in the same order. These curves are plotted in Figures 4, 5 and 6. The CN obtained from soils and vegetation data are plotted on these figures as combined with equations (8), (9) or (10) as appropriate. Figure 7 is a logarithmic plot of the coefficients of P in equations (8), (9) and (10) against the CN obtained from soils and vegetation information.

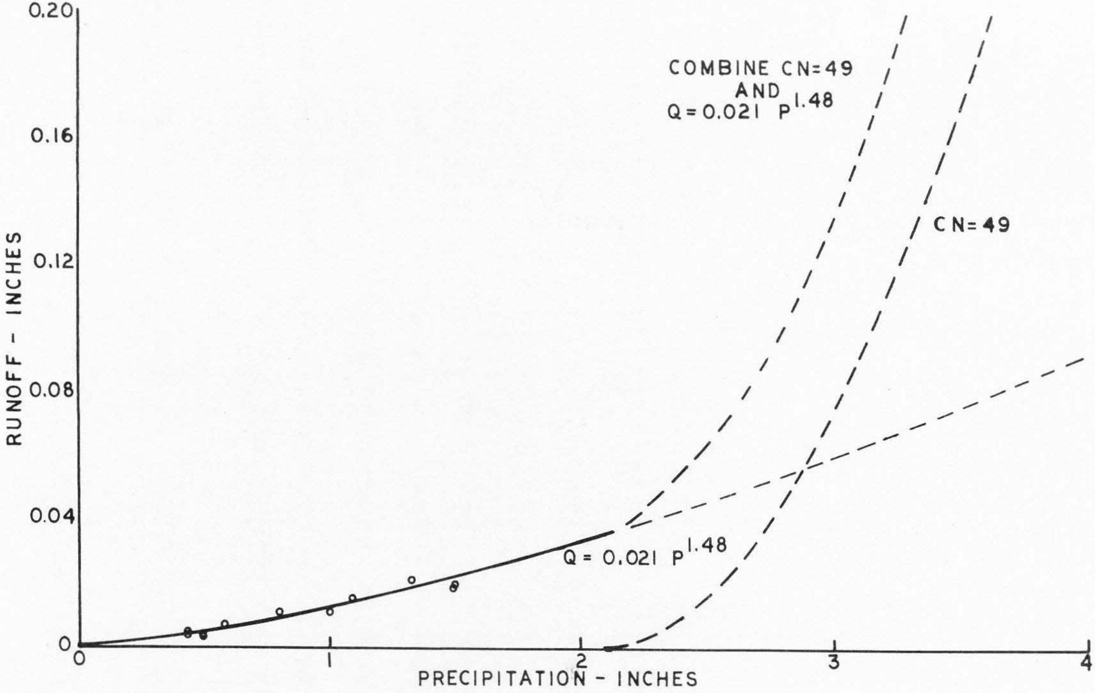

Figure 4. Estimated rainfall-runoff curve for Halfway Creek Watershed--Logarithmic analysis.

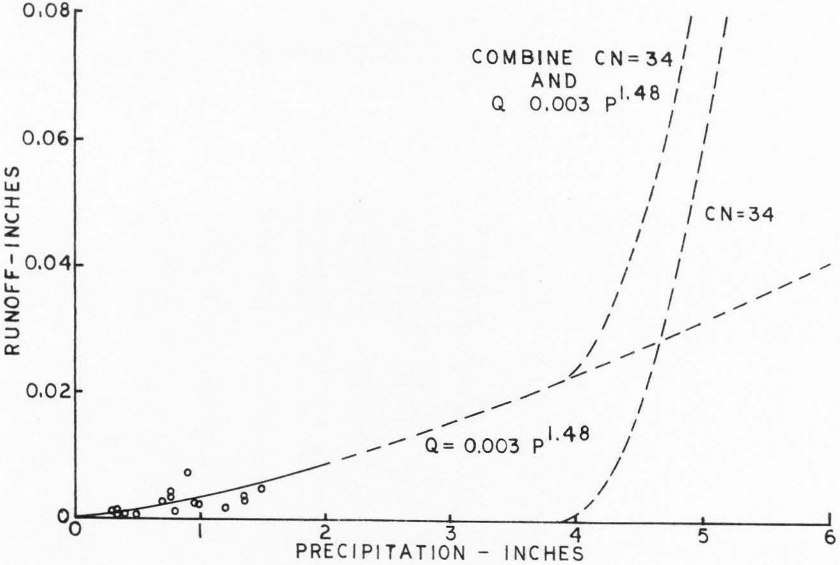

Figure 5. Estimated rainfall-runoff curve for Morris Creek Watershed--Logarithmic analysis.

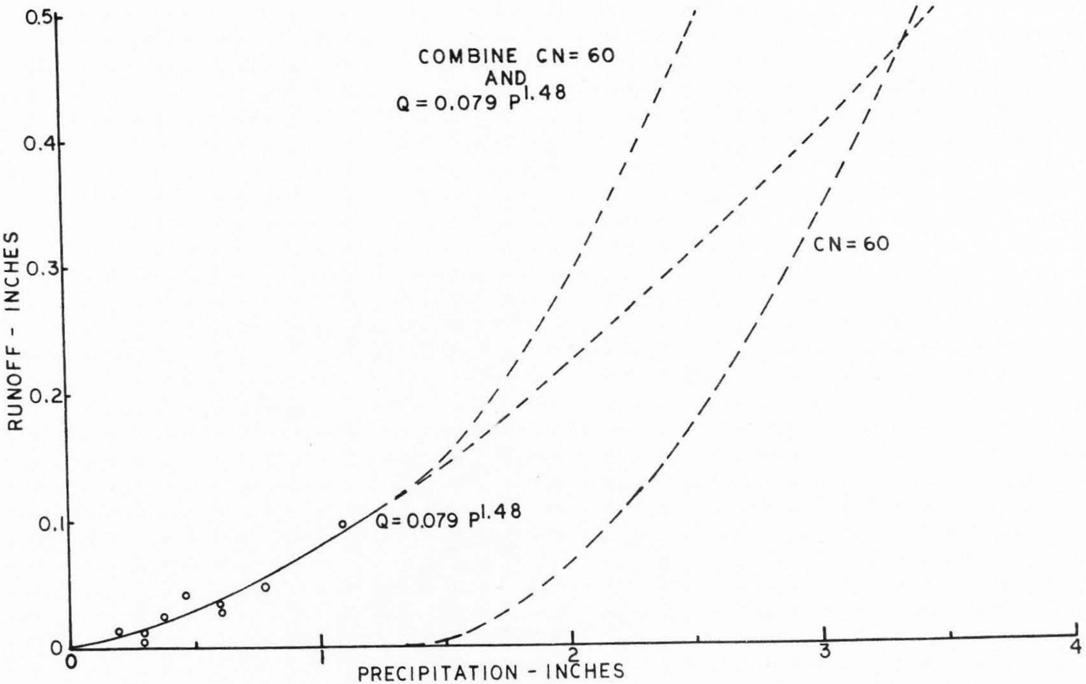

Figure 6. Estimated rainfall-runoff curve for Alpine Meadows Watershed--Logarithmic analysis.

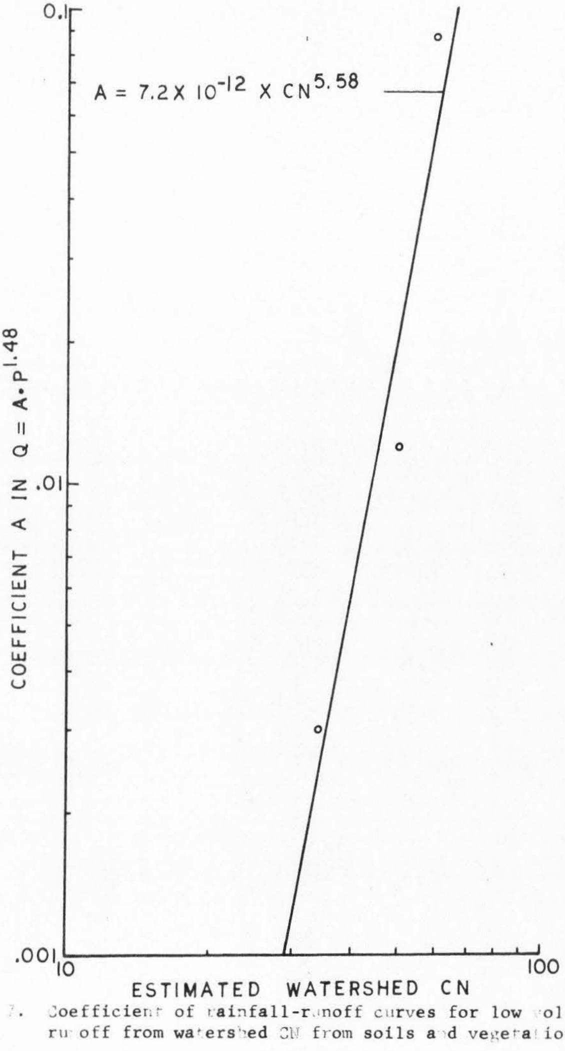

Figure 7. Coefficient of rainfall-runoff curves for low volumes of runoff from watershed CN from soils and vegetation data.

Estimating watershed lag factors with synthetic hydrographs

If rainfall and runoff records were always accurately timed and if rainfall came in sudden bursts, but in uniform rates, watershed lag time could be measured directly from plots of hyetographs and hydrographs. Neither condition is met in the basic data used for this study. The construction of synthetic hydrographs with the incremental triangular hydrograph procedure as proposed by the Soil Conservation Service (1964) allows cut and try estimation of watershed lag effects.

When the rain distribution is determined or fixed, the shape of a synthetic hydrograph produced depends on the estimate of watershed lag time as seen in the equation

$$q_{pi} = 484\ A\ Q_i\ /\ \triangle T_p \qquad (11)$$

where q_{pi} is the peak rate of flow of an incremental triangular hydrograph, A is the watershed area in square miles, Q_i is the generated incremental estimate of mass runoff and $\triangle T_p$ is the estimated time of rise of the incremental hydrograph. The relationship of T_p to watershed lag is defined by the Soil Conservation Service (1964) to be

$$\triangle T_p = \triangle D\ /\ 2 + L \qquad (12)$$

where $\triangle D$ is a chosen increment of time used to divide the mass rainfall curve into short, fairly uniform segments of developing a series of incremental triangular hydrographs, and L is the watershed lag time in hours. The incremental hydrographs may then be combined by addition into a composite synthetic hydrograph. If a natural rainstorm is used for the rainfall mass distribution curve, if the total volume of runoff is predicted correctly, and if the proper

ΔD is chosen, the resulting synthetic hydrograph should closely fit the actual runoff hydrograph.

Kent (1968) proposed the use of the approximation

$$\Delta T_p = 3\Delta D \tag{13}$$

to facilitate computer solution of peak flow estimates from incremental triangular hydrographs. This approximation may also be used to develop complete hydrographs. A program written in FORTRAN that will do this is included in Appendix C. This program is written to perform the following operations:

1. Compute a synthetic hydrograph from a natural rainstorm adjusted in depth to the estimated average watershed depth.
2. Compare this hydrograph to the actual hydrograph and compute the summed squares of the deviations between them.
3. If there is only one minimum point in curve of summed squared deviations, the program will search for it by making two adjustments:
    a. First, move the actual hydrograph in time to the position of best fit.
    b. Then, increase ΔD and repeat the operation in a.
    c. Repeat steps a and b until the minimum summed squared deviation is found.

Table 2 is a list of the T_p estimates computed with this procedure. The minimum squared deviations found and the time that the actual hydrograph was moved from the beginning of rain to the position of best fit are also listed in Table 2. These estimates could be refined somewhat by reducing the size of the ΔD increment if desired. Appendix D contains the plotted actual and synthetic hydrographs for

Table 2. Summary of goodness of fit data for hydrograph synthesis

Halfway Creek Watershed

Event Number	Date	Minimum sum of Deviations Squared	T_p Estimates	Time Move of Actual Hydrograph
1	7/1/1940	8.1723	1.8	1.2
2	9/12/1942	2.45	4.2	7.0
3	8/19/1945	19.7	0.6	0.8
4	7/27/1951	1.9	1.2	1.2
5	8/1/1952	5.5	0.6	0.2
6	7/26/1953	5.1	0.6	0.2
7	8/4/1954	2.1	0.6	0.4
8	8/19/1959	0.3	1.2	0.8
9	7/13/1962	2.8	1.8	1.2
10	9/13/1963	0.1	1.8	0.6
11	9/13/1963	0.1	1.8	1.2
12	7/18/1965	3.6	1.8	1.8
13	8/21/1965	0.1	1.2	0.8
14	8/21/1965	0.3	1.8	1.2
	Total		21.0	18.6
	Average		1.5	1.33
Without Number 2				
	Total		16.8	11.6
	Average		1.3	0.9

Estimate of T_p from Kirpich procedure = 0.30 hours.

Estimate of T_p from Mockus (Kent, 1968) procedure = 1.26 hours.

Table 2. Continued

Morris Creek Watershed

Event Number	Date	Minimum Sum of Deviations Squared	T_p Estimates	Time Move of Actual Hydrograph
15	7/1/1940	0.012	1.2	2.0
16	9/12/1942	0.036	2.4	0.8
17	8/3/1945	0.008	0.6	0.6
18	8/19/1945	0.021	3.6	4.8
19	8/13/1946	0.006	0.6	0.4
20	8/10/1947	0.125	0.6	0.8
21	7/27/1951	0.001	1.2	0.4
22	8/4/1951	0.006	1.2	1.6
23	8/19/1951	0.050	0.6	0.2
24	8/1/1952	0.106	1.2	1.2
25	7/26/1953	0.004	0.6	0.2
26	8/4/1954	0.019	2.4	2.4
27	7/11/1956	0.002	1.8	1.8
28	7/28/1956	0.002	0.6	0.6
29	8/21/1957	0.437	1.2	0.8
30	8/19/1959	0.002	1.2	2.4
31	7/18/1965	0.014	1.8	2.4
	Total		22.80	23.40
	Average		1.34	1.38

Estimate of T_p from Kirpich procedure = 0.19 hours.

Estimate of T_p from Mockus (Kent, 1968) procedure = 3.0 hours.

Table 2. Continued

Alpine Meadows Watershed

Event Number	Date	Minimum Sum of Deviations Squared	T_p Estimates	Time Move of Actual Hydrograph
32	7/16/1951	0.185	1.2	0.8
33	8/3/1951	0.815	2.4	1.6
34	7/28/1952	334.1	0.6	0.4
35	7/30/1952	13.6	0.6	0.4
36	7/10/1953	30.6	1.2	1.2
37	7/28/1953	447.2	0.6	0.6
38	8/31/1953	120.0	1.2	1.2
39	8/16/1955	140.0	0.6	0.4
40	8/3/1961	143.0	0.6	0.2
41	8/7/1961	11.8	1.8	1.2
	Total		10.80	8.0
	Average		1.08	0.8

Estimate of T_p from Kirpich procedure = 0.34 hours.

Estimate of T_p from Mockus (Kent, 1968) procedure = 0.96 hours.

the events studied. Table 2 also lists T_p estimates obtained by

$$T_p = 0.72\ T_c \tag{14}$$

where T_c is estimated from methods presented by Kirpich (1940) and Mockus (Kent, 1968).

Estimating sources of runoff

The volumes of runoff measured from these watersheds are important in that they may contribute to serious floods when combined with runoff from other watersheds. They also provide a supplemental water supply to depleted summertime streamflows. When converted to inches of runoff from the watershed, however, they are very small. Only two of the events studied approached one tenth of one inch of runoff. These were both on the Alpine Meadows Watershed. There was one event during the study period on Halfway Creek that may have approached this amount of runoff, but it caused a mud flow which submerged the runoff gage. This occurred on August 10, 1947. Other mud flows have occurred from this watershed.

The low volumes of runoff suggest that no significant amount of direct surface overland flow may have occurred from any rain event studied. Suppose all of the runoff occurs from effectively impervious areas. Now estimate the impervious surface area required to produce the amount of runoff to result in the Q/P ratios found in the rainfall-runoff comparisons. This is simply the product of the Q/P ratio and the total area of the watershed. The results are 5.1 acres for Halfway Creek, 0.47 acres for Morris Creek, and 24.8 acres for Alpine Meadows. The Alpine Meadows Watershed has an area of 20 acres or more of snow drift fields and barren areas adjacent to streams. There is also a small wet meadow area just above the runoff gage that would first take rain and runoff to replenish its depletions and then provide almost 100 per cent runoff. This may be the reason for the P axis intercept of best fit regression line in Figure 3. If this area is subtracted from 24.8 acres we still have 4.8 impervious acres.

All three watersheds have perennial streams. Nearly all of the rain that falls on these open streams must leave the watershed as direct flow. Open streams may be detected on aerial photographs. These stream lines may be transferred to the topographic maps and their lengths estimated. The estimates are 16,000 feet for Halfway Creek, 6,000 feet for Morris Creek, and 24,000 feet for Alpine Meadows. If we convert the areas listed above to square feet and divide by the estimated stream lengths, we obtain the estimated average stream widths required to produce the runoff volumes experienced during the period of study. These stream widths are 13.7 feet for Halfway Creek, 3.4 feet for Morris Creek, and 8.7 feet for Alpine Meadows. These figures are too high as estimates of average stream widths, but they are in the correct order of magnitude. The flowing streams tend to keep an area of soil and rocks saturated on their banks. There are rocky and barren areas very close to the streams that will contribute high percentages of rainfall to direct surface runoff or to 'quick return' subsurface flow. This kind of flow is often called interflow and may produce runoff very quickly through an interplay of static and kinetic flows. If these areas are included in the width estimates above they seem to be very realistic.

However, the fairly long lag times experienced and the apparent relationship shown in Figure 7 between soils and vegetation and the rainfall-runoff relationships may provide additional clues as to the sources of runoff. These factors indicate that the interflow from small source areas may supply more volume than runoff from stream surfaces. The slow lag times estimated for these steep watersheds indicate considerable resistance to flow. This is probably the result of flow through cracks in rocks, over boulders, through porous soils and perhaps, in some areas through humus and litter. The relationship shown in Figure 7 suggests that the CN developed from soils and cover information may indicate the size of small source areas on these high mountain watersheds that have high percentages of runoff. The combination of this relationship with the relationships shown in Figures 4, 5 and 6 might provide a basis for changing the rainfall-runoff curves (CN) shown in Figure 9 in Appendix A to improve estimates of potential runoff from similar watersheds. Further research is needed to confirm these curves or to improve and extend them.

OBSERVATIONS AND RECOMMENDATIONS

Observations

The very low volumes of runoff listed in Table 1 strongly indicate that only small parts of the watersheds have contributed runoff for the events studied. The standard runoff curve number (CN) developed as part of the Soil Conservation Service methods for estimating rainfall-runoff relationships appears to be a poor estimator of these low volumes of runoff when it is developed as a weighted average CN for the entire watershed either from soils and vegetation information or from rainfall-runoff comparisons.

The high estimates of lag time obtained from the procedures used in this thesis suggest quite high resistance to water flow. This suggests that more water comes from overland and subsurface flow than from rain falling directly on stream surfaces. This water may be flowing through cracks in rocks, through very porous soils very near the flowing streams, through wet humus or living vegetal matter such as moss and lichens along stream banks, or through litter on the soil surface. Rock outcrops and talus slopes lying close to the stream tributaries are suspected of providing the major source of runoff from the summer rainstorms on these well vegetated small high mountain watersheds.

Figure 7 suggests that the CN obtained from soils and vegetation information for the whole watershed may be an indicator of the size of the small portion of the watershed that actually produces runoff from summer rainstorms. Further research is needed to determine whether this evidence may become the basis for improving the runoff curve number as an estimator of runoff volumes from summer rains on small high mountain watersheds. One possible form these CN might take is shown for each watershed on Figures 4, 5 and 6 as the combined curve.

The consistent underestimates of peak rates of flow by the synthetic hydrograph procedure used in this study suggests a need to change or improve estimates of watershed lag time from the formula given as equation (13) to some shorter time relationship. Holtan and Overton (1963) suggest an "m" value derived from recession curve analysis as an estimator of watershed lag effects. Somewhat more sophisticated programming would be required for computer generation of the synthetic hydrographs to test this value, but its use should be further investigated. Field measurements would also provide a check on lag time estimates.

The excellent agreement of T_p estimates between those obtained by this study and those obtained from the Mockus procedure for Halfway Creek and Alpine Meadows is most interesting. The fairly poor comparison for the Morris Creek watershed is just as significant. Had the estimate of watershed curve number for Morris Creek also been about 50, the T_p estimate from the Mockus procedure would have been much closer to the 1.34 hours obtained from the synthetic hydrograph estimate. This suggests that the variations of CN may not be responsible for changing watershed lag characteristics when the volumes of runoff are very low. This finding is consistent with the earlier suggestions made about runoff volumes. The very poor comparison of Kirpich method estimates of T_p leads to serious doubts as to its usefulness for watersheds and conditions such as those studied in this thesis.

Though not presented in this thesis, the isohyetal plotting of summer rainfall events led the writer to the following tentative observations. Summer rainstorms in the high mountains are highly variable. Recorded amounts of rain for the same storm could vary from zero at one rain gage to almost an inch at another rain gage less than 3000 feet away. The storm patterns seem to be more significant than orographic effects for these storms. Rain gage catches differ between nearby gages at similar elevations as much as between nearby gages at different elevations. The lower elevation gages catch more rain than the higher gages almost as often as the inverse is true. The data obtained for this study are not sufficient for a true statistical test of these observations.

Recommendations

Serious deficiencies have been encountered in records of rainfall and runoff. These are partly a result of human errors, but are more often the result of instrument malfunction. Clocks stop or gain or lose time. Ink traces are lost while the pen is apparently still inked. Ink traces sometimes trace over and over at diminishing levels until some records are obliterated. Clocks between different gages are almost never properly synchronized. Improved instruments and procedures are seriously needed.

The present methods of measurement or sampling of hydrologic data need to be improved. Areal distribution of rain is almost an unknown factor, even when several rain gages exist in a fairly small area. Weirs and flume and sediment traps may significantly disturb time lag factors in runoff measurement. Recent developments in such remote sensing devices as radar offer great promise in reducing areal measurement errors. This kind of measurement should be developed on the experimental watersheds of the Agricultural Research Service and the Forest Service. This would facilitate further study of summer rainstorm patterns in the high mountains.

Range and forest surveys often provide little information about the actual total plant density or the horizontal per cent of area covered with plants. This cover estimate should be developed and related to site condition or other commonly surveyed factors. Soils information obtained with these surveys needs to be improved to allow better estimates of the hydrologic effects of the soil-plant complex.

Field studies of the hydraulic properties of the watersheds included in this study might provide additional valuable information. This study can be expanded with other estimates of rainfall-runoff characteristics and lag times to improve these comparisons.

