MODELING OF SOIL EROSION
IN
FORESTED WATERSHEDS

A Thesis

by

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ABSTRACT

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in

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