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APPENDIXES

Appendix A

The SCS synthetic unit-graph method

Theory of direct surface runoff volume. As seen in Figure 8, the general water balance equation for any watershed when ice and snow are not present can be expressed

$$P = (Q_2-Q_1) + (Z_2-Z_1) + (W_2-W_1) + (U_2-U_1) + (I_2-I_1) \qquad (15)$$

where P is precipitation. Q_1 is channel inflow or surface inflow into the watershed and Q_2 is surface outflow or channel outflow from the watershed. Z_1 is condensation and Z_2 is evapotranspiration. W_1 and W_2 are horizontal underground inflow and outflow. The quantity (U_2-U_1) is the change in both underground and surface storage during the specified time interval (Chebotarev, 1966).

For the case of direct surface runoff from a headwater watershed during a short duration storm, some of the variables may be combined or neglected in equation (15). Q_1 is eliminated when the boundary is defined unless artificial importation occurs. Z_1 may be considered a part of P as it occurs during a storm. Z_2 will include evaporation and transpiration during and shortly after the storm and will account for part of the initial abstraction (I_a) from P that must occur before any overland runoff takes place. W_1 and W_2 will usually be neglected during a short duration direct runoff event. The storage factor (U_2-U_1) as it pertains to underground water can change only as supplied by infiltration or depleted by base flow. Temporary storage on the surface of the watershed during a storm contributes to the effects of lag in time of outflow and supplies water for evaporation and infiltration. I_2 is the source of base flow at the watershed outlet and is estimated separately from the direct runoff

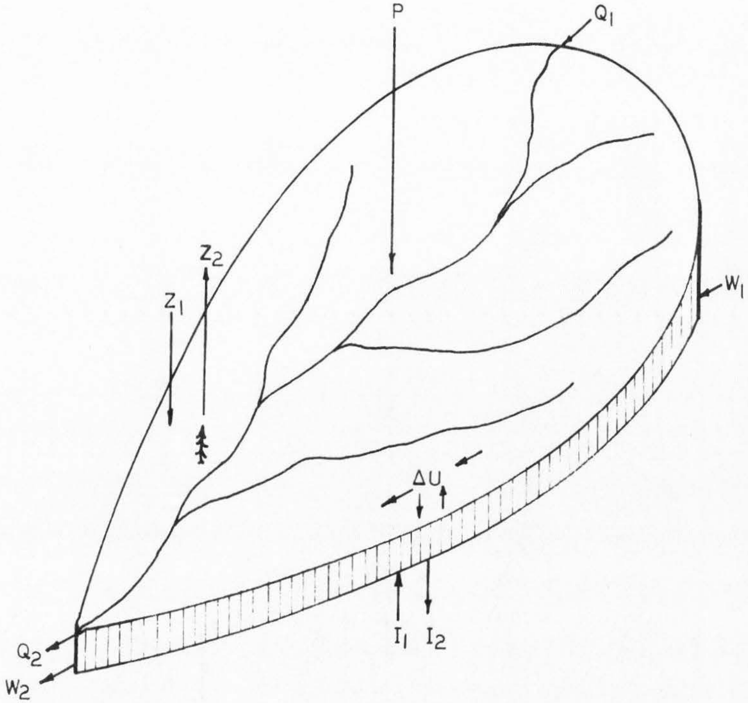

Figure 8. Water balance model of a small watershed

estimates. I_1 is infiltration through the watershed surface. I_1, W_1, W_2, U_2 and Z_2 when combined comprise the total abstractions (S) from P. Part of S is considered to be initial abstraction (I_a) and a remainder (F). Equation (15) may now be expressed

$$P = Q_2 + (F + I_a) \qquad (16)$$

Rearranging and dropping the subscript

$$Q = (P - I_a) - F \qquad (17)$$

$(P - I_a)$ is defined as effective rainfall, therefore

$$Q = P_e - F \qquad (18)$$

The SCS method assumes that for any time during the storm after direct runoff begins

$$F / S = Q / P_e \qquad (19)$$

Equations (18) and (19) combined give

$$Q = P_e^2 / (P_e + S) \qquad (20)$$

Studies of many small watersheds have led to an average estimate that $I_a = 0.2$ S. Resubstituting $P_e = (P - 0.2\ S)$

$$Q = (P - 0.2\ S)^2 / (P + 0.8\ S) \qquad (21)$$

Now define a rainfall-runoff curve number (CN) in terms of S as

$$CN = 1000 / (S + 10) \qquad (22)$$

Equations (18) and (19) combined produce a second degree equation for the solution of runoff in terms of precipitation and a rainfall-runoff curve number.

$$Q = [P - (200 / CN - 2)]^2 / (P + 800 / CN - 8) \qquad (23)$$

This equation has a distinct minimum point when Q equals zero for each value of CN where

$$P = (200 / CN) - 2 \qquad (24)$$

Equation (23) is meaningless for all values of P less than that computed in equation (24). When this is true there is assumed to be no overland runoff. Equation (23) can be solved for several values of CN and a chart may be made such as in Figure 9 for ready graphical solution of the equation.

Obtaining factors for the runoff equation. The use of equation (23) or Figure 9 presupposes some reasonable estimate or measurement of CN and P. P may be obtained from actual storm data or from charts of expected rainfall values for various durations and likelihood of occurrence. One source for this information is a set of precipitation-frequency maps for Utah (U. S. Weather Bureau, 1968). Precipitation data used in this study is found in Appendix C.

If precipitation and runoff are both measured quantities, for several events of sufficient magnitude for a small watershed, a value of CN may be estimated for that watershed using equation (23) or Figure 9. CN estimated by this method may be correlated to soil and vegetation information about the watershed. When this is done CN may be estimated for ungaged watersheds on the basis of soil and vegetation information.

The Forest Service has cooperated with the Soil Conservation Service in developing CN values for western forest and range complexes for small watersheds on the basis of information about soils, vegetation, and intensity of land use. CN may be estimated from Figures 10, 11, 12 and 13 which have been adapted from information presented by the Soil Conservation Service (1964). A value for CN for a small watershed is usually estimated as an areally weighted composite of CN values for subdivisions of the watershed. The CN is a practical estimate of the combined interception and infiltration effects in the rainfall-runoff characteristics of a watershed.

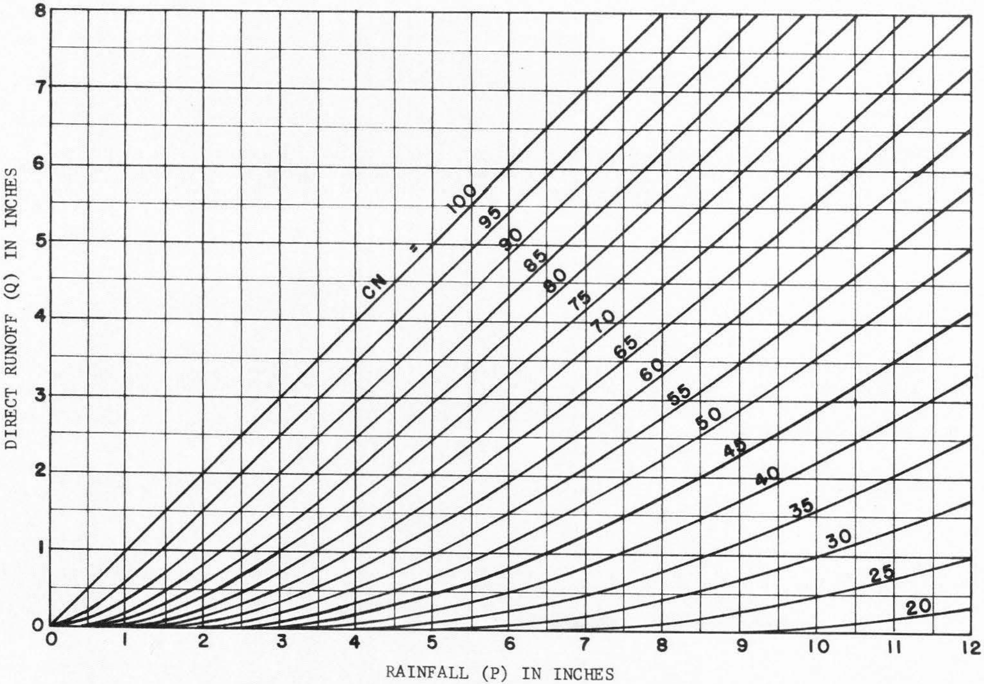

Figure 9. Estimation of runoff from rainfall using runoff curve number (CN)

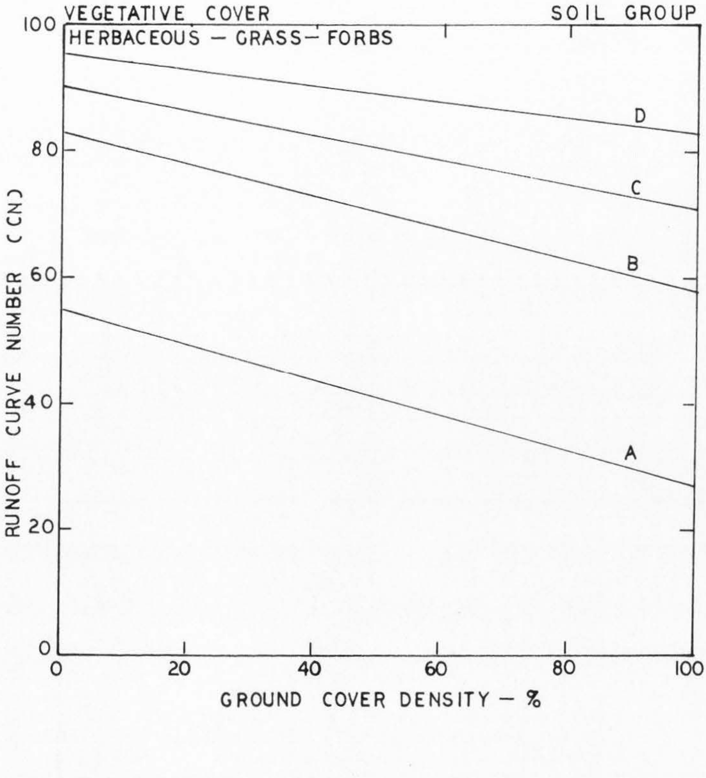

Figure 10. Curve numbers (CN) for forest-range soil cover complexes in the Western United States (SCS, 1964)

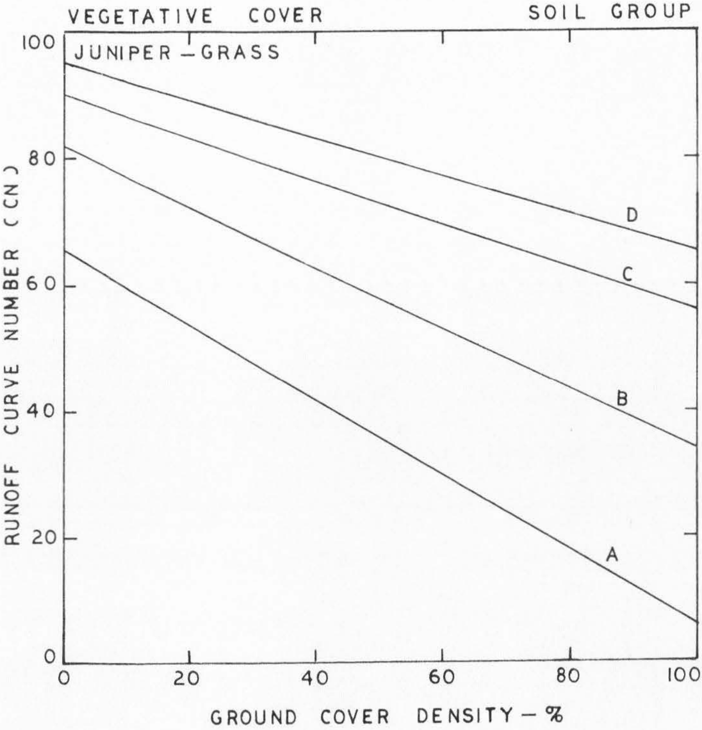

Figure 11. Curve numbers (CN) for forest-range soil cover complexes in the Western United States (SCS. 1964)

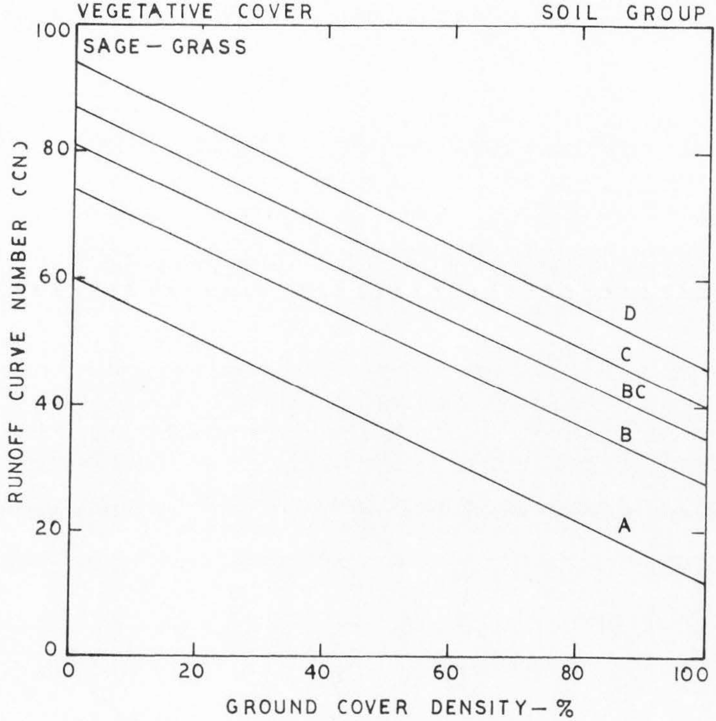

Figure 12. Curve numbers (CN) for forest-range soil cover complexes in the Western United States (SCS, 1964)

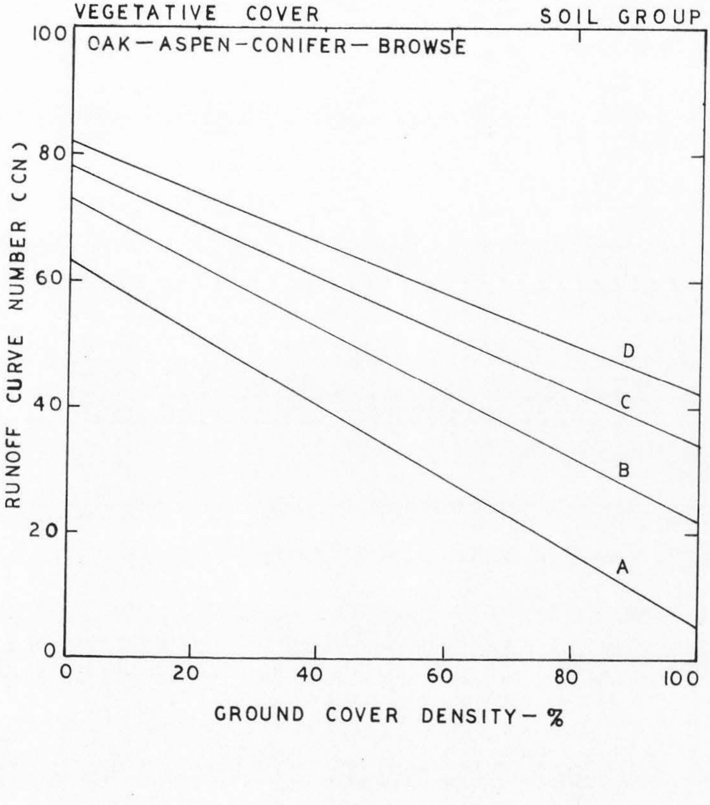

Figure 13. Curve numbers (CN) for forest-range soil cover complexes in the Western United States (SCS, 1964)

Soils in the watershed. From the point of view of the problem discussed in this paper, the most important property of soil is its infiltration or water intake rate. Logic tells us that a soil with a high intake rate will produce less direct runoff than a soil with a low intake rate. The intake rate may be limited by the transmission rate of the saturated soil. The property is called soil permeability.

An exact quantitative analysis of the intake rates and transmission rates of watershed soils would be very difficult, if not impossible. There are many factors that can influence or radically change the intake rate of a soil. A saturated or frozen soil will generally have a lower intake rate than a moist, warm soil. Chemical changes in a soil may affect this property. Biological agents change soil composition, structure, texture and position. However, some approximate analysis of soil properties in the watershed must be made as the basis for runoff prediction from precipitation information.

The SCS method proposes the use of a limit condition of the minimum rate of infiltration obtained for a bare soil when completely wetted for a long time. The determination of this index is empirical and approximate. On this basis, four rather broad hydrologic groupings are given to classify soils. These are simply A, B, C and D. The Forest Service in Utah has also defined groups AB, BC, and CD as hydrologic soil groupings whose characteristics fall between the primary groupings. A description of these groups is given in Table 3, as taken from the SCS handbook, and in Table 4, as taken from an unpublished information sheet obtained from the regional hydrologist's office of the Forest Service in Ogden, Utah.

Table 3. Hydrologic soils groups as defined in the SCS handbook

Hydrologic Soil Group	Description
A	(Low runoff potential) Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
B	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
C	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
D	(High runoff potential) Soils have very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Table 4. Hydrologic soils groups as defined by the Forest Service

Hydrologic Soil Group	Description
A	Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of deep ($\leq$ 3 feet) well to excessively drained sands, loamy sands, sandy loams, or gravels. These soils have a high rate of water transmission and a low runoff potential (3.00 inches of infiltration per hour or more). Paralithic soils - granitic soils more than 20 inches deep with a deep decomposed contact zone.
B	Soils having moderate infiltration rates consisting chiefly of moderately deep (20 inches) moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (1.25 to 3.00 inches per hour). Paralithic soils - granitic soils less than 20 inches deep with a decomposed contact zone.
C	Soils having slow infiltration rates consisting chiefly of soils with a layer that impedes the downward movement of water and soils moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission (0.5 to 1.25 inches per hour). 1. A Change of one or two percolation classes within 10 inches of the surface, depending on roots and structures. 2. Moderately fractured limestone at less than 20 inches. 3. The change in permeability is at less than 20 inches. 4. Soils having moderate compaction in the upper 8 inches of profile.
D	Soils having very slow infiltration rates consisting cheifly of clay soils with a high swelling potential, soils with a high permanent water table, soils with a claypan or clay layer near the surface, and shallow soils over nearly impervious materials. These soils have a slow rate of water transmission (less than 0.50 inches per hour).

Table 4. Continued

Hydrologic Soil Group	Description
D Continued	1. Less than 12 inches of soil over flat lying sandstones, limestones, etc.
	2. Lithosols - generally averaging less than 1 inch per hour infiltration.
	3. Clay layer or shallow over shale.
	4. A change of two or more percolation classes in the profile.
	5. Non-wetting soils, dry silt, sand, etc.
AB	Hydrologic soil group whose characteristics fall between primary soil groups.
BC	Same as above.
CD	Same as above.

The Soil Conservation Service and other agencies of the U. S. Department of Agriculture have been conducting soil surveys for many years. Much of the agricultural land and some of the public land in this country has been soil surveyed. The minimum infiltration rate of a soil type can be inferred approximately from the soil description written from the soil survey data. A list of over 4000 soil type names with their hydrologic group classification is given in the SCS handbook. This is not a list of all soils, but the local soil scientist can compare the properties of unlisted soils with listed soils with which he is familiar. The soils of the local watershed may be classified from this information. When the watershed soils have not been surveyed, a field reconnaisance may be performed by experienced personnel. Local Forest Service and SCS personnel may be sufficiently familiar with the watershed to make a tentative classification of the soils. The hydrologic soil groups are then outlined on a base map of the watershed and their areas determined by a dot or grid method or they may be planimetered. Impervious areas are kept as separate units. Small areas of differing soils may be included in larger areas if they cover less than three per cent of the combined area.

Watershed vegetation. The following statement can be found in the context of the "Hydrology Handbook".

> Of the natural agencies affecting soil structure and its permeability to water none is more important than the impact of rain ... The conditions at the soil surface are often the critical ones that govern infiltration. The arrangement of soil particles in the surface layer may either permit a high rate of intake or cause a very low rate, and is sensitive to great readjustment by either man or nature. An aggregated, porous structure usually is found where a considerable quantity of organic matter is in the soil, where tillage has not been excessive, and where sod forming crops have been included. However, such favorable surface structure may be largely destroyed if the soil, when bare, receives high intensity rains ... The presence of vegetative cover, either as a canopy or as a mulch of dead vegetation, has ... pronounced effects upon the rate of infiltration. The character of surface cover, therefore, is a matter of prime importance. The degree of protection provided is about proportional to its density. (American Society of Civil Engineers, 1949, p 34-37)

Figures 10, 11, 12 and 13 provide estimates of CN according to hydrologic soil group and vegetative cover type and density. Cover density includes litter if present. Adjustments have been made in the basic data to conform to the assumption that $I_a = 0.2$ S and that average moisture conditons prevail.

Vegetation cover types and density may be estimated from field reconnaissance or from vegetation survey maps and data. On public forest and range land where private use for grazing is permitted, the

Forest Service or the Bureau of Land Management may have range vegetation surveys on file. These are usually maps with the appropriate symbols and keys at a scale of 2 inches per mile. Where commercial timber is available on public lands there may be a timber survey. Much of the state of Utah has been mapped under one of these surveys. Sample data for these surveys is taken from field transect lines or area plots. This sample data is extended with the interpretation of aerial photographs and the judgment of the technician in the field. Some specific watersheds involved in projects authorized under the Small Watersheds Act (Public Law 566) may have quite detailed hydrologic analysis surveys in the files of local, regional, or state offices of the Forest Service or the Soil Conservation Service. There are a number of such watersheds in Utah, but generally these watersheds have very limited precipitation or runoff data. Some general vegetation maps are also on file at the office of the Sevier Basin Study of the Soil Conservation Service, now located in Salt Lake City, Utah.

Where surveys have been made they give information concerning vegetation species, density of cover, canopy and litter, and other information taken from visual measurement or observation, such as slope, aspect, evidence of erosion, surface soil texture, and evidence of grazing and wildlife. Other information may include range site, name and condition or forest site class and index.

From the information gathered in these surveys and the requisite soils information, the watershed can be subdivided into hydrologic complexes so that the soils-cover relationship within each complex is relatively homogeneous. A CN can then be estimated for each complex and these can be combined by weighting by areas into a CN estimate for the watershed.

Antecedent soil moisture. The CN determined from Figures 10, 11, 12 and 13 are given for the average moisture existing for the soils and vegetation or land use conditions described. If soil moisture conditions on the watershed are normally wetter or drier than the average of similar lands in the United States, an adjustment in CN should be made. Tables 5 and 6 (Soil Conservation Service, 1964) give suggested adjustments for three levels of antecedent moisture conditions. AMC II is the average level, AMC III is for the wetter level and AMC I is for the drier level. These adjustments are usually applied after the watershed CN is estimated, but may be applied to watershed soil-vegetation complexes if desired.

Table 5. Seasonal rainfall limits for AMC

	Total 5-day antecedent rainfall	
AMC group	Dormant season	Growing season
I	Less than 0.5	Less than 1.4
II	0.5 to 1.1	1.4 to 2.1
III	Over 1.1	Over 2.1

The triangular hydrograph. The method for using watershed soils, soil moisture and vegetation information to estimate a rainfall-runoff volume relationship for that watershed has been discussed. The runoff volume, however, may tell very little about its rate of flow. The design of spillways or flood control storage requires an estimate of probable peak flows. This may sometimes be obtained from a frequency analysis as previously mentioned, or from some kind of routing

Table 6. Curve numbers (CN) adjustments for wet or dry antecedent moisture conditions

CN for conditions		
II	I	III
100	100	100
95	87	98
90	78	96
85	70	94
80	63	91
75	57	88
70	51	85
65	46	82
60	40	78
55	35	74
50	31	70
45	26	65
40	22	60
35	18	55
30	15	50

procedure on larger watersheds or river basins. On smaller watersheds the estimate may be made through some kind of hydrograph analysis.

A basic tool for estimating runoff hydrographs for storm of different amounts and intensities on a watershed is the unit hydrograph. Since many watershed characteristics, such as shape, size and slope are relatively constant from year to year, if two storms are similar in duration and amount, the two runoff hydrographs should be quite similar as well.

> The theory of the unit hydrograph as now conceived, is based on the observation that, at a given point on a given stream, not only is the base of the hydrograph of direct runoff resulting from a storm of unit duration constant, regardless of the volumes of rainfall or runoff, but also the ordinates of the hydrograph vary directly as the volume of runoff. ... The unit hydrograph ... may be defined as the discharge hydrograph resulting from one inch of direct runoff generated uniformly over the tributary area at a uniform rate during a specified period of time. (American Society of Civil Engineers, 1949, p. 105)

The unit hydrograph is curvilinear. The SCS method approximates a short duration single peaked runoff hydrograph with a triangular hydrograph according to the principle of the unit hydrograph. Complex runoff hydrographs can be constructed from combining several short duration triangular hydrographs computed for corresponding portions of a rainstorm. This procedure has proven to be reasonably accurate when used on small agricultural watersheds. Useful relationships have been developed for estimating the dimensions of a triangular hydrograph. Figure 14 shows these dimensions.

The volume of runoff is the area under the hydrograph in acre inches per acre or simple inches. Time is in hours, and the rate of flow is in inches per hour. From Figure 14 we obtain

$$q_i = 2Q \;/\; T_p + T_r \qquad (25)$$

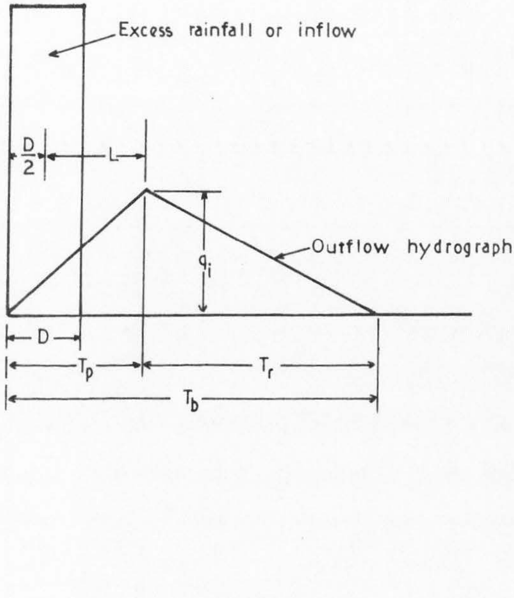

Figure 14. The triangular hydrograph.

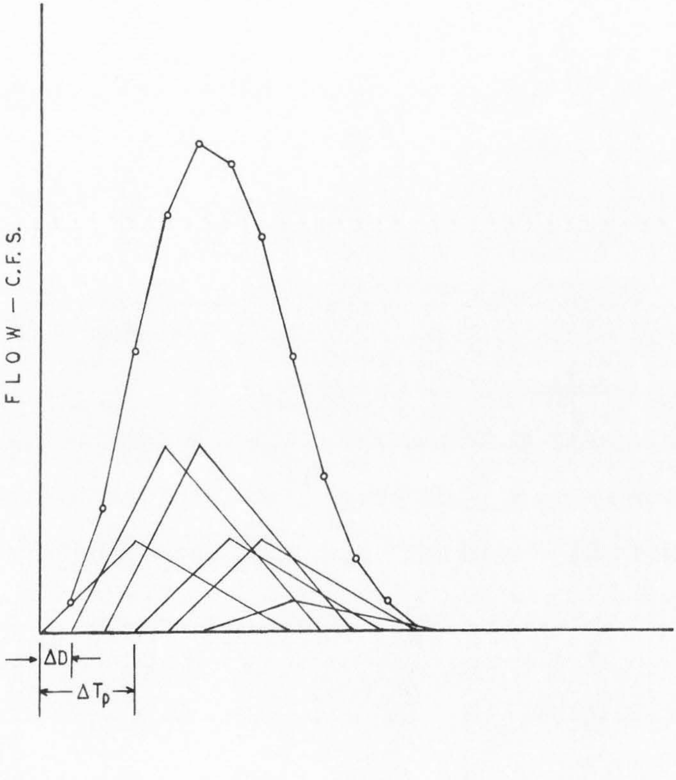

Figure 15. Development of a composite hydrograph by summing incremental triangular hydrographs.

From evaluating many actual hydrographs the average relationship is devised (Kent, 1968)

$$T_r = 1.67\ T_p \tag{26}$$

Combining, we have

$$q_i = Q\ /\ 1.335\ T_p \tag{27}$$

Converting q_i in inches per hour to q_p to cubic feet per second (c.f.s.) we have

$$q_p = 484\ A\ Q\ /\ T_p \tag{28}$$

when A is drainage area in square miles. When equation (26) is not correct, 484 will not be the correct coefficient for equation (28). This coefficient depends on the shape of the hydrograph. From Figure 9 we find that

$$T_p = D\ /\ 2 + L \tag{29}$$

where D is the duration of excess rainfall that produces the runoff hydrograph and L is defined as lag time. The relationship

$$L = 0.6\ T_c \tag{30}$$

is an average taken from the study of a large number of watersheds. T_c is the time of concentration or the average travel time of a particle of direct runoff from the hydraulically most distant point in a watershed to the watershed outlet. If a complex hydrograph is to be constructed from combining incremental hydrographs the portions of an event, the ΔD chosen should be less than T_c and preferably about 0.2 of T_p. Figure 15 presents a visual concept of the procedure to be followed to obtain a composite synthetic hydrograph from incremental hydrographs.

There are several methods for estimating T_c. Perhaps the most accurate is to estimate channel hydraulics, for various levels of flow, from channel reaches surveyed in the field. Two approximate methods described in the Soil Conservation Service literature have been developed by Kirpich (1940) and Mockus (Kent, 1968). Figures 16 and 17 are self explanatory nomographs developed for these methods. In Figure 17 watershed slope (S_w) may be estimated from direct measurement in the field, or the equation

$$S_w = 100 \text{ MN} / A \tag{31}$$

may be used where N is the total length of the contours in the watershed in feet, N is the contour interval in feet and A is the area of the watershed in square feet. If the watershed is very small, S_w may be computed as the ratio of the difference in elevation between the watershed outlet and the most distant ridge to the approximate average length of the watershed.

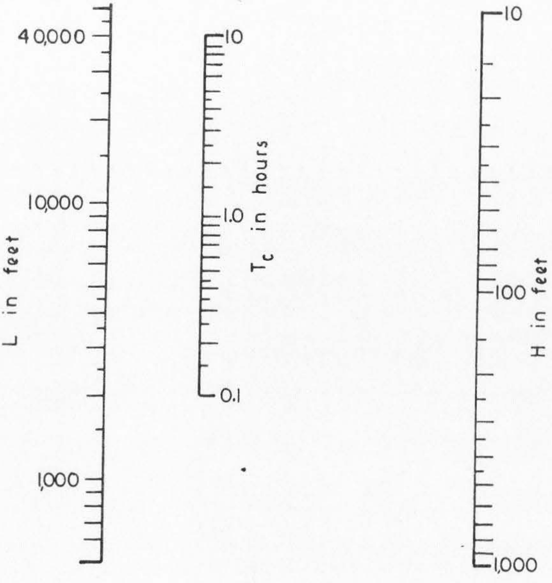

Figure 16. The Kirpich nomograph for estimating time of concentration (T_c)

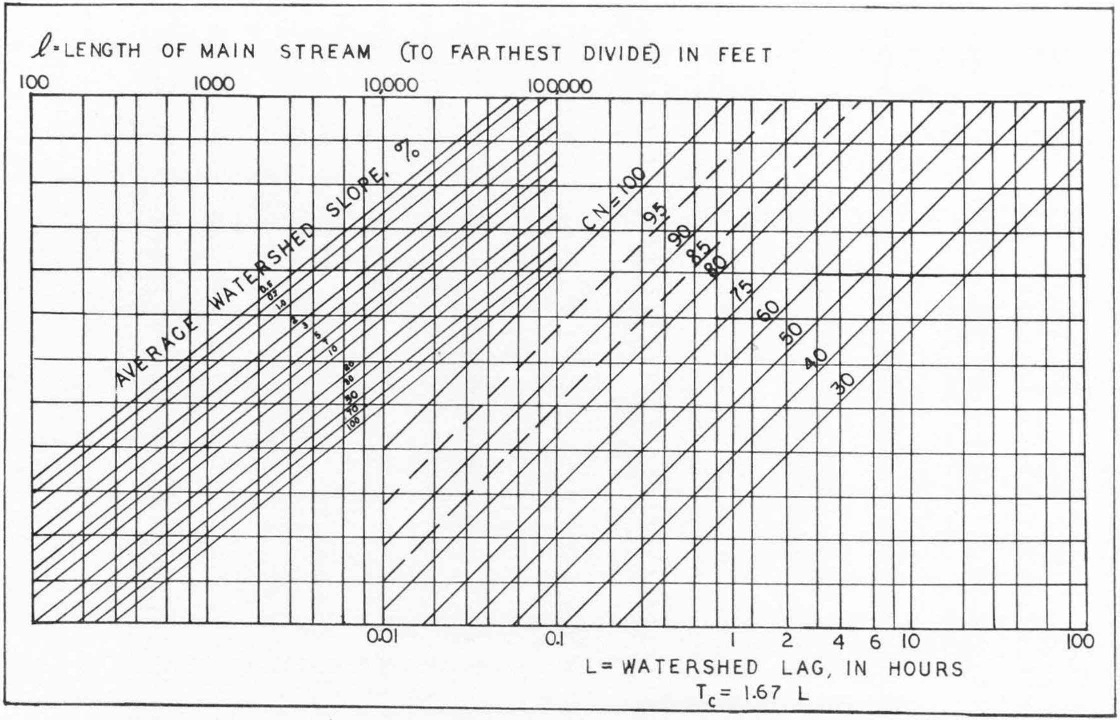

Figure 17. The Mockus nomograph for estimating time of concentration (T_c)

Appendix B
General description of watersheds

General description. Three small watersheds in two areas have been selected for this study. Table 7 lists their names, planimetered drainage areas, and the stream to which they are a tributary watershed. Each of these larger streams has the same name as the town near its mouth. These are all small high mountain watersheds. Figures 18 and 19 are small maps of these watersheds. All develop an appreciable snowpack with drifts that usually last through May and early June. In some years remnants of larger drifts last through the summer season. Rainfall on these drifts probably contributes nearly 100 per cent of its volume to runoff, but evaluation of the effects of these drifts is very difficult unless information is available about their areal extent, water holding capacity, melting rates and frequency of occurrence. Part of the base flow from a watershed will be melt from these drifts when they exist. All of these streams normally have perennial flow. All of these watersheds are located in the north to south lying chain of the Wasatch Mountains that form the eastern rim of the Great Basin. These mountains supply most of the water for Utah's "fertile cresent."

These watersheds were selected for this study because they are small, located in Utah, high in elevation, have been fairly well instrumented for several years, and are not seriously affected by artificial importation of water. If differences from other studies are noticed in watershed areas, lengths, or other properties, they are the result of independent measurement with tools of limited accuracy.

Halfway Creek Watershed. This watershed is on the lower north slope of Farmington Canyon. It has an average watershed slope of

Table 7. List of selected watersheds

Name of Watershed	Tributary to	Drainage Area $Miles^2$	Drainage Area Acres	Watershed Length Feet	Upper Elevation Feet	Lower Elevation Feet	Average Channel Slope Ft/Ft
Alpine Meadows	Ephraim Creek	0.57	366	5,320	10,444	9,850	0.112
Halfway Creek	Farmington Creek	0.72	464	7,040	9,160	6,200	0.420
Morris Creek	Farmington Creek	0.24	156	4,600	8,307	6,080	0.484

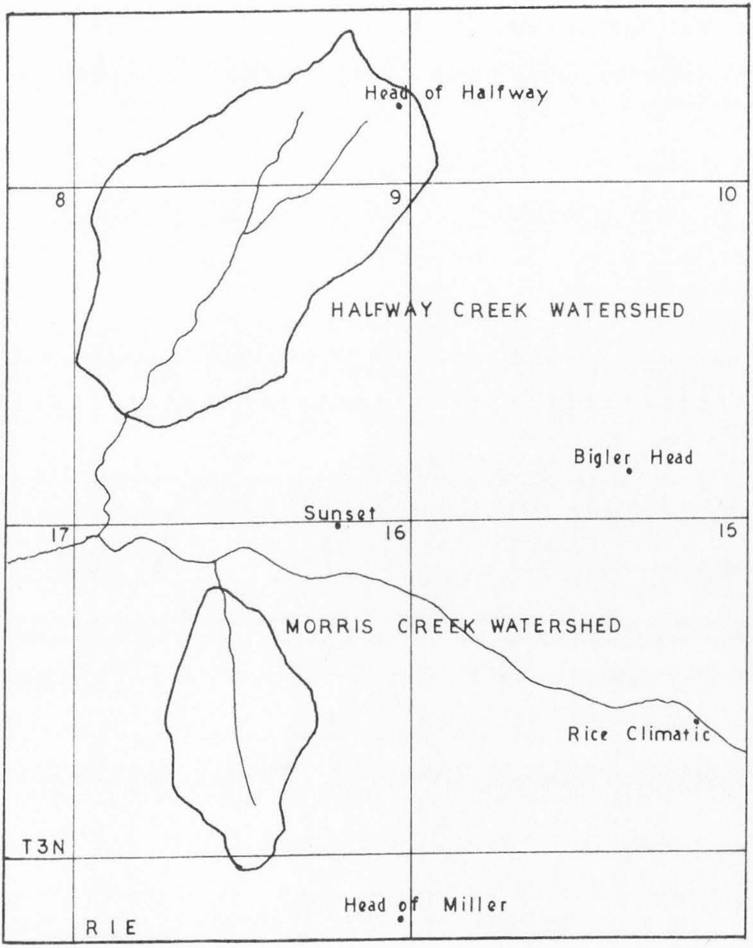

Figure 18. Farmington Canyon Watersheds. Estimate of average elevation: Halfway Creek - 7600 ft. Morris Creek - 7200 ft.

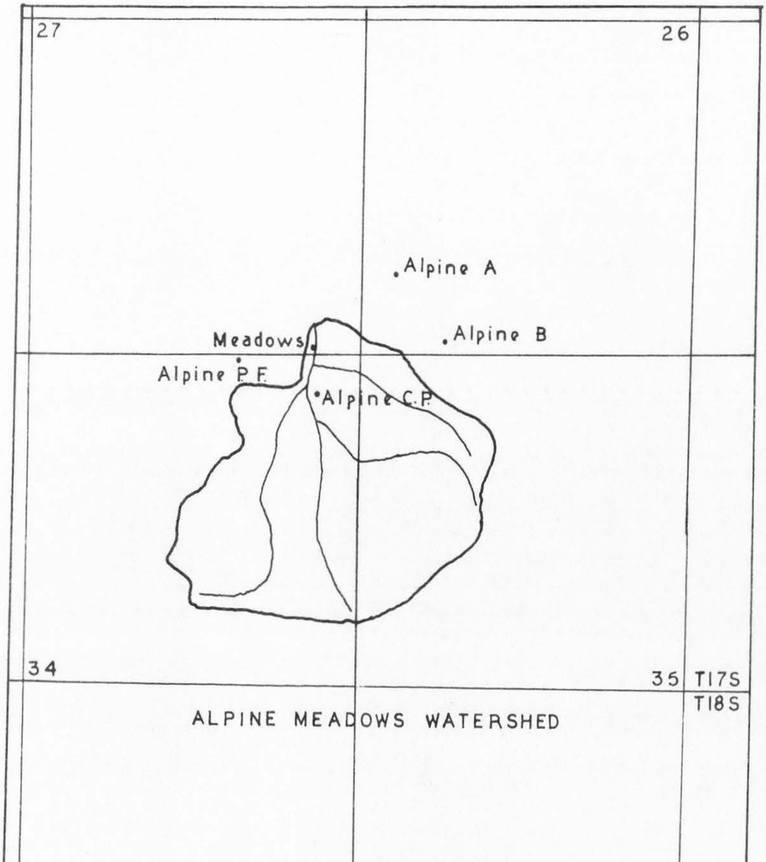

Figure 19. Alpine Meadows Watershed, east of Ephraim Utah. Average elevation - 10,000 ft.

about 58 per cent and an average channel slope of 0.42 feet drop per foot of horizontal length. The main channel essentially bisects the watershed from top to south and forms the intersection of two steeply angled planes. The stream flows in a south-southwesterly direction. The extreme upper end of the watershed is more densely vegetated than the west and has less of its area in rocky outcrops. The west side has more area in rock outcrops and talus slopes. This is apparently the result of erosion of the upper ends of granite formations that dip westward.

The hydrologic soil groups on this watershed range from B to C. Most of the watershed is classified in the BC soil group. Much of the lower west side of the watershed has a C soil group and the lower east end of the watershed has a B hydrologic soils group classification. Figure 20 is a map showing estimated hydrologic soils groups and cover types.

The vegetative cover information is from a survey obtained from the Intermountain Forest and Range Experiment Station in Logan, Utah. As far as the writer is aware, this survey is unpublished and untitled. The vegetation varies from a snowbush, sagebrush, grass and weed complex at the upper end to a beautiful tall dense grove of oak and maple at the lower east end of the watershed. Most of the west side is gambel scrub oak with various kinds of brush such as scrub maple, sagebrush, chokecherry and snowbush. The east side is more densely covered with similar vegetation with the tall groves at the lower end and some mapped areas of aspen groves. Table 8 is the computation of the runoff curve number for the watershed from soils and vegetation information for the areas shown in Figure 20.

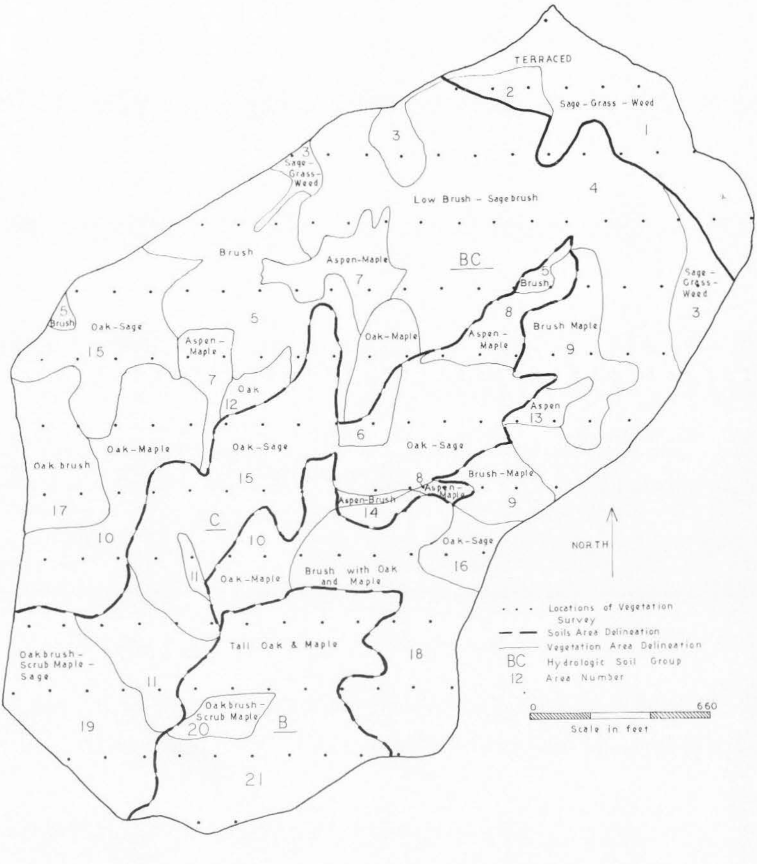

Figure 20. Estimated hydrologic soils groups and cover types, Halfway Creek Watershed.

Table 8. Halfway Creek Watershed CN estimation

Area Number	Vegetation	Cover Density %	Hydrologic Soil Group	CN	Drainage Area Acres	Sum of Products
1	Terraced sage - Grass weed	25	BC	70	28.7	
2	Terraced low brush - Sagebrush	55	BC	56	2.9	
3	Sage - Grass - Weed	25	BC	70	12.9	
4	Low brush - Sagebrush	55	BC	56	84.7	
5	Brush	68	BC	44	28.8	
6	Brush	68	C	48	4.0	
7	Aspen - Maple	47	BC	54	13.8	
8	Aspen - Maple	47	C	57	7.6	
9	Brush - Maple	88	BC	34	19.7	
10	Oak - Maple	76	BC	40	42.3	
11	Oak - Maple	76	C	44	12.5	
12	Oak	76	BC	40	2.9	
13	Aspen	50	BC	52	2.6	
14	Aspen - Brush	70	C	47	0.8	

Table 8. Continued

Area Number	Vegetation	Cover Density %	Hydrologic Soil Group	CN	Drainage Area Acres	Sum of Products
15	Oak - Sage	51	C	55	56.0	
16	Oak - Sage	51	BC	52	25.4	
17	Oakbrush	70	BC	43	13.1	
18	Brush with Oak and Maple	91	BC	33	31.4	
19	Oakbrush - Scrub Maple - Sage	67	C	48	24.6	
20	Oakbrush - Scrub Maple	67	B	38	4.2	
21	Tall Oak and Maple	66	B	54	45.9	
	Total				464.8	23,475
	Estimated CN					50

Note: Without the terraced area CN would be 49.

The earliest runoff event used for this study occurred July 1, 1940. The latest used occurred August 21, 1965. There are 12 other events used in the study as shown in Appendix C. The highest summer rainfall produced peak flow for these events was 7.9 cubic feet per second above base flow on August 19, 1965. However, there was a mud flow flood on August 10, 1947, that is not included because the runoff gage was covered with debris and sediment.

The location of nearby rain gages are shown in Figure 18, except for the Farmington Warehouse gage located downstream in the town of Farmington. The rain events and data used for this study are listed in Appendix C. The normal precipitation extends from an estimated 25 inches at the mouth to as high as 40 inches at the upper end of the watershed (U. S. Weather Bureau, 1962).

Morris Creek Watershed. This watershed is located on the lower south slope of Farmington Canyon. It is the steepest of the three watersheds with an average watershed slope of about 60 per cent and an average channel slope of 0.48 foot drop per foot of horizontal length. It is narrow at both ends and wide in the middle. The stream has cut a V shaped canyon. The main stream flows in a north-northwesterly direction. Two tributaries meet the main stream low in the canyon and extend upward into the wide center part of the watershed. The soils on the watershed are fairly uniform and are given a hydrologic soil group classification of BC based on field observation that bare spots will produce a moderately high degree of runoff.

At the extreme upper end of the watershed where drifting occurs the vegetation is sagebrush, snowberry and snowbush, with weeds and wild flowers. This kind of low vegetation extends down the left and right ridges for some distance. Below this and between the upper ridges scrub oak and maple surround groves of fir and aspen. In the upper center section of the watershed there are extensive fir covered areas mixed with aspen groves. Below this and on the steeper slopes above the fir is more sparse with tall growths of oak, aspen, and maple filling between. A vegetative study in 1953 (Peterson, 1954) found the average plant cover over the watershed to be about 55 per cent. Litter was found to cover about 84 per cent of the watershed. The watershed has shown an increase in vegetative and litter cover since 1939.

Figure 21 is adapted from a vegetative survey map provided by the Intermountain Forest and Range Experiment Station at Logan, Utah. Table 9 is the computation of the runoff curve number (CN) estimate based on the soils and vegetation information.

The earliest runoff event used in this study occurred July 10, 1936. The latest happened on July 18, 1965. The highest summer rainfall produced peak flow during the period was 0.93 cubic feet per second above base flow on August 10, 1947. This was the same event that caused the mud flow which covered the Halfway Creek gaging site. Probable reasons for this low flood record include low grazing use and the north aspect of the watershed which permits a more evenly distributed water supply to the watershed vegetation.

The Halfway Creek and Morris Creek watersheds have been treated as one in plotting isohyetal maps for estimating average watershed rainfall amounts. Figure 18 shows nearby rain gage locations. The rain gage records used for this study are given in Appendix C. Average annual rainfall amounts are similar to those for Halfway Creek, except

Figure 21. Vegetative survey map, Morris Creek Watershed.

Table 9. Morris Creek Watershed CN estimation

Area Number	Vegetation	Cover Density %	Hydrologic Soil Group	CN	Drainage Area Acres	Sum of Products
1	Sage - Snowberry	58	BC	54	2.5	
2	Fir - Aspen - Mixed Browse	90	BC	33	20.2	
3	Large Aspen - Mixed Browse	93	BC	32	19.4	
4	Sage - Weed	69	BC	49	5.0	
5	Brush - Weed	30	BC	67	2.1	
6	Small Aspen	95	BC	31	3.5	
7	Fir - Mixed Browse	90	BC	33	114.0	
	Total				166.7	5,678
	Estimated CN					34

that this is a lower watershed and will not extend to 40 inches of rain at the upper end of the watershed.

Alpine Meadows Watershed. This watershed is located at the upper southeast end of the Ephraim Creek drainage area. It is highest of the three watersheds with an average elevation of about 10,100 feet above sea level. Snow drifts persist later into the season than on the other two watersheds. It is the flattest of these watersheds with an average watershed slope of about 17 per cent and an average channel slope of about 0.11 foot drop per horizontal foot of length. The main stream has many tributaries extending in a radial pattern to the upper ridges. The watershed is shaped like a cut of pie. Figure 19 is a small map of the watershed showing its location by township is section numbers and showing the locations of nearby rain gages. The estimated mean annual precipitation is 35 inches.

The soils on this watershed are fairly uniform and are classified as in hydrologic soil group CD based on field observations that bare spots will produce a high degree of runoff. The predominant soil is tentatively classified by texture as a silty clay loam.

Figure 22 is a vegetation overlay prepared from aerial photograph interpretation. The approximation of per cent of aerial photograph area was used instead of map area to prepare the runoff curve number estimate found in Table 10.

The rainfall and runoff data used for the study of this watershed are listed in Appendix C.

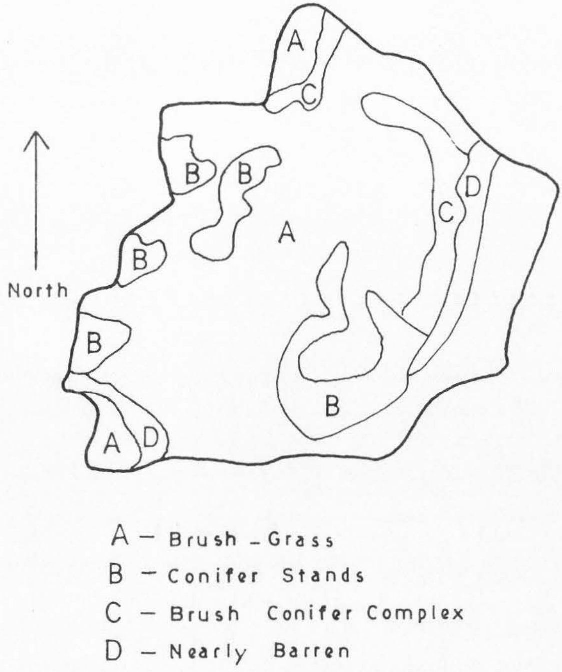

Figure 22. Vegetation overlay, Alpine Meadows Watershed

Table 10. Ephraim Creek-Alpine Meadows Watershed CN estimation

Area Number	Vegetation	Cover Density %	Hydrologic Soil Group	CN	Aerial Photograph Area - In^2	Area %	Sum of Products
A	Brush - Grass	60	CD	62	6.67	73.7	
B	Conifer stands	90	CD	42	1.34	14.8	
C	Brush - Conifer complex	70	CD	51	0.57	6.3	
D	Nearly barren - Herbaceous	5	CD	92	0.46	5.1	
	Totals				9.04	100.0	5,980
	Estimated CN						60

Appendix C

Computer program and basic data

```
      DIMENSION NAME(34),NDAY(45),TIME(45),ADFLO(45),ADEP(45),KDAY(30),
     1HOUR(30),PTIME(30),RDEP(30),QTIME(45),RDPTH(30),QTINT(500),
     2RHINT(500),QFLNT(500),RDINT(500),QSYN(500),QP(500),QINC(500),
     3SFLOW(500),NGAGE(10),SSDEV(50),SS(50),HEAD(26),QSTOR(500),
     4QRSTP(500),STRFL(500)
      ICOUNT=0
C     READ IN RUNOFF DATA, CONVERT TIME TO CONTINUOUS VALUES, AND PRINT.
C     RUNOFF DATA WAS PREPARED WITH DECIMAL TIME VALUES.
   30 READ(5,1)(NAME(I),I = 1,34)
    1 FORMAT(34A2)
      READ(5,3) N, AREA
      IF(N - 999)117,116,116
  117 AREAK = (AREA / 640.0) * 484.0
      WRITE(6,2) (NAME(I),I = 1,34)
    2 FORMAT('1',34A2)
    3 FORMAT(5X,I3,9X,F9.2)
      WRITE(6,14)AREA
   14 FORMAT(' SURFACE DRAINAGE AREA = ',F5.0,' ACRES')
      READ(5,23)(HEAD(I),I = 1,26)
   23 FORMAT(26A2)
      DO 66 I = 1,N
      READ(5,4) MONTH,NDAY(I),NYEAR,TIME(I),ADFLO(I),ADEP(I)
    4 FORMAT(I7,I6,I6,F5.2,8X,F8.3,F8.5)
      IF(NDAY(I) - NDAY(1))130,66,130
  130 TIME(I) = TIME(I) + 24.00
   66 CONTINUE
C     ADFLO IS THE NATURAL HYDROGRAPH LESS THE BASE FLOW IN CFS.
C     ADEP IS THE CORRESPONDING MASS RUNOFF IN INCHES.
      READ(5,25)ADJPK,TPEST,TSPAN
   25 FORMAT(17X,F7.2,12X,F8.2,14X,F5.2)
      WRITE(6,24)MONTH,NDAY(1),NYEAR
   24 FORMAT('0THE RUNOFF HYDROGRAPH FOR ',I2,I3,I5,' AS ADJUSTED FOR BA
     1SE FLOW'/' WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.')
      WRITE(6,15)
```

```
   15 FORMAT('      TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
     1    TIME  FLOW')
      WRITE(6,9)(TIME(I),ADFLO(I),I = 1,N)
    9 FORMAT(1X,F8.2,F6.2,F8.2,F6.2,F8.2,F6.2,F8.2,F6.2,F8.2,F6.2)
      WRITE(6,27)ADJPK,TPEST,TSPAN,ADEP(N)
   27 FORMAT(' THE ADJUSTED PEAK FLOW IS ',F6.2,' CFS.'/' THE STORM TIME
     1 OF RISE WAS ',F5.2,' HOURS.'/' THE STORM RUNOFF LASTED ',F5.2,' H
     2OURS.'/' THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS ',F8.5,'
     3INCHES.')
C     READ RAINFALL DATA, ADJUST TO CONTINUOUS DECIMAL TIME AND PRINT.
      READ(5,5)(NGAGE(I),I = 1,10),M,RBAR
    5 FORMAT(10A2,5X,I5,F9.2)
      DO 67 I = 1,M
      READ(5,6)NSTAT,MPM,MNTHR,KDAY(I),KYR,HOUR(I),RTIME(I),RDEP(I)
    6 FORMAT(1X,I1,I2,3X,I2,I3,I5,F3.0,F5.2,F4.2)
      IF(NSTAT - 3) 121,122,121
  122 WRITE(6,16)
   16 FORMAT(49H TIME OR DEPTH OF RAIN IS UNKNOWN FOR THIS EVENT )
      GO TO 30
  121 IF(MPM - 2) 123,124,123
  124 HOUR(I) = HOUR(I) + 12.00
      RTIME(I) = RTIME(I) + 12.00
  123 IF(KDAY(I) - KDAY(1)) 125,126,125
  125 HOUR(I) = HOUR(I) + 24.00
      RTIME(I) = RTIME(I) + 24.00
  126 HOUR(I) = ((RTIME(I) - HOUR(I)) / 0.60) + HOUR(I)
   67 CONTINUE
      WRITE(6,201)(NGAGE(I),I = 1,10)
  201 FORMAT('0','THE RAIN GAGE RECORD IS FROM ',10A2)
      WRITE(6,22)RBAR
   22 FORMAT(' THE ESTIMATED AVERAGE WATERSHED RAINFALL IS ',F5.2)
      WRITE(6,28)
   28 FORMAT(' THE TIME IS DECIMAL, THE DEPTH IS INCHES.')
      WRITE(6,202)
```

```
  202 FORMAT('      TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
     1   TIME DEPTH')
      WRITE(6,9)(HOUR(I),RDEP(I),I = 1,M)
C     MAKE RAIN AND RUNOFF TIME COMPATIBLE AND MOVE THE RUNOFF HYDRO-
C     GRAPH TO THE BEGINNNING TIME OF RAINFALL .
      IF(NDAY(1) - KDAY(1)) 127,128,129
  127 DO 68 I = 1,M
      HOUR(I) = HOUR(I) + 24.0
   68 CONTINUE
      GO TO 128
  129 DO 69 I = 1,N
      TIME(I) = TIME(I) + 24.00
   69 CONTINUE
  128 QTADJ = HOUR(1) - TIME(1)
      DO 52 K = 1,N
      QTIME(K) = TIME(K) + QTADJ
   52 CONTINUE
C     ADJUST THE RAINFALL TO THE ESTIMATED AVERAGE AMOUNT BY USING
C     CONSTANT (PX / PT) RATIOS.
      DO 53 K = 1,M
      RDPTH(K) = RDEP(K) * (RBAR / RDEP(M))
   53 CONTINUE
C     RATIO IS THE RATIO OF RUNOFF VOLUME TO ESTIMATED AVERAGE RAINFALL
C     VOLUME FOR THIS EVENT.
      RATIO = ADEP(N) / RDPTH(M)
C     COMMENCE THE MAJOR LOOP WHICH FINDS THE NEAR OPTIMUM TIME
C     INCREMENT FOR DEVELOPING THE COMPOSITE SYNTHETIC HYDROGRAPH FROM
C     TRIANGULAR INCREMENTAL HYDROGRAPHS WHERE TR = 3/8 TB.
      DELTA = 0.00
      NRUN = 1
  105 DELTA = DELTA + 0.20
      IF(NRUN - 30)114,135,135
  135 WRITE(6,21)
   21 FORMAT('0DELTA HAS BEEN INCREMENTED 30 TIMES.')
```

```
      GO TO 115
  114 DO 60 I = 1,500
      QP(I) = 0.00
      QFLNT(I) = 0.00
      QINC(I) = 0.00
      RDINT(I) = 0.00
      SFLOW(I) = 0.00
      QTINT(I) = 0.00
      QSYN(I) = 0.00
      RHINT(I) = 0.00
   60 CONTINUE
      CALL INTRP (DELTA,QTIME,ADFLO,QTINT,QFLNT,N,NQ)
      CALL INTRP (DELTA,HOUR,RDPTH,RHINT,RDINT,M,MR)
      TP = 3.0 * DELTA
C     COMPUTE THE SYNTHETIC MASS RUNOFF CURVE, THE RUNOFF FOR EACH DELTA
C     TIME INCREMENT, THE ESTIMATED PEAK FLOW FOR EACH INCREMENTAL
C     HYDROGRAPH, AND SUM THE INCREMENTAL HYDROGRAPHS.
      DO 54 I = 1,MR
      QSYN(I) = RDINT(I) * RATIO
   54 CONTINUE
      DO 70 I = 2,MR
      DQ = QSYN(I) - QSYN(I - 1)
      QP(I) = AREAK * DQ / TP
   70 CONTINUE
      LNGTH = MR + 7
      DO 72 J = 1,MR
      QINC(J) = 0.00
      QINC(J + 1) = QP(J + 1) / 3.0
      QINC(J + 2) = QP(J + 1) * 2.0 / 3.0
      QINC(J + 3) = QP(J + 1)
      QINC(J + 4) = QP(J + 1) * 0.80
      QINC(J + 5) = QP(J + 1) * 0.60
      QINC(J + 6) = QP(J + 1) * 0.40
      QINC(J + 7) = QP(J + 1) * 0.20
```

```
          QINC(J + 8) = 0.00
          DO 72 I = 1,LNGTH
          SFLOW(I) = SFLOW(I) + QINC(I)
   72 CONTINUE
C         BEGIN THE INNER LOOP WHICH FINDS THE NEAR OPTIMUM TIME LOCATION
C         FOR THE ACTUAL RUNOFF HYDROGRAPH TO FIT THE SYNTHETIC HYDROGRAPH
C         AND COMPUTES THE SUM OF SQUARED DEVIATIONS BETWEEN THE TWO
C         HYDROGRAPHS FOR THE TIME INCREMENT SET IN THE MAJOR LOOP.
  145 NREP = 1
          DO 73 I = 1,50
          SSDEV(I) = 0.00
   73 CONTINUE
  109 NJ = NQ + NREP
          DO 59 I = 1,NJ
          DEV = SFLOW(I) - QFLNT(I)
          SSDEV(NREP) = SSDEV(NREP) + (DEV**2)
   59 CONTINUE
          IF(NREP - 1) 106,106,107
  107 IF(SSDEV(NREP) - SSDEV(NREP - 1)) 106,106,108
C         SAVE THIS ACTUAL HYDROGRAPH LOCATION IN QSTOR(I) AND MOVE QFLNT
C         ONE DELTA TIME INCREMENT TO THE RIGHT.  REPEAT REPITIONS UNTIL THE
C         MINIMUM SSDEV IS FOUND.
  106 DO 74 I = 1,NJ
          QSTOR(I) = QFLNT(I)
   74 CONTINUE
          DO 62 I = 1,NQ
          NCNT = NQ + NREP - I
          NCNTR = NCNT + 1
          QFLNT(NCNTR) = QFLNT(NCNT)
   62 CONTINUE
          NREP = NREP + 1
          IF(NREP - 30) 109,109,133
  133 WRITE(6,20)
   20 FORMAT('0THE ACTUAL HYDROGRAPH HAS BEEN MOVED 30 TIMES.  GO TO THE
```

```
     1 NEXT RUN.')
      NRUN = NRUN + 1
      GO TO 146
  108 NREP = NREP - 1
  146 SS(NRUN) = SSDEV(NREP)
      IF(NRUN - 1) 112,112,111
  111 IF(SS(NRUN) - SS(NRUN - 1)) 112,112,113
  112 DO 211 I = 1,NJ
      QRSTR(I) = QSTOR(I)
  211 CONTINUE
      STRDT = DELTA
      STRP = NREP
      LNSTR = LNGTH
      TMOV = STRP * DELTA
      NSAV = NJ - 1
      DO 254 I = 1,LNSTR
      STRFL(I) = SFLOW(I)
  254 CONTINUE
      NRUN = NRUN + 1
      GO TO 105
C     RETURN TO THE BEGINNING OF THE RUN LOOP.
  113 CONTINUE
C     SET UP TIME COORDINATES.
  115 DO 63 I = 2,500
      AI = I - 1
      QTINT(I) = QTINT(1) + (AI * STRDT)
   63 CONTINUE
      WRITE(6,8)STRDT,TMOV
    8 FORMAT('0THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = ',
     1F5.2,/' AND MOVED ',F6.2,' HOURS TO THE TIME OF BEST FIT.')
      WRITE(6,15)
      WRITE(6,9)(QTINT(I),QRSTR(I),I = 1,NSAV)
      WRITE(6,10)STRDT
   10 FORMAT(46H0THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =,F5.2)
```

```
      WRITE(6,15)
      WRITE(6,9)(QTINT(I),STRFL(I),I = 1,LNSTR)
      WRITE(6,11)RATIO
   11 FORMAT(' THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS ',F8.5)
      SSQ= SS(NRUN - 1)
      WRITE(6,255) SSQ
  255 FORMAT(' THE MINIMUM SUM OF DEVIATIONS SQUARED IS ',F10.5)
      GO TO 30
  116 STOP
      END

END OF UNIVAC 1108 FORTRAN V COMPILATION.     0 *DIAGNOSTIC* MESSAGE(S)
```

```
      SUBROUTINE INTRP (DELTA,X,Y,U,W,L,K)
      DIMENSION U(500),W(500),X(45),Y(45)
      U(1) = X(1)
      W(1) = Y(1)
      J = L + 1
      X(J) = X(J - 1) + DELTA
      Y(J) = Y(J - 1)
      K = 1
      DO 84 I = 2,500
      U(I) = 0.0
      W(I) = 0.0
   84 CONTINUE
      DO 65 I = 2,J
      HOR = X(I) - X(I - 1)
      VERT = Y(I) - Y(I - 1)
      SLOPE = VERT / HOR
  118 U(K + 1) = U(K) + DELTA
      IF(K - 75)151,150,150
  151 IF(U(K + 1) - X(I)) 119,120,65
  119 W(K + 1) = Y(I - 1) + SLOPE * (U(K + 1) - X(I-1))
      K = K + 1
      GO TO 118
  120 W(K + 1) = Y(I)
      K = K + 1
   65 CONTINUE
      GO TO 155
  150 WRITE(6,154)K
  154 FORMAT(' THERE ARE ',I3,' POINTS ON THE INTERPOLATED CURVE.')
  155 RETURN
      END

END OF UNIVAC 1108 FORTRAN V COMPILATION.      0 *DIAGNOSTIC* MESSAGE(S)
```

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 9 12 1942 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
3.10	.00	4.00	.13	4.25	.46	4.40	.29	5.00	.33
5.25	1.35	5.60	1.79	5.90	1.51	6.10	2.09	6.40	1.79
6.70	1.24	7.35	.97	7.40	.35	8.10	.27	8.80	.13
9.00	.34	11.00	.15	13.00	.07	15.00	.00		

THE ADJUSTED PEAK FLOW IS 2.09 CFS.
THE STORM TIME OF RISE WAS 3.00 HOURS.
THE STORM RUNOFF LASTED 11.90 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .01051 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.00
THE TIME IS DECIMAL, THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
.50	.12	4.27	.17	4.77	.24	5.25	.30	5.87	.38
6.48	.40	9.00	.40	16.97	.92				

THERE ARE 75 POINTS ON THE INTERPOLATED CURVE.

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = 1.40
AND MOVED 7.00 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
.50	.00	1.90	.00	3.30	.00	4.70	.00	6.10	.00
7.50	.30	8.90	1.51	10.30	.90	11.70	.15	13.10	.23
14.50	.13	15.90	.08	17.30	.03	18.70	.00	20.10	.00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = 1.40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
.50	.00	1.90	.00	3.30	.02	4.70	.05	6.10	.13
7.50	.20	8.90	.23	10.30	.21	11.70	.21	13.10	.25
14.50	.27	15.90	.30	17.30	.32	18.70	.30	20.10	.24
21.50	.16	22.90	.09	24.30	.04	25.70	.01	27.10	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .01051
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 2.45112

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 7 1 1943 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
3.00	.00	3.60	.12	4.50	.66	5.00	1.96	5.70	6.30
6.00	3.93	6.25	2.64	6.70	1.38	7.05	1.22	7.50	.70
8.00	.46	8.50	.33	9.10	.20	10.90	.06	12.00	.00

THE ADJUSTED PEAK FLOW IS 6.30 CFS.
THE STORM TIME OF RISE WAS 2.70 HOURS.
THE STORM RUNOFF LASTED 9.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .01921 INCHES.

THE RAIN GAGE RECORD IS FROM FARMINGTON WH
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.50
THE TIME IS DECIMAL, THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
3.33	.00	3.83	.08	4.05	.10	4.33	.30	4.55	.33
4.62	.43	4.92	.44	5.13	.52	5.25	.67	6.08	.89
6.92	.90	7.50	1.01						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .60
AND MOVED 1.20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
3.33	.00	3.93	.00	4.53	.12	5.13	.48	5.73	1.44
6.33	4.44	6.93	3.93	7.53	1.66	8.13	1.05	8.73	.56
9.33	.36	9.93	.22	10.53	.16	11.13	.12	11.73	.07
12.33	.03	12.93	.00	13.53	.00	14.13	.00		

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .60

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
3.33	.00	3.93	.11	4.53	.52	5.13	1.16	5.73	1.97
6.33	2.42	6.93	2.51	7.53	2.18	8.13	1.66	8.73	1.19
9.33	.69	9.93	.32	10.53	.17	11.13	.08	11.73	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .01281
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 8.17228

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 8 19 1945 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.45	.00	20.00	6.55	20.10	12.79	20.55	4.22	20.80	2.19
21.90	.79	23.00	.35	25.00	.11	27.00	.00		

THE ADJUSTED PEAK FLOW IS 12.79 CFS.
THE STORM TIME OF RISE WAS .65 HOURS.
THE STORM RUNOFF LASTED 7.55 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .02166 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.33
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
21.08	.00	21.17	.04	21.27	.05	21.58	.06	21.73	.08
21.83	.57	21.97	1.06	22.05	1.17	22.13	1.20	22.58	1.21
22.72	1.28	23.02	1.30						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .80 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
21.08	.00	21.28	.00	21.48	.00	21.68	.00	21.88	2.38
22.08	4.77	22.28	9.67	22.48	9.93	22.68	6.12	22.88	3.41
23.08	2.12	23.28	1.94	23.48	1.56	23.68	1.28	23.88	1.00
24.08	.77	24.29	.70	24.48	.63	24.68	.55	24.88	.48
25.08	.40	25.28	.34	25.48	.32	25.68	.30	25.88	.27
26.08	.25	26.28	.23	26.46	.20	26.68	.18	26.88	.15
27.08	.13	27.28	.11	27.48	.10	27.68	.09	27.88	.08
28.08	.07	28.28	.05	28.48	.04	28.68	.03	28.88	.02
29.08	.00	29.28	.00	29.48	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
21.08	.00	21.28	.16	21.48	.35	21.68	.59	21.88	2.77
22.08	6.32	22.28	9.95	22.48	9.85	22.68	7.81	22.88	5.85
23.08	3.90	23.28	1.71	23.48	.69	23.68	.46	23.88	.27
24.08	.09	24.28	.02	24.48	.00				

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .01629
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 19.72237

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 7 27 1951 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
23.60	.00	24.00	.36	24.30	3.40	24.45	1.19	24.50	.58
25.00	.29	25.30	.15	26.20	.14	27.00	.00		

THE ADJUSTED PEAK FLOW IS 3.40 CFS.
THE STORM TIME OF RISE WAS .70 HOURS.
THE STORM RUNOFF LASTED 3.40 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00357 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .50
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
23.00	.00	23.30	.23	23.58	.31	24.08	.41	24.53	.46
25.70	.50	25.97	.52						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED 1.20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
23.00	.00	23.40	.00	23.80	.00	24.20	.86	24.60	1.93
25.00	.40	25.40	.20	25.80	.15	26.20	.14	26.60	.11
27.00	.04	27.40	.00	27.80	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
23.00	.00	23.40	.17	23.80	.41	24.20	.69	24.60	.73
25.00	.67	25.40	.54	25.80	.38	26.20	.22	26.60	.15
27.00	.10	27.40	.06	27.80	.03	28.20	.02	28.60	.00
29.00	.00								

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00714
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 1.93915

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 8 1 1952 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
5.00	.00	5.30	1.11	5.65	4.94	5.90	4.26	6.00	3.22
6.50	.85	7.00	.47	8.00	.24	10.00	.11	12.00	.04
13.00	.00								

THE ADJUSTED PEAK FLOW IS 4.94 CFS.
THE STORM TIME OF RISE WAS .65 HOURS.
THE STORM RUNOFF LASTED 8.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .01058 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .80
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
4.50	.00	4.73	.38	4.85	.56	5.00	.71	5.18	.76
5.70	.80								

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
4.50	.00	4.70	.74	4.90	2.20	5.10	4.39	5.30	4.53
5.50	3.22	5.70	2.27	5.90	1.32	6.10	.78	6.30	.62
6.50	.47	6.70	.43	6.90	.38	7.10	.34	7.30	.29
7.50	.25	7.70	.23	7.90	.22	8.10	.20	8.30	.19
8.50	.18	8.70	.16	8.90	.15	9.10	.13	9.30	.12
9.50	.11	9.70	.10	9.90	.09	10.10	.08	10.30	.08
10.50	.07	10.70	.06	10.90	.05	11.10	.05	11.30	.04
11.50	.04	11.70	.03	11.90	.02	12.10	.01	12.30	.00
12.50	.00	12.70	.00	12.90	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
4.50	.00	4.70	.84	4.90	2.41	5.10	4.31	5.30	4.95
5.50	4.46	5.70	3.48	5.90	2.37	6.10	1.20	6.30	.45
6.50	.17	6.70	.07	6.90	.02	7.10	.00	7.30	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .01322
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 5.49520

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 7 26 1953 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
4.50	.00	5.20	4.59	5.50	2.59	5.70	.21	6.40	.27
7.40	.10	9.80	.00						

THE ADJUSTED PEAK FLOW IS 4.59 CFS.
THE STORM TIME OF RISE WAS .70 HOURS.
THE STORM RUNOFF LASTED 5.30 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00732 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .30
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
16.25	.00	16.40	.23	16.92	.31				

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
16.25	.00	16.45	1.31	16.65	2.62	16.85	3.93	17.05	3.92
17.25	2.59	17.45	.21	17.65	.23	17.85	.25	18.05	.26
18.25	.25	18.45	.22	18.65	.18	18.85	.15	19.05	.11
19.25	.09	19.45	.08	19.65	.08	19.85	.07	20.05	.06
20.25	.05	20.45	.04	20.65	.04	20.85	.03	21.05	.02
21.25	.01	21.45	.00	21.65	.00	21.85	.00		

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
16.25	.00	16.45	1.09	16.65	2.33	16.85	3.71	17.05	3.39
17.25	2.84	17.45	2.05	17.65	1.20	17.85	.34	18.05	.14
18.25	.03	18.45	.00						

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .02440
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 5.09203

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 8 4 1954 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
14.30	.00	14.50	.32	15.00	3.62	15.60	1.37	16.00	.83
17.00	.23	18.00	.12	18.60	.25	19.20	.24	20.00	.09
22.00	.00								

THE ADJUSTED PEAK FLOW IS 3.62 CFS.
THE STORM TIME OF RISE WAS .70 HOURS.
THE STORM RUNOFF LASTED 7.70 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00884 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.31
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
14.42	.00	14.53	.05	14.75	.22	14.97	.55	15.12	.75
15.37	.87	16.07	.94	16.47	.99	17.82	1.04	18.37	1.19
19.05	1.26	19.37	1.31						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .40 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
14.42	.00	14.62	.00	14.82	.32	15.02	1.64	15.22	2.96
15.42	3.25	15.62	2.50	15.82	1.75	16.02	1.24	16.22	.97
16.42	.77	16.62	.65	16.82	.53	17.02	.41	17.22	.29
17.42	.22	17.62	.19	17.82	.17	18.02	.15	18.22	.13
18.42	.14	18.62	.18	18.82	.23	19.02	.25	19.22	.25
19.42	.24	19.62	.22	19.82	.19	20.02	.15	20.22	.11
20.42	.09	20.62	.08	20.82	.07	21.02	.06	21.22	.05
21.42	.04	21.62	.03	21.82	.02	22.02	.01	22.22	.00
22.42	.00	22.62	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
14.42	.00	14.62	.15	14.82	.57	15.02	1.39	15.22	2.19
15.42	2.67	15.62	2.55	15.82	2.07	16.02	1.46	16.22	.93
16.42	.55	16.62	.38	16.82	.31	17.02	.26	17.22	.21
17.42	.17	17.62	.14	17.82	.12	18.02	.18	18.22	.30
18.42	.48	18.62	.57	18.82	.58	19.02	.53	19.22	.48
19.42	.42	19.62	.36	19.82	.28	20.02	.19	20.22	.12
20.42	.06	20.62	.02	20.82	.00				

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00675
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 2.07504

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 8 19 1959 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
21.00	.00	22.00	.03	23.00	.05	23.50	.73	23.80	.44
23.90	.96	24.00	.83	24.05	.87	24.50	.37	25.00	.19
26.00	.08	27.00	.06	28.00	.05	30.00	.05	31.00	.09
32.00	.09	33.00	.05	34.00	.03				

THE ADJUSTED PEAK FLOW IS .96 CFS.
THE STORM TIME OF RISE WAS 2.90 HOURS.
THE STORM RUNOFF LASTED 13.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00356 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .50
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
20.50	.00	20.65	.05	21.67	.07	21.82	.11	23.05	.14
23.20	.28	23.42	.31	27.00	.31	28.00	.32	28.03	.35
29.82	.37	29.98	.41	30.43	.42				

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED .80 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
20.50	.00	20.90	.00	21.30	.01	21.70	.02	22.10	.03
22.50	.04	22.90	.05	23.30	.60	23.70	.44	24.10	.71
24.50	.34	24.90	.19	25.30	.15	25.70	.10	26.10	.08
26.50	.07	26.90	.06	27.30	.05	27.70	.05	28.10	.05
28.50	.05	28.90	.05	29.30	.05	29.70	.05	30.10	.06
30.50	.07	30.90	.09	31.30	.09	31.70	.09	32.10	.08
32.50	.06	32.90	.05	33.30	.04	33.70	.04	34.10	.03
34.50	.00								

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
20.50	.00	20.90	.05	21.30	.10	21.70	.16	22.10	.19
22.50	.21	22.90	.22	23.30	.30	23.70	.39	24.10	.50
24.50	.40	24.90	.28	25.30	.19	25.70	.09	26.10	.00
26.50	.00	26.90	.00	27.30	.00	27.70	.00	28.10	.04
28.50	.08	28.90	.11	29.30	.10	29.70	.09	30.10	.11
30.50	.13	30.90	.14	31.30	.12	31.70	.09	32.10	.06
32.50	.03	32.90	.00	33.30	.00				

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00712
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .29640

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0  FARMINGTON CANYON  HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA =  464. ACRES

THE RUNOFF HYDROGRAPH FOR  7 13 1962 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  14.50   .00    15.00  1.56    15.50  3.72    16.00  2.14    17.00   .99
  18.00   .48    20.00   .24    24.00   .07    27.00   .00
THE ADJUSTED PEAK FLOW IS    3.72 CFS.
THE STORM TIME OF RISE WAS   1.00 HOURS.
THE STORM RUNOFF LASTED 12.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS    .01471 INCHES.

THE RAIN GAGE RECORD IS FROM  SUNSET
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS   1.09
THE TIME IS DECIMAL. THE DEPTH IS INCHES.
   TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
  11.75   .00    11.93   .13    12.05   .33    12.15   .60    12.25   .73
  12.45   .86    12.77   .96    13.18  1.05    13.58  1.09

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =   .60
AND MOVED    1.20 HOURS TO THE TIME OF BEST FIT.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  11.75   .00    12.35   .00    12.95  1.99    13.55  3.09    14.15  1.79
  14.75  1.10    15.35   .73    15.95   .46    16.55   .39    17.15   .32
  17.75   .25    18.35   .22    18.95   .19    19.55   .17    20.15   .14
  20.75   .12    21.35   .09    21.95   .07    22.55   .05    23.15   .04
  23.75   .03    24.35   .01    24.95   .00    25.55   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .60
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  11.75   .00    12.35   .70    12.95  1.57    13.55  2.53    14.15  2.37
  14.75  1.92    15.35  1.35    15.95   .78    16.55   .20    17.15   .05
  17.75   .00    18.35   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS    .01350
THE MINIMUM SUM OF DEVIATIONS SQUARED IS     2.79016
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0  FARMINGTON CANYON  HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA =  464. ACRES

THE RUNOFF HYDROGRAPH FOR  9 13 1963 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   4.00   .00     6.00   .08     7.00   .17     8.00   .33     9.00   .27
   9.50   .71    10.00   .42    11.00   .11    13.00   .00
THE ADJUSTED PEAK FLOW IS     .71 CFS.
THE STORM TIME OF RISE WAS   5.50 HOURS.
THE STORM RUNOFF LASTED   9.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS    .00354 INCHES.

THE RAIN GAGE RECORD IS FROM  HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS   1.00
THE TIME IS DECIMAL. THE DEPTH IS INCHES.
   TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
   4.75   .00     4.93   .03     5.40   .09     5.62   .12     6.05   .25
   6.52   .33     7.22   .38     7.37   .44     7.67   .47     7.97   .57
   8.15   .67     9.35   .76     9.50   .96    10.02   .99

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =   .60
AND MOVED     .60 HOURS TO THE TIME OF BEST FIT.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   4.75   .00     5.35   .02     5.95   .05     6.55   .07     7.15   .11
   7.75   .17     8.35   .27     8.95   .32     9.55   .28    10.15   .62
  10.75   .42    11.35   .24    11.95   .10    12.55   .07    13.15   .03
  13.75   .00    14.35   .00    14.95   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .60
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   4.75   .00     5.35   .02     5.95   .07     6.55   .15     7.15   .20
   7.75   .24     8.35   .27     8.95   .30     9.55   .34    10.15   .33
  10.75   .32    11.35   .24    11.95   .15    12.55   .08    13.15   .04
  13.75   .00    14.35   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS    .00354
THE MINIMUM SUM OF DEVIATIONS SQUARED IS      .12334
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0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 9 13 1963 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.00	.00	14.00	.24	14.50	.80	15.50	.25	17.00	.08
24.00	.00								

THE ADJUSTED PEAK FLOW IS .81 CFS.
THE STORM TIME OF RISE WAS 1.50 HOURS.
THE STORM RUNOFF LASTED 11.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00302 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .44
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
13.57	.00	14.15	.06	14.20	.09	14.28	.18	14.40	.24
14.57	.26	14.75	.35	15.08	.40	15.45	.44		

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .60
AND MOVED 1.20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.67	.00	14.27	.00	14.87	.15	15.47	.47	16.07	.64
16.67	.30	17.27	.19	17.87	.12	18.47	.07	19.07	.07
19.67	.06	20.27	.05	20.87	.05	21.47	.04	22.07	.03
22.67	.03	23.27	.02	23.87	.02	24.47	.00	25.07	.00
25.67	.00	26.27	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .60

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.67	.00	14.27	.07	14.87	.24	15.47	.43	16.07	.51
16.67	.45	17.27	.33	17.87	.21	18.47	.09	19.07	.02
19.67	.00								

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00586
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .09352

0 FARMINGTON CANYON HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA = 464. ACRES

THE RUNOFF HYDROGRAPH FOR 7 18 1965 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
20.50	.00	21.20	3.89	22.00	2.81	24.00	.57	26.00	.27
28.00	.09	30.00	.02	32.00	.00				

THE ADJUSTED PEAK FLOW IS 3.89 CFS.
THE STORM TIME OF RISE WAS .70 HOURS.
THE STORM RUNOFF LASTED 11.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .01868 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.50
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
19.92	.00	20.03	.14	20.35	.29	20.50	.31	20.73	.53
20.87	.78	21.00	.95	21.08	1.03	21.22	1.17	21.27	1.26
21.52	1.38	22.28	1.55						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .60
AND MOVED 1.80 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.92	.00	20.52	.00	21.12	.00	21.72	3.33	22.32	3.21
22.92	2.47	23.52	1.80	24.12	1.13	24.72	.56	25.32	.47
25.92	.38	26.52	.29	27.12	.22	27.72	.17	28.32	.11
28.92	.08	29.52	.06	30.12	.04	30.72	.02	31.32	.01
31.92	.00	32.52	.00	33.12	.00	33.72	.00		

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .60

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.92	.00	20.52	.26	21.12	1.09	21.72	2.21	22.32	3.01
22.92	2.89	23.52	2.32	24.12	1.59	24.72	.86	25.32	.29
25.92	.06	26.52	.00						

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .01245
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 3.62905

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0  FARMINGTON CANYON  HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA =  464. ACRES

THE RUNOFF HYDROGRAPH FOR  8 21 1965 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  10.75   .00    12.10  1.22    13.00   .37    14.00   .13    15.00   .08
  17.00   .02    19.00   .00
THE ADJUSTED PEAK FLOW IS    1.22 CFS.
THE STORM TIME OF RISE WAS   1.35 HOURS.
THE STORM RUNOFF LASTED  8.25 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS    .00427 INCHES.

THE RAIN GAGE RECORD IS FROM  HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS    .44
THE TIME IS DECIMAL. THE DEPTH IS INCHES.
   TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
  10.12   .00    10.27   .01    10.48   .07    10.75   .20    11.05   .28
  11.35   .35    11.82   .38

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =    .40
AND MOVED    .90 HOURS TO THE TIME OF BEST FIT.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  10.12   .00    10.52   .00    10.92   .36    11.32   .72    11.72  1.08
  12.12   .98    12.52   .60    12.92   .33    13.32   .23    13.72   .14
  14.12   .11    14.52   .09    14.92   .07    15.32   .06    15.72   .05
  16.12   .04    16.52   .03    16.92   .02    17.32   .02    17.72   .01
  18.12   .00    18.52   .00    18.92   .00    19.32   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .40
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  10.12   .00    10.52   .09    10.92   .36    11.32   .74    11.72  1.00
  12.12   .98    12.52   .80    12.92   .56    13.32   .31    13.72   .12
  14.12   .03    14.52   .00    14.92   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS    .00970
THE MINIMUM SUM OF DEVIATIONS SQUARED IS      .14218
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0  FARMINGTON CANYON  HALFWAY CREEK WATERSHED
SURFACE DRAINAGE AREA =  464. ACRES

THE RUNOFF HYDROGRAPH FOR  8 21 1965 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  21.50   .00    23.25  1.37    24.00   .86    25.00   .23    27.00   .07
  29.00   .05    31.00   .03    35.00   .00
THE ADJUSTED PEAK FLOW IS    1.37 CFS.
THE STORM TIME OF RISE WAS   1.75 HOURS.
THE STORM RUNOFF LASTED 13.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS    .00672 INCHES.

THE RAIN GAGE RECORD IS FROM  HEAD OF HALFWAY
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS    .58
THE TIME IS DECIMAL. THE DEPTH IS INCHES.
   TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
  22.87   .00    23.00   .04    23.18   .06      .00   .33    24.13   .35
  24.40   .44    24.83   .47

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =    .60
AND MOVED   1.20 HOURS TO THE TIME OF BEST FIT.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  22.87   .00    23.47   .00    24.07   .47    24.67   .94    25.27  1.33
  25.87   .92    26.47   .55    27.07   .23    27.67   .18    28.27   .13
  28.87   .08    29.47   .07    30.07   .06    30.67   .06    31.27   .05
  31.87   .04    32.47   .03    33.07   .03    33.67   .02    34.27   .02
  34.87   .01    35.47   .00    36.07   .00    36.67   .00    37.27   .00
  37.87   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .60
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
  22.87   .00    23.47   .32    24.07   .65    24.67  1.08    25.27   .99
  25.87   .91    26.47   .66    27.07   .40    27.67   .14    28.27   .07
  28.87   .00    29.47   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS    .01159
THE MINIMUM SUM OF DEVIATIONS SQUARED IS      .34864
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0 FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 9 12 1942 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
3.50	.00	4.00	.03	5.53	.02	5.90	.06	6.10	.06
6.55	.21	7.00	.12	7.53	.07	8.00	.06	9.00	.02
10.00	.00	12.00	.00						

THE ADJUSTED PEAK FLOW IS .21 CFS.
THE STORM TIME OF RISE WAS 3.05 HOURS.
THE STORM RUNOFF LASTED 8.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00222 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.00
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
2.33	.00	2.60	.06	2.97	.13	3.25	.16	4.08	.17
6.75	.19	7.50	.26	9.83	.44	10.92	.51	12.08	.59
13.33	.68	14.00	.74						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .80
AND MOVED .80 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
2.33	.00	3.13	.03	3.93	.03	4.73	.06	5.53	.18
6.33	.07	7.13	.05	7.93	.02	8.73	.00	9.53	.00
10.33	.00	11.13	.00	11.93	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .80

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
2.33	.00	3.13	.00	3.93	.02	4.73	.02	5.53	.02
6.33	.02	7.13	.01	7.93	.01	8.73	.02	9.53	.02
10.33	.03	11.13	.03	11.93	.03	12.73	.03	13.53	.03
14.33	.03	15.17	.03	15.93	.02	16.73	.02	17.53	.00
18.33	.00	19.13	.00	19.93	.00				

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00222
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .03567

0 FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 7 1 1940 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
1.60	.00	2.60	.07	3.00	.14	3.80	.30	4.30	.22
4.50	.17	5.00	.10	6.00	.10	7.00	.05	8.00	.04
9.00	.04	10.00	.02	12.00	.00				

THE ADJUSTED PEAK FLOW IS .30 CFS.
THE STORM TIME OF RISE WAS 2.20 HOURS.
THE STORM RUNOFF LASTED 10.40 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00504 INCHES.

THE RAIN GAGE RECORD IS FROM MUD CREEK
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.50
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
2.30	.00	3.47	.03	4.13	.16	4.43	.37	4.58	.38
4.80	.53	5.00	.56	5.45	.90	5.67	1.01	6.33	1.13
6.97	1.17	7.22	1.20	7.65	1.38	8.25	1.38	8.62	1.41
8.30	1.57								

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED 2.00 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
2.30	.00	2.70	.00	3.10	.00	3.50	.00	3.90	.00
4.30	.03	4.70	.05	5.10	.10	5.50	.18	5.90	.26
6.30	.27	6.70	.20	7.10	.13	7.50	.10	7.90	.10
8.30	.10	8.70	.08	9.10	.06	9.50	.05	9.90	.05
10.30	.04	10.70	.04	11.10	.04	11.50	.03	11.90	.03
12.30	.02	12.70	.01	13.10	.00	13.50	.00	13.90	.00
14.30	.00	14.70	.00	15.10	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
2.30	.00	2.70	.00	3.10	.00	3.50	.00	3.90	.02
4.30	.04	4.70	.09	5.10	.13	5.50	.18	5.90	.22
6.30	.23	6.70	.20	7.10	.15	7.50	.12	7.90	.10
8.30	.09	8.70	.08	9.10	.08	9.50	.08	9.90	.07
10.30	.05	10.70	.03	11.10	.02	11.50	.00	11.90	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00336
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .01174

O FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 3 1945 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
18.10	.00	19.05	.48	19.50	.21	19.95	.09	21.00	.02
22.00	.00								

THE ADJUSTED PEAK FLOW IS .48 CFS.
THE STORM TIME OF RISE WAS .95 HOURS.
THE STORM RUNOFF LASTED 3.90 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00329 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .77
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
18.75	.00	19.00	.05	19.17	.11	19.38	.23	19.67	.64
20.33	.79	20.72	.80	21.33	.85	22.18	.88		

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .60 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
18.75	.00	18.95	.00	19.15	.00	19.35	.10	19.55	.20
19.75	.30	19.95	.40	20.15	.45	20.35	.33	20.55	.21
20.75	.16	20.95	.10	21.15	.03	21.35	.07	21.55	.05
21.75	.04	21.95	.03	22.15	.02	22.35	.02	22.55	.01
22.75	.00	22.95	.00	23.15	.00	23.35	.00		

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
18.75	.00	18.95	.00	19.15	.04	19.35	.09	19.55	.19
19.75	.31	19.95	.40	20.15	.40	20.35	.33	20.55	.26
20.75	.17	20.95	.10	21.15	.06	21.35	.05	21.55	.04
21.75	.04	21.95	.03	22.15	.03	22.35	.02	22.55	.02
22.75	.01	22.95	.00	23.15	.00	23.35	.00	23.55	.00
23.75	.00								

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00427
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .00784

O FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 19 1945 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
21.55	.00	22.00	.45	22.20	.28	22.80	.17	23.00	.23
23.50	.07	24.00	.03	25.00	.00				

THE ADJUSTED PEAK FLOW IS .45 CFS.
THE STORM TIME OF RISE WAS .45 HOURS.
THE STORM RUNOFF LASTED 3.45 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00295 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.36
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
20.75	.00	21.05	.04	21.83	.59	22.45	.69	22.72	1.36

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = 1.20
AND MOVED 4.80 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
20.75	.00	21.95	.00	23.15	.00	24.35	.00	25.55	.18
26.75	.04	27.95	.00	29.15	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = 1.20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
20.75	.00	21.95	.01	23.15	.05	24.35	.08	25.55	.09
26.75	.07	27.95	.05	29.15	.03	30.35	.01	31.55	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00217
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .02056

D FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 13 1946 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
.00	.00	.50	.22	1.00	.08	1.50	.03	2.50	.00

THE ADJUSTED PEAK FLOW IS .22 CFS.
THE STORM TIME OF RISE WAS .50 HOURS.
THE STORM RUNOFF LASTED 2.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00111 INCHES.

THE RAIN GAGE RECORD IS FROM MUD CREEK
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .30
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
.78	.00	.92	.28	1.75	.38	2.00	.39		

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .40 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
.78	.00	.98	.00	1.18	.09	1.38	.18	1.58	.19
1.78	.14	1.98	.08	2.18	.06	2.38	.04	2.58	.03
2.78	.02	2.98	.02	3.18	.00	3.38	.00	3.58	.00
3.78	.00								

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
.78	.00	.98	.05	1.18	.11	1.38	.17	1.58	.16
1.78	.13	1.98	.11	2.18	.07	2.38	.03	2.58	.02
2.78	.01	2.98	.00	3.18	.00	3.38	.00	3.58	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00370
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .00644

D FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 17 1947 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
12.50	.00	12.95	.94	13.10	.44	13.40	.31	13.70	.16
14.00	.11	14.50	.07	15.10	.03	16.00	.02	18.00	.00

THE ADJUSTED PEAK FLOW IS .94 CFS.
THE STORM TIME OF RISE WAS .45 HOURS.
THE STORM RUNOFF LASTED 5.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00410 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .76
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
11.75	.00	11.79	.03	12.22	.08	12.33	.57	12.58	.68
13.08	.79	14.00	.81						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .80 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
11.75	.00	11.95	.00	12.15	.00	12.35	.00	12.55	.42
12.75	.83	12.95	.44	13.15	.35	13.35	.26	13.55	.16
13.75	.13	13.95	.10	14.15	.08	14.35	.07	14.55	.05
14.75	.04	14.95	.03	15.15	.03	15.35	.02	15.55	.02
15.75	.02	15.95	.01	16.15	.01	16.35	.01	16.55	.00
16.75	.00	16.95	.00	17.15	.00	17.35	.00	17.55	.00
17.75	.00	17.95	.00	18.15	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
11.75	.00	11.95	.02	12.15	.04	12.35	.23	12.55	.43
12.75	.62	12.95	.54	13.15	.47	13.35	.30	13.55	.19
13.75	.09	13.95	.08	14.15	.08	14.35	.07	14.55	.05
14.75	.03	14.95	.02	15.15	.00	15.35	.00	15.55	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00539
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .12496

D FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 7 27 1951 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
12.50	.00	12.53	.01	12.75	.00	12.83	.03	13.00	.02
13.25	.06	13.50	.10	13.75	.09	14.00	.07	14.25	.05
14.50	.04	14.75	.02	15.00	.00	15.25	.00		

THE ADJUSTED PEAK FLOW IS .10 CFS.
THE STORM TIME OF RISE WAS 1.00 HOURS.
THE STORM RUNOFF LASTED 2.75 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00075 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .50
THE TIME IS DECIMAL, THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
23.08	.00	23.33	.12						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED .40 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
23.08	.00	23.48	.03	23.88	.07	24.28	.09	24.68	.06
25.08	.04	25.48	.00	25.88	.00	26.28	.00		

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
23.08	.00	23.48	.02	23.88	.05	24.28	.07	24.68	.06
25.08	.04	25.48	.03	25.88	.01	26.28	.00		

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00150
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .00139

D FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 4 1951 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
9.00	-.00	9.25	.00	9.50	.02	9.75	.04	10.00	.09
10.25	.15	10.33	.17	10.45	.18	10.58	.17	10.75	.14
11.00	.11	11.60	.11	11.75	.10	12.00	.07	12.25	.04
12.50	.03	12.75	.02	13.00	.01	13.25	.01	13.50	.00

THE ADJUSTED PEAK FLOW IS .18 CFS.
THE STORM TIME OF RISE WAS 1.45 HOURS.
THE STORM RUNOFF LASTED 4.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00200 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .76
THE TIME IS DECIMAL, THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
8.75	.00	9.53	.08	9.85	.11	10.13	.27	10.30	.34
10.38	.48	10.67	.57	10.83	.62	11.08	.72	11.68	.87

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED 1.60 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
8.75	-.00	9.15	-.00	9.55	-.00	9.95	-.00	10.35	.01
10.75	.05	11.15	.14	11.55	.17	11.95	.11	12.35	.11
12.75	.09	13.15	.05	13.55	.03	13.95	.01	14.35	.00
14.75	.00	15.15	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
8.75	.00	9.15	.00	9.55	.00	9.95	.02	10.35	.05
10.75	.08	11.15	.12	11.55	.13	11.95	.12	12.35	.10
12.75	.07	13.15	.04	13.55	.02	13.95	.00	14.35	.00
14.75	.00								

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00263
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .00589

0 FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 19 1951 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
22.00	.00	22.08	.00	22.17	.00	22.25	.05	22.33	.08
22.50	.32	22.67	.55	22.75	.49	23.00	.27	23.25	.18
23.50	.13	23.75	.10	24.00	.08	24.25	.05	24.50	.04
24.75	.03	25.00	.02	25.25	.01	25.50	.01	25.75	.01
26.00	.00								

THE ADJUSTED PEAK FLOW IS .55 CFS.
THE STORM TIME OF RISE WAS .67 HOURS.
THE STORM RUNOFF LASTED 4.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00288 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .95
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
20.32	.00	20.67	.50	21.15	.57	21.50	.68	21.67	.76
22.17	.79	22.67	.81	25.00	.81	26.00	.85		

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
20.32	.00	20.52	.02	20.72	.18	20.92	.45	21.12	.44
21.32	.28	21.52	.20	21.72	.15	21.92	.12	22.12	.10
22.32	.08	22.52	.06	22.72	.04	22.92	.03	23.12	.03
23.32	.03	23.52	.02	23.72	.01	23.92	.01	24.12	.00
24.32	.00	24.52	.00	24.72	.00				

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
20.32	.00	20.52	.06	20.72	.19	20.92	.30	21.12	.32
21.32	.28	21.52	.24	21.72	.21	21.92	.16	22.12	.13
22.32	.10	22.52	.08	22.72	.05	22.92	.03	23.12	.02
23.32	.01	23.52	.00	23.72	.00	23.92	.00	24.12	.00
24.32	.00	24.52	.00	24.72	.00	24.92	.00	25.12	.00
25.32	.00	25.52	.00	25.72	.01	25.92	.02	26.12	.02
26.32	.02	26.52	.01	26.72	.00	26.92	.00	27.12	.00
27.32	.00	27.52	.00						

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00303
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .05031

0 FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 1 1952 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
4.00	.00	4.25	.13	4.42	.43	4.54	.76	4.75	.48
5.00	.20	5.25	.10	5.53	.06	5.75	.03	6.00	.02
6.25	.00	6.50	.00	6.75	.00	7.00	.00		

THE ADJUSTED PEAK FLOW IS .75 CFS.
THE STORM TIME OF RISE WAS .54 HOURS.
THE STORM RUNOFF LASTED 3.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00272 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .70
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
4.58	.00	4.75	.31	4.83	.41	5.00	.57		

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED 1.20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
4.58	.00	4.98	.00	5.38	.00	5.78	.39	6.18	.43
6.58	.12	6.98	.05	7.38	.02	7.78	.00	8.18	.00
8.58	.00	8.98	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
4.58	.00	4.98	.09	5.38	.18	5.78	.26	6.18	.22
6.58	.16	6.98	.11	7.38	.05	7.78	.00	8.18	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00389
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .10582

D FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 7 26 1953 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
17.44	.00	17.57	.04	17.62	.03	17.75	.05	18.00	.17
18.08	.20	18.25	.16	18.50	.09	18.75	.06	19.00	.04
19.25	.03	19.50	.02	19.75	.00	20.00	.00	20.25	.00

THE ADJUSTED PEAK FLOW IS .20 CFS.
THE STORM TIME OF RISE WAS .64 HOURS.
THE STORM RUNOFF LASTED 2.81 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00102 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .40
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
16.70	.00	16.83	.38	17.33	.45				

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
40.70	.00	40.90	.03	41.10	.09	41.30	.18	41.50	.17
41.70	.11	41.90	.07	42.10	.05	42.30	.04	42.50	.03
42.70	.02	42.90	.00	43.10	.00	43.30	.00	43.50	.00
43.70	.00	43.90	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
40.70	.00	40.90	.06	41.10	.12	41.30	.19	41.50	.16
41.70	.13	41.90	.09	42.10	.05	42.30	.00	42.50	.00
42.70	.00	42.90	.00						

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00255
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .00395

D FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 8 4 1954 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
14.25	.00	14.50	.00	14.75	.05	14.87	.05	14.86	.09
14.37	.10	15.00	.14	15.15	.15	15.25	.30	15.33	.37
15.50	.30	15.75	.20	16.00	.14	16.25	.11	16.50	.08
16.75	.07	17.00	.06	17.25	.05	17.50	.04	17.75	.03
18.15	.04	18.25	.05	18.50	.07	18.75	.10	18.83	.11
19.00	.10	19.25	.09	19.50	.07	19.75	.05	20.00	.04
20.25	.04	20.50	.02	20.75	.02	21.00	.01	21.25	.01
21.50	.01	21.75	.01	22.00	.00	22.25	.00		

THE ADJUSTED PEAK FLOW IS .37 CFS.
THE STORM TIME OF RISE WAS 1.08 HOURS.
THE STORM RUNOFF LASTED 8.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00362 INCHES.

THE RAIN GAGE RECORD IS FROM HEAD OF MILLER
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.35
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
13.75	.00	14.05	.02	14.58	.04	14.92	.42	15.25	.87
15.75	.93	16.58	1.09	16.75	1.14				

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .80
AND MOVED 2.40 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.75	.00	14.55	.00	15.35	.00	16.15	.14	16.95	.17
17.75	.08	18.55	.04	19.35	.05	20.15	.10	20.95	.04
21.75	.02	22.55	.01	23.35	.00	24.15	.00	24.95	.00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .80

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.75	.00	14.55	.00	15.35	.05	16.15	.10	16.95	.16
17.75	.14	18.55	.12	19.35	.08	20.15	.05	20.95	.01
21.75	.00	22.55	.00						

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00268
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .01869

0 FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 7 11 1956 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.25	.00	19.33	.02	19.50	.02	19.60	.03	19.75	.04
19.83	.05	20.00	.09	20.04	.10	20.08	.10	20.12	.09
20.25	.08	20.50	.05	20.75	.03	21.00	.02	21.25	.00
21.50	.00	21.75	.00	22.00	.00				

THE ADJUSTED PEAK FLOW IS .10 CFS.
THE STORM TIME OF RISE WAS .79 HOURS.
THE STORM RUNOFF LASTED 2.75 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00055 INCHES.

THE RAIN GAGE RECORD IS FROM SUNSET
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .35
THE TIME IS DECIMAL, THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
19.13	.00	19.23	.24	19.37	.48	19.42	.53	19.60	.57

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .60
AND MOVED 1.80 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.13	.00	19.73	.00	20.33	.00	20.93	.05	21.53	.06
22.13	.01	22.73	.00	23.33	.00	23.93	.00		

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .60

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.13	.00	19.73	.01	20.33	.02	20.93	.04	21.53	.03
22.13	.02	22.73	.01	23.33	.00	23.93	.00		

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00157
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .00202

0 FARMINGTON CANYON MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA = 156. ACRES

THE RUNOFF HYDROGRAPH FOR 7 28 1956 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
22.40	.00	22.50	.00	22.75	.04	23.00	.09	23.17	.12
23.25	.13	23.33	.12	23.50	.10	23.75	.07	24.00	.04
24.25	.03	24.50	.02	24.75	.01	25.00	.01	25.25	.01
25.50	.00								

THE ADJUSTED PEAK FLOW IS .13 CFS.
THE STORM TIME OF RISE WAS .85 HOURS.
THE STORM RUNOFF LASTED 3.10 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .00089 INCHES.

THE RAIN GAGE RECORD IS FROM SUNSET
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .35
THE TIME IS DECIMAL, THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
22.17	.00	22.37	.05	22.60	.10	22.70	.16	22.82	.28
22.92	.31	23.08	.49	23.52	.52	23.78	.56		

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .60 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
22.17	.00	22.37	.00	22.57	.00	22.77	.02	22.97	.05
23.17	.09	23.37	.12	23.57	.11	23.77	.08	23.97	.06
24.17	.05	24.37	.04	24.57	.03	24.77	.02	24.97	.01
25.17	.01	25.37	.01	25.57	.00	25.77	.00	25.97	.00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
22.17	.00	22.37	.00	22.57	.01	22.77	.04	22.97	.07
23.17	.10	23.37	.12	23.57	.11	23.77	.09	23.97	.07
24.17	.04	24.37	.02	24.57	.00	24.77	.00	24.97	.00
25.17	.00	25.37	.00						

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .00254
THE MINIMUM SUM OF DEVIATIONS SQUARED IS .00245

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0  FARMINGTON CANYON    MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA =   464. ACRES

THE RUNOFF HYDROGRAPH FOR  8 21 1957 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   22.40   .00    23.20   .38    23.63  1.11    23.75   .99    24.00  1.61
   24.30  2.07    25.35   .67    26.00   .25    26.75   .10    27.75   .00
THE ADJUSTED PEAK FLOW IS     2.07 CFS.
THE STORM TIME OF RISE WAS    1.90 HOURS.
THE STORM RUNOFF LASTED   5.35 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS    .00727 INCHES.

THE RAIN GAGE RECORD IS FROM  SUNSET
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS     .90
THE TIME IS DECIMAL, THE DEPTH IS INCHES.
   TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
   22.20   .00    22.35   .05    22.50   .11    22.67   .18    22.93   .25
   23.02   .31    23.13   .47    23.22   .64    23.30   .70    23.48   .74
   23.67   .83    23.98   .99    24.25  1.03

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =    .40
AND MOVED     .80 HOURS TO THE TIME OF BEST FIT.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   22.20   .00    22.60   .00    23.00   .19    23.40   .38    23.80  1.11
   24.20  1.61    24.60  1.94    25.00  1.40    25.40   .87    25.80   .51
   26.20   .26    26.60   .17    27.00   .10    27.40   .06    27.80   .02
   28.20   .00    28.60   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .40
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   22.20   .00    22.60   .10    23.00   .31    23.40   .81    23.80  1.28
   24.20  1.65    24.60  1.57    25.00  1.26    25.40   .84    25.80   .47
   26.20   .17    26.60   .04    27.00   .00    27.40   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS    .00808
THE MINIMUM SUM OF DEVIATIONS SQUARED IS       .43709
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0  FARMINGTON CANYON    MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA =   156. ACRES

THE RUNOFF HYDROGRAPH FOR  8 19 1959 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   14.40   .00    15.00   .02    15.50   .05    16.00   .10    16.10   .10
   16.60   .07    17.00   .04    17.50   .02    18.30   .01    19.00   .01
   20.00   .00    22.00   .00
THE ADJUSTED PEAK FLOW IS      .10 CFS.
THE STORM TIME OF RISE WAS    1.60 HOURS.
THE STORM RUNOFF LASTED   7.60 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS    .00111 INCHES.

THE RAIN GAGE RECORD IS FROM  SUNSET
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS     .80
THE TIME IS DECIMAL, THE DEPTH IS INCHES.
   TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
   20.33   .00    20.45   .08    22.90   .18    23.03   .49    23.18   .62
   23.55   .67

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =    .40
AND MOVED    2.40 HOURS TO THE TIME OF BEST FIT.
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   20.33   .00    20.73   .00    21.13   .00    21.53   .00    21.93   .00
   22.33   .00    22.73   .01    23.13   .03    23.53   .06    23.93   .10
   24.33   .08    24.73   .06    25.13   .03    25.53   .02    25.93   .01
   26.33   .01    26.73   .01    27.13   .00    27.53   .00    27.93   .00
   28.33   .00    28.73   .00    29.13   .00    29.53   .00    29.93   .00
   30.33   .00    30.73   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .40
   TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   20.33   .00    20.73   .00    21.13   .01    21.53   .02    21.93   .02
   22.33   .02    22.73   .02    23.13   .03    23.53   .06    23.93   .08
   24.33   .07    24.73   .05    25.13   .04    25.53   .02    25.93   .00
   26.33   .00    26.73   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS    .00139
THE MINIMUM SUM OF DEVIATIONS SQUARED IS       .00193
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0  FARMINGTON CANYON    MORRIS CREEK WATERSHED
SURFACE DRAINAGE AREA =  156. ACRES

THE RUNOFF HYDROGRAPH FOR  7 18 1965 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
    14.50   .00    14.90   .00    15.50   .35    15.70   .18    16.00   .10
    16.20   .06    16.90   .03    18.00   .01    19.00   .00
THE ADJUSTED PEAK FLOW IS     .35 CFS.
THE STORM TIME OF RISE WAS   1.00 HOURS.
THE STORM RUNOFF LASTED   4.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS    .00179 INCHES.

THE RAIN GAGE RECORD IS FROM  RICE
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS   1.20
THE TIME IS DECIMAL. THE DEPTH IS INCHES.
     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
    19.58   .00    19.75   .01    19.85   .09    20.00   .12    20.10   .26
    20.17   .28    20.23   .37    20.42   .74    20.52   .87    20.77   .96
    20.85  1.03    21.05  1.16    21.20  1.30    21.28  1.41    22.03  1.57
    22.30  1.60

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =    .60
AND MOVED     2.40 HOURS TO THE TIME OF BEST FIT.
     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
    19.58   .00    20.18   .00    20.78   .00    21.38   .00    21.98   .12
    22.58   .18    23.18   .06    23.78   .03    24.38   .02    24.98   .01
    25.58   .00    26.18   .00    26.78   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =   .60
     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
    19.58   .00    20.18   .00    20.78   .03    21.38   .07    21.98   .09
    22.58   .09    23.18   .08    23.78   .05    24.38   .03    24.98   .01
    25.58   .00    26.18   .00    26.78   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS    .00149
THE MINIMUM SUM OF DEVIATIONS SQUARED IS      .01400
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0   EPHRAIM CREEK WATERSHED    ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA =  376. ACRES

THE RUNOFF HYDROGRAPH FOR  7 16 1951 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
    TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   16.15   .00    16.25   .42    16.33   .51    16.40   .50    16.50   .64
   16.55   .64    16.60   .77    16.73   .64    16.80   .60    17.00   .60
   17.25   .48    17.50   .48    17.75   .16    18.00   .13    19.00   .07
   20.00   .05    22.00   .00
THE ADJUSTED PEAK FLOW IS     .77 CFS.
THE STORM TIME OF RISE WAS    .45 HOURS.
THE STORM RUNOFF LASTED  5.85 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS   .00276 INCHES.

THE RAIN GAGE RECORD IS FROM  ALPINE AREA B
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS    .40
THE TIME IS DECIMAL. THE DEPTH IS INCHES.
    TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
   16.00   .00    16.33   .24

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =   .40
AND MOVED     .80 HOURS TO THE TIME OF BEST FIT.
    TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   16.00   .00    16.40   .00    16.80   .64    17.20   .60    17.60   .48
   18.00   .16    18.40   .12    18.80   .10    19.20   .07    19.60   .05
   20.00   .05    20.40   .04    20.80   .03    21.20   .03    21.60   .02
   22.00   .00    22.40   .00    22.80   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .40
    TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
   16.00   .00    16.40   .22    16.80   .44    17.20   .65    17.60   .52
   18.00   .39    18.40   .26    18.80   .13    19.20   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS   .00690
THE MINIMUM SUM OF DEVIATIONS SQUARED IS      .18524
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0   EPHRAIM CREEK WATERSHED    ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA =  376. ACRES

THE RUNOFF HYDROGRAPH FOR  8  3 1951 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.
    TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
    9.00   .00     9.25   .07     9.50   .14     9.75   .38    10.00  1.27
   10.20  1.27    10.24  1.37    10.35  1.36    10.50  1.15    10.75   .62
   11.00   .41    11.25   .31    11.50   .22    11.75   .19    12.00   .16
   13.00   .07    14.00   .00
THE ADJUSTED PEAK FLOW IS    1.38 CFS.
THE STORM TIME OF RISE WAS   1.74 HOURS.
THE STORM RUNOFF LASTED   5.00 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS   .00449 INCHES.

THE RAIN GAGE RECORD IS FROM  ALPINE AREA B
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS    .30
THE TIME IS DECIMAL. THE DEPTH IS INCHES.
    TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH     TIME DEPTH
    8.33   .13     8.50   .19

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA =   .80
AND MOVED    1.60 HOURS TO THE TIME OF BEST FIT.
    TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
    8.33   .00     9.13   .00     9.93   .55    10.73   .94    11.53   .25
   12.33   .14    13.13   .07    13.93   .01    14.73   .00    15.53   .00

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA =  .80
    TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW     TIME  FLOW
    8.33   .00     9.13   .06     9.93   .11    10.73   .17    11.53   .13
   12.33   .10    13.13   .07    13.93   .03    14.73   .00
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS   .01497
THE MINIMUM SUM OF DEVIATIONS SQUARED IS      .81460
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0 EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 7 28 1952 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
11.35	.00	11.50	.49	11.75	31.47	11.85	45.46	12.00	33.46
12.25	25.64	12.50	12.41	12.75	6.20	13.00	4.55	13.10	4.06
13.25	4.05	13.45	4.77	13.75	3.16	14.00	2.33	14.50	1.39
15.00	1.02	16.00	.58	17.00	.40	18.00	.21	19.00	.10
20.00	.05	21.00	.00						

THE ADJUSTED PEAK FLOW IS 45.46 CFS.
THE STORM TIME OF RISE WAS .50 HOURS.
THE STORM RUNOFF LASTED 9.65 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .09690 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE AREA B
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS 1.10
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
10.98	.00	11.02	.21	11.22	.49	11.38	.67	11.48	.74
11.62	.87	11.73	.89	11.83	.95	12.38	1.05	12.60	1.13
12.90	1.17								

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .40 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
10.98	.00	11.18	.00	11.38	6.69	11.58	31.47	11.78	37.46
11.98	28.77	12.18	20.35	12.38	11.17	12.58	6.20	12.78	4.88
12.98	4.06	13.18	4.41	13.38	4.23	13.58	3.16	13.78	2.50
13.98	2.05	14.18	1.67	14.38	1.35	14.58	1.20	14.78	1.06
14.98	.95	15.18	.87	15.38	.76	15.58	.69	15.78	.60
15.98	.55	16.18	.52	16.38	.48	16.58	.44	16.78	.41
16.98	.37	17.18	.33	17.38	.30	17.58	.26	17.78	.22
17.98	.20	18.18	.18	18.38	.15	18.58	.13	18.78	.11
18.98	.10	19.18	.09	19.38	.08	19.58	.07	19.78	.05
19.98	.04	20.18	.03	20.38	.02	20.58	.01	20.78	.00
20.98	.00	21.18	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
10.98	.00	11.18	5.80	11.38	14.57	11.58	25.52	11.78	28.28
11.98	27.04	12.18	22.77	12.38	17.25	12.58	11.50	12.78	8.86
12.98	7.45	13.18	5.30	13.38	4.17	13.58	2.65	13.78	1.43
13.98	.48	14.18	.12	14.38	.00				

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .08809
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 334.06251

0 EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 7 30 1952 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
10.30	.00	10.50	.36	10.75	7.42	11.00	4.62	11.25	1.83
11.50	.95	11.75	.60	12.00	.34	12.25	.23	12.50	.22
13.00	.17	14.00	.11	18.00	.00				

THE ADJUSTED PEAK FLOW IS 7.41 CFS.
THE STORM TIME OF RISE WAS .45 HOURS.
THE STORM RUNOFF LASTED 7.70 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .01199 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE MEADOWS
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .20
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
10.00	.00	10.17	.03	10.28	.17	10.42	.24	11.28	.27

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .40 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
10.00	.00	10.20	.00	10.40	.35	10.60	6.00	10.80	5.74
11.00	3.50	11.20	1.65	11.40	.95	11.60	.67	11.80	.45
12.00	.29	12.20	.23	12.40	.22	12.60	.20	12.80	.18
13.00	.16	13.20	.15	13.40	.14	13.60	.13	13.80	.11
14.00	.10	14.20	.10	14.40	.09	14.60	.09	14.80	.08
15.00	.08	15.20	.07	15.40	.07	15.60	.05	15.80	.06
16.00	.05	16.20	.05	16.40	.04	16.60	.03	16.80	.03
17.00	.02	17.20	.02	17.40	.01	17.60	.00	17.80	.00
18.00	.00	18.20	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
10.00	.00	10.20	.49	10.40	2.11	10.60	3.84	10.80	4.83
11.00	4.06	11.20	3.17	11.40	2.22	11.60	1.20	11.80	.39
12.00	.22	12.20	.12	12.40	.05	12.60	.01	12.80	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .05995
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 13.62832

0 EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 7 10 1953 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
16.25	.00	16.50	2.18	16.70	10.48	16.75	11.31	16.80	12.74
17.00	9.99	17.25	5.63	17.50	4.77	17.75	4.04	18.00	2.55
18.25	1.81	18.50	1.36	19.00	.85	20.00	.41	21.00	.32
22.00	.22	23.00	.15	24.00	.09	27.00	.00		

THE ADJUSTED PEAK FLOW IS 12.74 CFS.
THE STORM TIME OF RISE WAS .55 HOURS.
THE STORM RUNOFF LASTED 10.75 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .03457 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE CATTLE PAST
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .60
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
16.25	.00	16.75	.35	17.17	.45	17.83	.60		

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED 1.20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
16.25	.00	16.65	.00	17.05	.00	17.45	8.41	17.85	8.32
18.25	4.94	18.65	3.44	19.05	1.81	19.45	1.20	19.85	.83
20.25	.65	20.65	.48	21.05	.39	21.45	.35	21.85	.31
22.25	.28	22.65	.24	23.05	.21	23.45	.18	23.85	.15
24.25	.13	24.65	.10	25.05	.09	25.45	.07	25.85	.06
26.25	.05	26.65	.04	27.05	.02	27.45	.01	27.85	.00
28.25	.00								

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
16.25	.00	16.65	1.27	17.05	3.19	17.45	5.53	17.95	6.22
18.25	5.88	18.65	4.87	19.05	3.23	19.45	1.60	19.85	.72
20.25	.24	20.65	.00						

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .05762
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 30.63477

0 EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 7 28 1953 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
11.60	.00	11.75	.78	11.80	1.21	11.85	39.77	12.10	20.76
12.25	10.65	12.30	6.66	12.50	4.89	12.70	3.94	12.75	3.42
13.00	1.64	13.25	.98	13.50	.55	14.00	.28	14.50	.14
15.00	.12	18.00	.00						

THE ADJUSTED PEAK FLOW IS 39.77 CFS.
THE STORM TIME OF RISE WAS .25 HOURS.
THE STORM RUNOFF LASTED 6.40 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .04063 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE CATTLE PAST
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .47
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
11.50	.00	12.00	.28	12.75	.39	13.75	.40	14.58	.41
15.50	.46	16.00	.47						

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .60 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
11.50	.00	11.70	.00	11.90	.00	12.10	1.21	12.30	28.36
12.50	14.03	12.70	5.77	12.90	4.41	13.10	3.07	13.30	1.64
13.50	1.12	13.70	.73	13.90	.50	14.10	.39	14.30	.28
14.50	.23	14.70	.17	14.90	.14	15.10	.13	15.30	.12
15.50	.11	15.70	.11	15.90	.10	16.10	.09	16.30	.08
16.50	.07	16.70	.07	16.90	.06	17.10	.05	17.30	.04
17.50	.03	17.70	.02	17.90	.02	18.10	.00	18.30	.00
18.50	.00	18.70	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
11.50	.00	11.70	1.53	11.90	4.59	12.10	8.61	12.30	10.59
12.50	10.52	12.70	9.31	12.90	7.58	13.10	5.23	13.30	3.19
13.50	1.90	13.70	1.17	13.90	.67	14.10	.40	14.30	.36
14.50	.37	14.70	.45	14.90	.64	15.10	.94	15.30	1.25
15.50	1.49	15.70	1.57	15.90	1.48	16.10	1.19	16.30	.89
16.50	.58	16.70	.32	16.90	.15	17.10	.07	17.30	.02
17.50	.00								

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .08645
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 447.19478

D EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 8 31 1953 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.05	.00	19.25	.33	19.30	.46	19.40	13.66	19.55	13.65
19.60	14.59	19.70	13.34	19.75	12.95	19.85	10.33	20.00	10.33
20.25	15.34	20.30	15.95	20.50	10.50	20.75	8.21	21.00	4.49
21.25	2.37	21.50	1.43	21.75	.95	22.00	.59	22.50	1.49
23.00	1.42	23.50	1.41	24.00	.52	24.25	.41	24.50	.56
24.75	.67	25.00	.57	25.25	.74	25.50	.91	25.75	1.09
26.00	1.53	26.10	1.91	26.26	1.81	26.50	2.31	26.75	1.97
27.00	1.52	28.00	.63	29.00	.35	30.00	.17	33.00	.10
36.00	.00								

THE ADJUSTED PEAK FLOW IS 15.95 CFS.
THE STORM TIME OF RISE WAS 1.25 HOURS.
THE STORM RUNOFF LASTED 16.95 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .07617 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE CATTLE PAST
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .79
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
19.00	.00	19.75	.32	20.33	.60	21.00	.66	22.75	.66
24.00	.74	24.02	.74	24.67	.82	25.25	.87		

THERE ARE 75 POINTS ON THE INTERPOLATED CURVE.

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .40
AND MOVED 1.20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.00	.00	19.40	.00	19.80	.00	20.20	13.66	20.60	10.33
21.00	15.34	21.40	9.13	21.80	4.06	22.20	1.62	22.60	.81
23.00	1.04	23.40	1.47	23.80	1.42	24.20	1.41	24.60	.79
25.00	.41	25.40	.63	25.80	.68	26.20	.80	26.60	1.26
27.00	1.81	27.40	2.11	27.80	1.47	28.20	1.12	28.60	.77
29.00	.56	29.40	.45	29.80	.35	30.20	.27	30.60	.20
31.00	.17	31.40	.16	31.60	.15	32.20	.14	32.60	.13
33.00	.12	33.40	.11	33.80	.10	34.20	.09	34.60	.07
35.00	.06	35.40	.05	35.80	.03	36.20	.02	36.60	.00
37.00	.00	37.40	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .40

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
19.00	.00	19.40	1.18	19.80	3.56	20.20	7.27	20.60	9.69
21.00	10.45	21.40	9.08	21.80	6.74	22.20	4.01	22.60	1.98
23.00	.77	23.40	.55	23.80	.86	24.20	1.40	24.60	1.98
25.00	2.55	25.40	2.96	25.80	2.64	26.20	2.07	26.60	1.37
27.00	.78	27.40	.33	27.80	.09	28.20	.00		

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .09542
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 119.98804

D EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 9 16 1955 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.50	.00	13.60	.20	13.75	.57	13.80	12.19	13.95	20.64
14.10	16.65	14.20	12.49	14.25	8.51	14.50	3.06	14.75	1.60
15.00	.69	15.50	.36	15.75	.30	16.00	.19	16.50	.09
17.00	.08	18.00	.06	19.00	.03	20.00	.02	21.00	.01
23.00	.00								

THE ADJUSTED PEAK FLOW IS 20.64 CFS.
THE STORM TIME OF RISE WAS .45 HOURS.
THE STORM RUNOFF LASTED 9.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .02798 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE CATTLE PAST
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .61
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
13.47	.00	13.58	.25	13.67	.47	13.77	.57	13.92	.61

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .40 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.47	.00	13.67	.00	13.87	.45	14.07	17.92	14.27	16.65
14.47	7.42	14.67	3.07	14.87	1.90	15.07	1.06	15.27	.63
15.47	.49	15.67	.36	15.87	.31	16.07	.23	16.27	.17
16.47	.13	16.67	.09	16.87	.09	17.07	.08	17.27	.08
17.47	.07	17.67	.07	17.87	.06	18.07	.06	18.27	.05
18.47	.05	18.67	.04	18.87	.04	19.07	.03	19.27	.03
19.47	.03	19.67	.02	19.87	.02	20.07	.02	20.27	.02
20.47	.01	20.67	.01	20.87	.01	21.07	.01	21.27	.01
21.47	.00	21.67	.00	21.87	.00	22.07	.00	22.27	.00
22.47	.00	22.67	.00	22.87	.00	23.07	.00	23.27	.00
23.47	.00								

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.47	.00	13.67	3.41	13.87	7.73	14.07	12.15	14.27	11.12
14.47	8.62	14.67	5.97	14.87	3.32	15.07	.67	15.27	.06
15.47	.00								

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .04587
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 140.38840

0 EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 8 3 1961 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
13.20	.00	13.25	.03	13.40	.55	13.50	.83	13.52	3.84
13.60	13.85	13.65	21.93	13.75	26.84	13.85	24.97	13.90	21.27
14.00	17.60	14.20	13.83	14.25	12.51	14.50	5.64	14.75	2.91
15.00	1.53	15.25	.98	15.35	.78	15.50	.60	15.75	.39
16.00	.27	16.50	.15	17.00	.07	17.50	.02	18.00	.00

THE ADJUSTED PEAK FLOW IS 26.84 CFS.
THE STORM TIME OF RISE WAS .55 HOURS.
THE STORM RUNOFF LASTED 4.80 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .04867 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE AREA B
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .77
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
12.75	.00	12.92	.36	13.05	.61	13.28	.65	13.53	.68
17.00	.68	17.63	.70	18.08	.93				

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .20
AND MOVED .20 HOURS TO THE TIME OF BEST FIT.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
12.75	.00	12.95	.55	13.15	13.35	13.35	25.90	13.55	17.60
13.75	13.83	13.95	8.79	14.15	4.55	14.35	2.63	14.55	1.53
14.75	1.09	14.95	.72	15.15	.52	15.35	.37	15.55	.27
15.75	.22	15.95	.18	16.15	.13	16.35	.10	16.55	.07
16.75	.05	16.95	.03	17.15	.02	17.35	.00	17.55	.00
17.75	.00	17.95	.00						

THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .20

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
12.75	.00	12.95	3.91	13.15	9.72	13.35	15.82	13.55	15.86
13.75	12.86	13.95	9.41	14.15	5.63	14.35	1.85	14.55	.42
14.75	.12	14.95	.00	15.15	.00	15.35	.00	15.55	.00
15.75	.00	15.95	.00	16.15	.00	16.35	.00	16.55	.00
16.75	.00	16.95	.00	17.15	.04	17.35	.15	17.55	.31
17.75	.73	17.95	1.60	18.15	2.74	18.35	3.33	18.55	3.07
18.75	2.26	18.95	1.49	19.15	.75	19.35	.21	19.55	.00

THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .06321
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 143.32532

0 EPHRAIM CREEK WATERSHED ALPINE CATTLE PASTURE OR MEADOWS
SURFACE DRAINAGE AREA = 376. ACRES

THE RUNOFF HYDROGRAPH FOR 8 7 1961 AS ADJUSTED FOR BASE FLOW
WITH DECIMAL TIME AND FLOW IN CFS IS LISTED BELOW.

TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
15.50	.00	15.75	.00	16.00	.44	16.10	2.85	16.23	10.67
16.25	10.47	16.35	10.47	16.50	9.52	16.75	4.29	16.85	2.85
17.00	2.09	17.25	1.15	17.50	7.98	17.75	.47	18.00	.35
18.50	.19	19.00	.12	20.00	.04	21.00	.02	22.00	.00

THE ADJUSTED PEAK FLOW IS 10.67 CFS.
THE STORM TIME OF RISE WAS .73 HOURS.
THE STORM RUNOFF LASTED 6.50 HOURS.
THE ADJUSTED VOLUME OF RUNOFF FOR THIS EVENT IS .02456 INCHES.

THE RAIN GAGE RECORD IS FROM ALPINE AREA B
THE ESTIMATED AVERAGE WATERSHED RAINFALL IS .38
THE TIME IS DECIMAL. THE DEPTH IS INCHES.

TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH	TIME	DEPTH
15.67	.00	15.88	.09	16.17	.27	16.92	.28	18.17	.30

THIS IS THE ACTUAL HYDROGRAPH INCREMENTED TO DELTA = .60
AND MOVED 1.20 HOURS TO THE TIME OF BEST FIT.

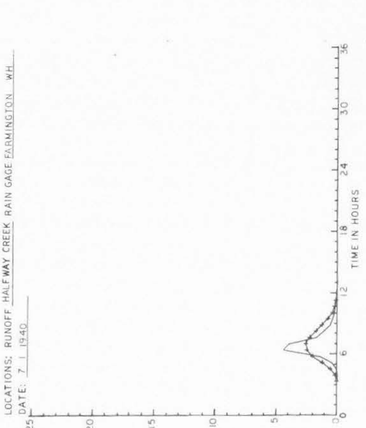
TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
15.67	.00	16.27	.00	16.87	2.86	17.47	5.34	18.07	2.50
18.67	.40	19.27	.19	19.87	.11	20.47	.07	21.07	.04
21.67	.02	22.27	.00	22.87	.00	23.47	.00		

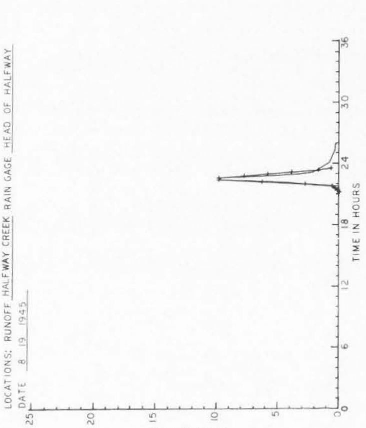
THIS IS THE SYNTHETIC HYDROGRAPH WITH DELTA = .60

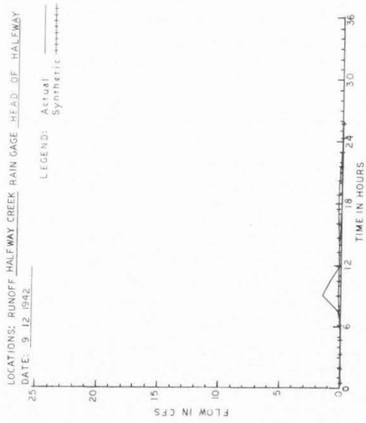
TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW	TIME	FLOW
15.67	.00	16.27	1.17	16.87	2.37	17.47	3.62	18.07	3.03
18.67	2.40	19.27	1.70	19.87	.94	20.47	.16	21.07	.09
21.67	.03	22.27	.00	22.87	.00				

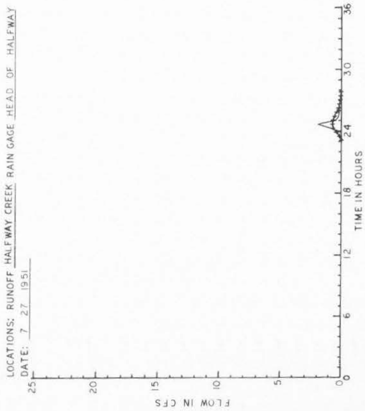
THE RATIO OF RUNOFF TO RAINFALL FOR THIS EVENT IS .06463
THE MINIMUM SUM OF DEVIATIONS SQUARED IS 11.83067

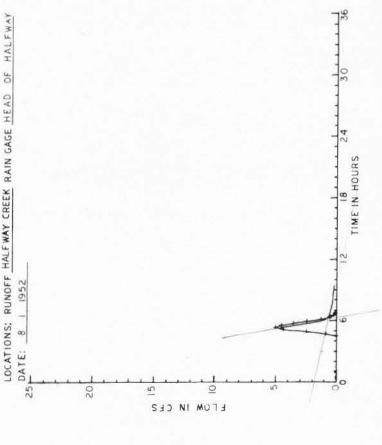
Appendix D
Graphical comparisons of hydrographs

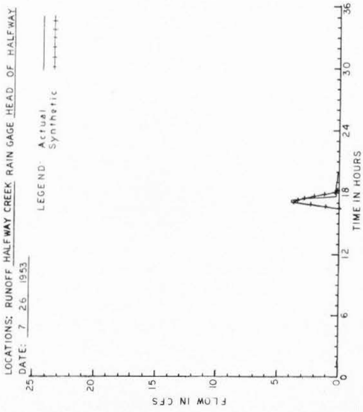

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE FARMINGTON WH
DATE: 7 1 1940
FLOW IN CFS
TIME IN HOURS

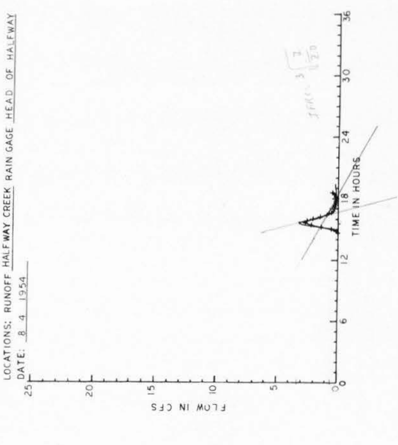

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE 8 19 1945
FLOW IN CFS
TIME IN HOURS

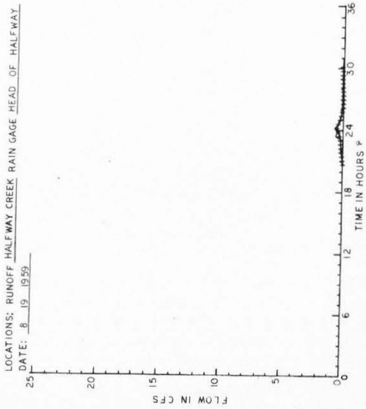

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 9 12 1942
LEGEND: Actual
Synthetic
FLOW IN CFS
TIME IN HOURS

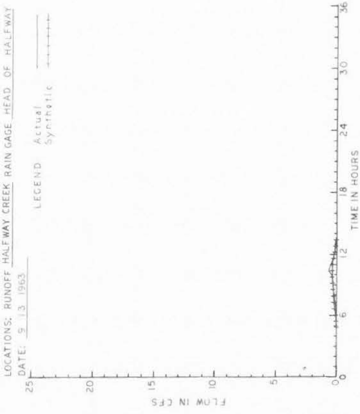

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 7 27 1951
FLOW IN CFS
TIME IN HOURS

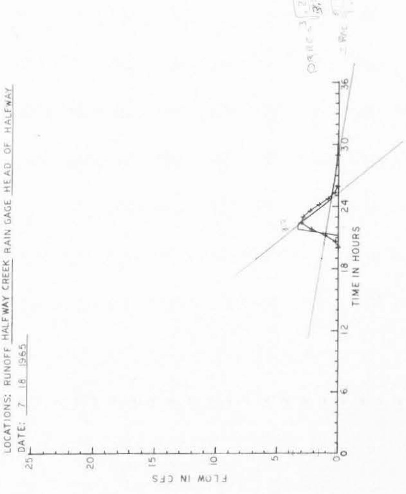

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 8 1 1952
FLOW IN CFS
25
20
15
10
5
0
TIME IN HOURS
0
6
12
18
24
30
36

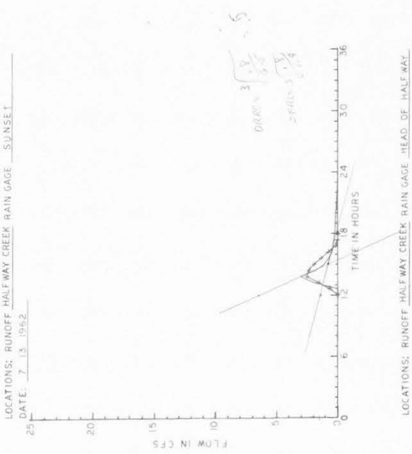

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 7 26 1953
LEGEND: Actual
Synthetic
FLOW IN CFS
25
20
15
10
5
0
TIME IN HOURS
0
6
12
18
24
30
36

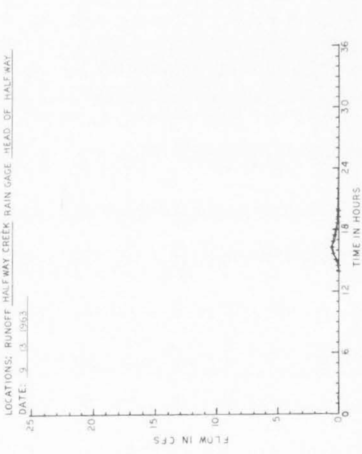

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 8 4 1954
FLOW IN CFS
25
20
15
10
5
0
TIME IN HOURS
0
6
12
18
24
30
36

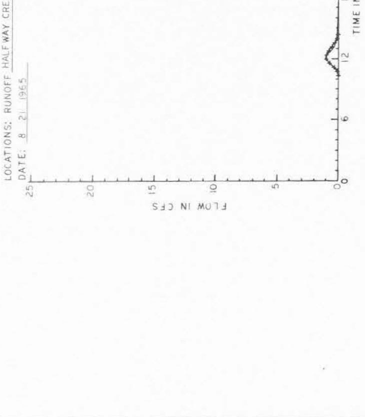

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 8 19 1959
FLOW IN CFS
25
20
15
10
5
0
TIME IN HOURS
0
6
12
18
24
30
36

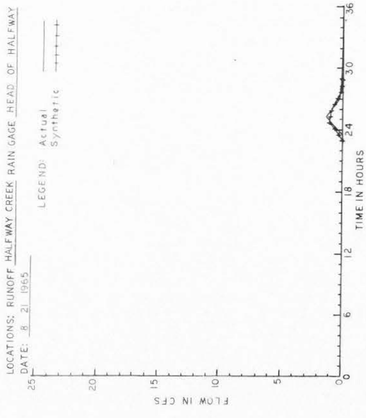

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 9 13 1963
LEGEND Actual
Synthetic
FLOW IN CFS
TIME IN HOURS
0 5 10 15 20 25
0 6 12 18 24 30 36

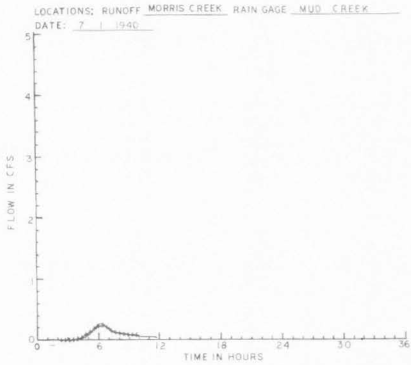

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 7 18 1965
FLOW IN CFS
TIME IN HOURS
0 5 10 15 20 25
0 6 12 18 24 30 36

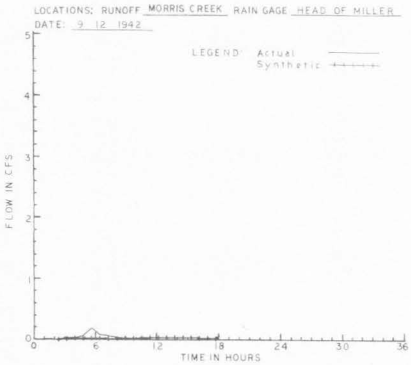

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE SUNSET
DATE: 7 13 1962
FLOW IN CFS
TIME IN HOURS
0 5 10 15 20 25
0 6 12 18 24 30 36

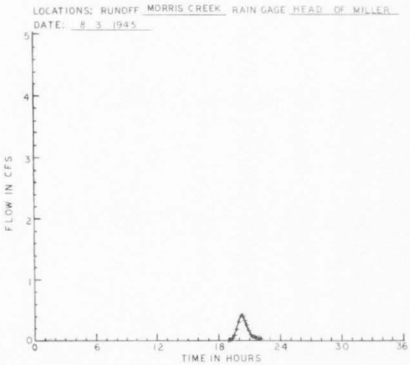

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 9 13 1963
FLOW IN CFS
TIME IN HOURS
0 5 10 15 20 25
0 6 12 18 24 30 36

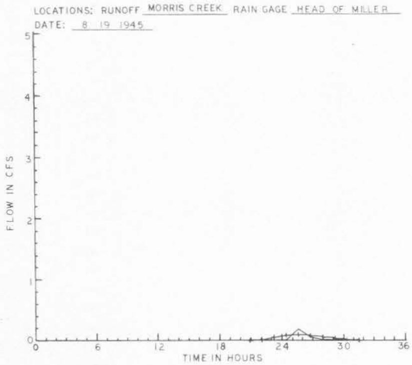

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 8 21 1965
FLOW IN CFS
25
20
15
10
5
0
0
6
12
18
24
30
36
TIME IN HOURS

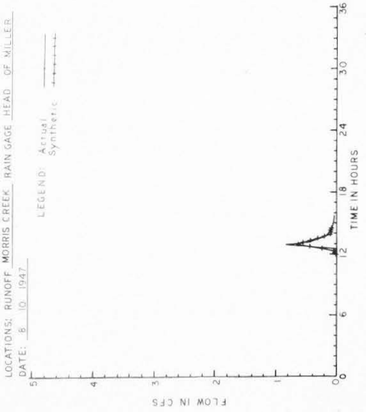

LOCATIONS: RUNOFF HALFWAY CREEK RAIN GAGE HEAD OF HALFWAY
DATE: 8 21 1965
LEGEND: Actual
Synthetic
FLOW IN CFS
25
20
15
10
5
0
0
6
12
18
24
30
36
TIME IN HOURS

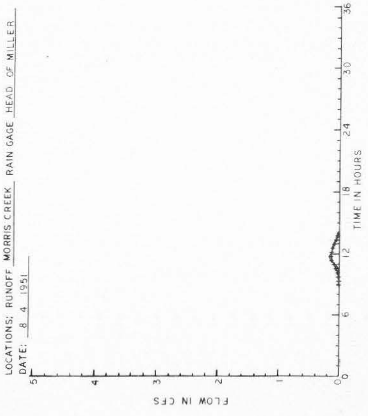

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE MUD CREEK
DATE: 7 1 1940
FLOW IN CFS
0
1
2
3
4
5
0
6
12
18
24
30
36
TIME IN HOURS

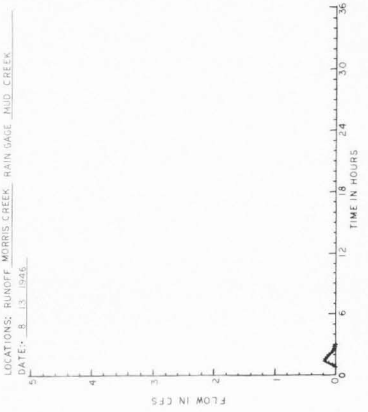

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 9 12 1942
LEGEND: Actual
Synthetic
FLOW IN CFS
0
1
2
3
4
5
0
6
12
18
24
30
36
TIME IN HOURS

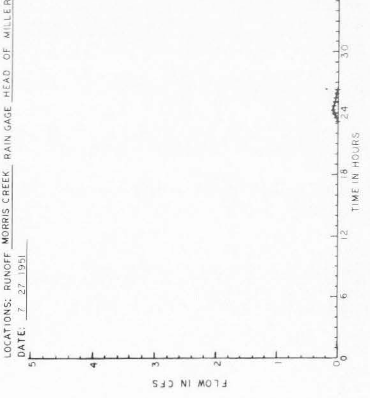

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 8 3 1945
FLOW IN CFS
0
1
2
3
4
5
0
6
12
18
24
30
36
TIME IN HOURS

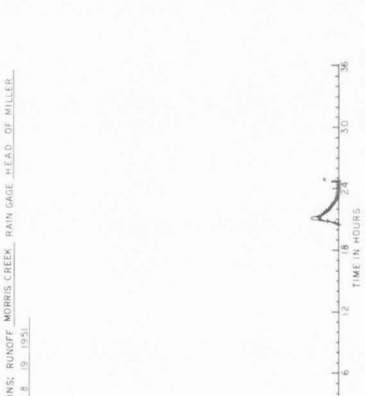

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 8 19 1945
FLOW IN CFS
0
1
2
3
4
5
0
6
12
18
24
30
36
TIME IN HOURS

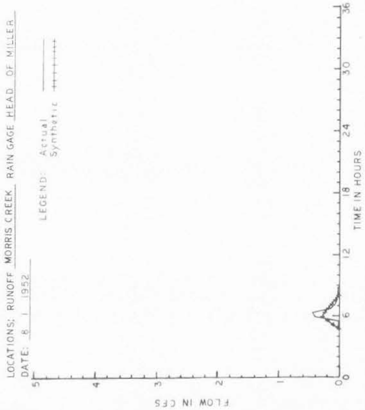

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 8 10 1947
LEGEND: Actual
Synthetic
FLOW IN CFS
TIME IN HOURS

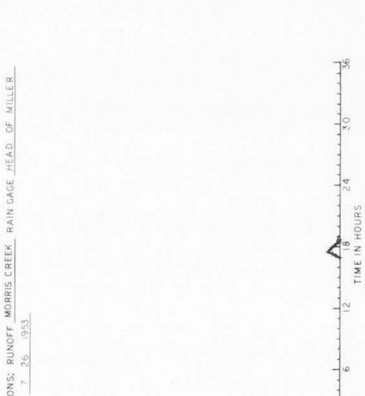

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 8 4 1951
FLOW IN CFS
TIME IN HOURS

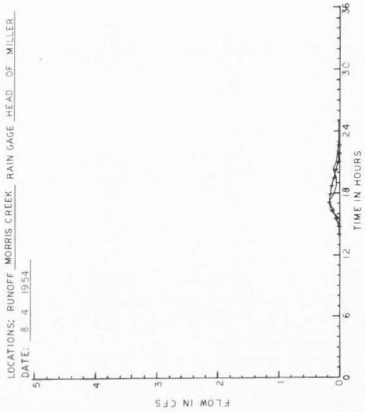

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE MUD CREEK
DATE: 8 13 1946
FLOW IN CFS
TIME IN HOURS

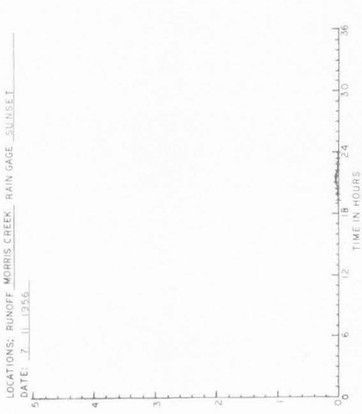

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 7 27 1951
FLOW IN CFS
TIME IN HOURS

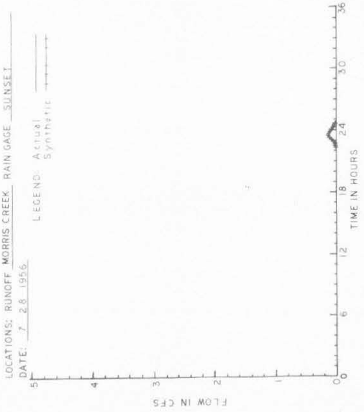

LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 8 19 1951
FLOW IN CFS
TIME IN HOURS


LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 8 1 1952
LEGEND: Actual
Synthetic
FLOW IN CFS
TIME IN HOURS


LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 7 26 1953
FLOW IN CFS
TIME IN HOURS


LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE HEAD OF MILLER
DATE: 8 4 1954
FLOW IN CFS
TIME IN HOURS


LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE SUNSET
DATE: 7 11 1956
FLOW IN CFS
TIME IN HOURS
0
1
2
3
4
5
6
12
18
24
30
36


LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE SUNSET
DATE: 7 28 1956
LEGEND: Actual
Synthetic
FLOW IN CFS
TIME IN HOURS
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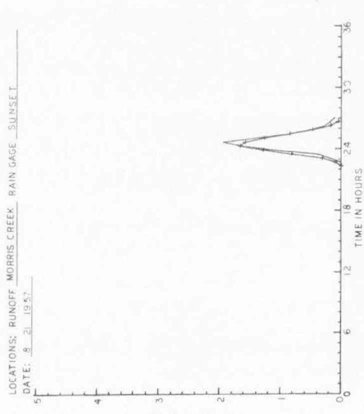
1
2
3
4
5
6
12
18
24
30
36


LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE SUNSET
DATE: 8 21 1957
FLOW IN CFS
TIME IN HOURS
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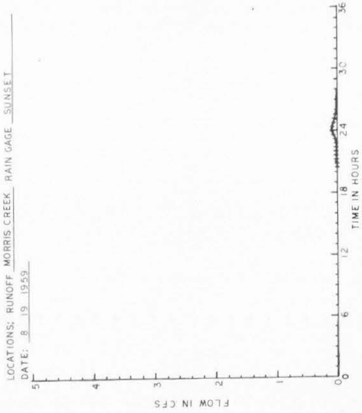
36


LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE SUNSET
DATE: 8 19 1959
FLOW IN CFS
TIME IN HOURS
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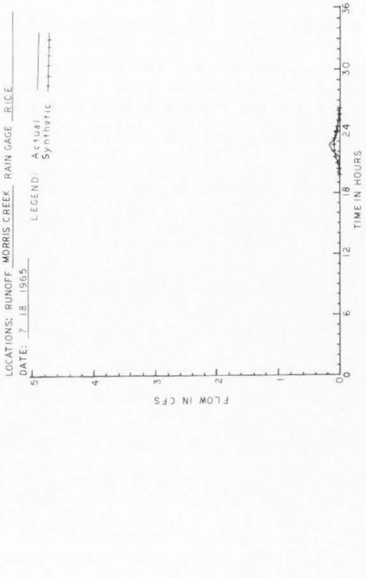
LOCATIONS: RUNOFF MORRIS CREEK RAIN GAGE RICE
DATE: 7 18 1965
LEGEND: Actual
Synthetic
FLOW IN CFS
TIME IN HOURS
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30
36
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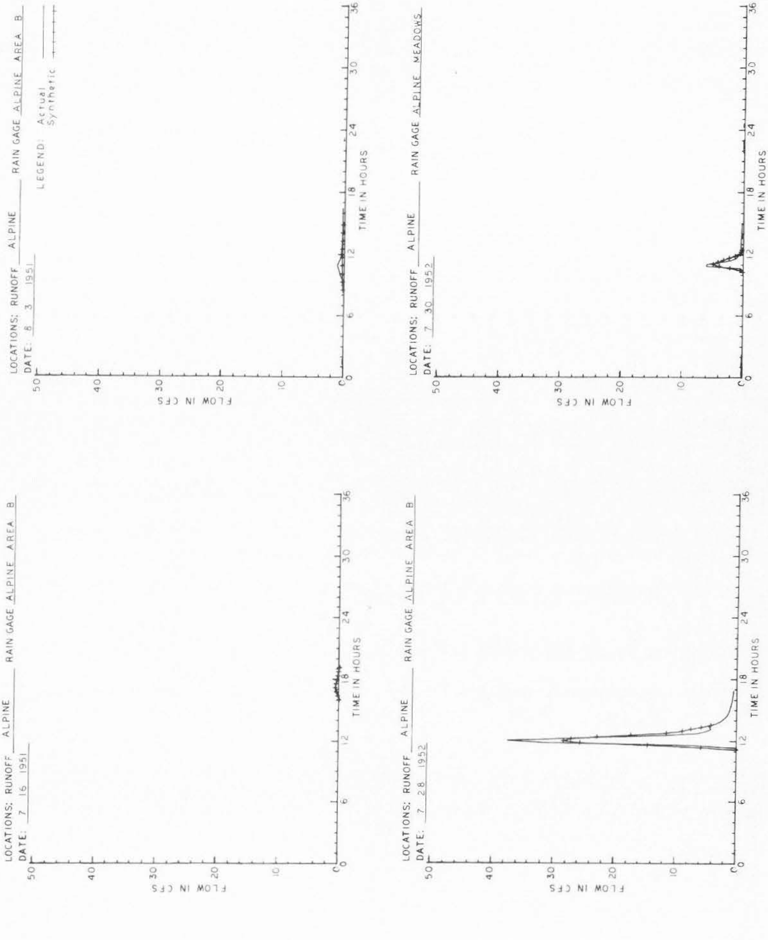
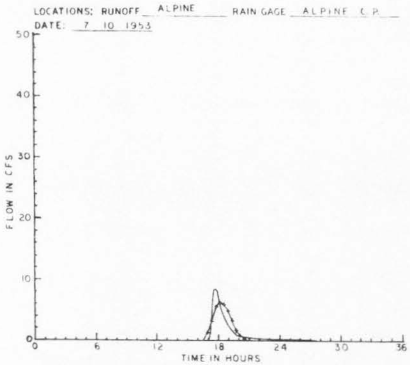

LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE AREA B
DATE: 8 3 1951
LEGEND: Actual
Synthetic
FLOW IN CFS
TIME IN HOURS
LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE MEADOWS
DATE: 7 30 1952
FLOW IN CFS
TIME IN HOURS
LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE AREA B
DATE: 7 16 1951
FLOW IN CFS
TIME IN HOURS
LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE AREA B
DATE: 7 28 1952
FLOW IN CFS
TIME IN HOURS


LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE C.P.
DATE: 7 10 1953
FLOW IN CFS
TIME IN HOURS
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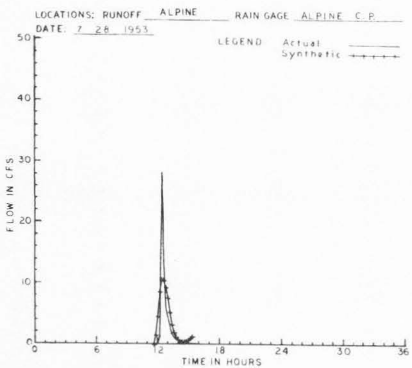
LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE C.P.
DATE: 7 28 1953
LEGEND Actual
Synthetic
FLOW IN CFS
TIME IN HOURS
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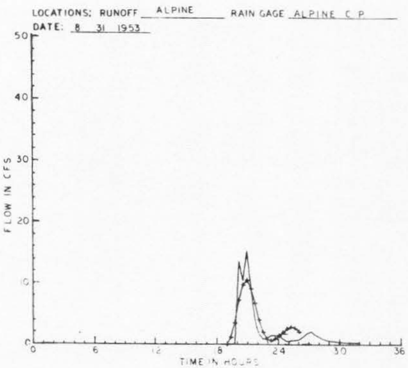
LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE C.P.
DATE: 8 31 1953
FLOW IN CFS
TIME IN HOURS
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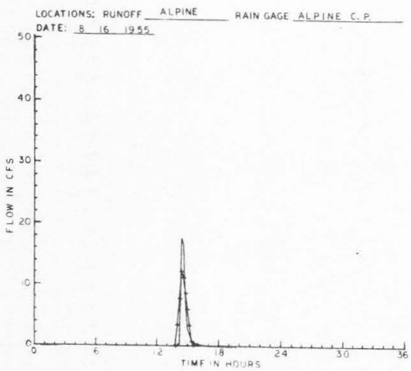
LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE C.P.
DATE: 8 16 1955
FLOW IN CFS
TIME IN HOURS
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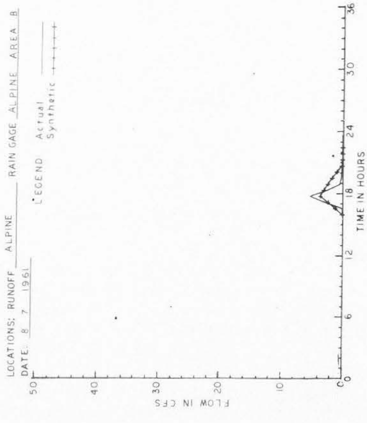
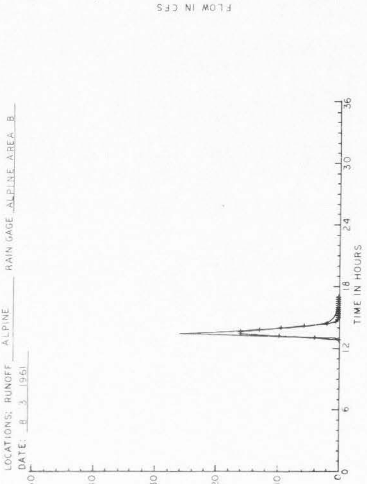

LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE AREA B
DATE: 8 7 1961
LEGEND Actual
Synthetic
FLOW IN CFS
TIME IN HOURS


LOCATIONS: RUNOFF ALPINE RAIN GAGE ALPINE AREA B
DATE: 8 3 1961
FLOW IN CFS
TIME IN HOURS

VITA

Clive H. Walker

Candidate for the Degree of

Master of Science

Thesis: Estimating the Rainfall-Runoff Characteristics of Selected Small Utah Watersheds

Major Field: Water Resources Engineering

Biographical Information:

Personal Data: Born at Nampa, Idaho, November 28, 1935, son of Clive Stevenson and Ardeth Hansen Walker; lived on a small farm until 1953; married Margaret Vay Broadbent, June 8, 1956; three children--Annette, Vida Maria and Clive Steven.

Education: Attended elementary school near Meridian, Idaho; attended Central Junior High School, Nampa, Idaho; graduated from Nampa High School in 1953; honors include attendance at Idaho Boys State; received a Bachelor of Science degree from Utah State University in Civil Engineering, with academic background in history, education, language and biological science, in 1960; completed the requirements for a Master of Science degree in Water Resources Engineering, 1970.

Professional Experience: 1962-present, employed by the Soil Conservation Service as a civil or hydraulic engineer; presently employed as hydraulic engineer on the watershed and river basin planning staff at Casper, Wyoming; previous experiences include a training position in hydraulic engineering at Portland, Oregon, work unit engineer at Logan, Utah, and Richfield, Utah; temporary assignments have included flood damage reporting in Oregon and watershed project construction inspection in Arizona and Utah; 1962-1966, served as supply officer, executive officer, and company commander of various Utah National Guard and U. S. Army Reserve artillery and engineering units in Utah; 1960-1962, served as engineer combat platoon leader, supply officer, personnel officer and Assistant adjutant in the U. S. Army Corps of Engineer units at Fort Lewis, Washington; 1960, research engineering technician, Agricultural Research Service, Brawley, California; 1957-1960, civil engineering trainee, Agricultural Research Service, Logan, Utah.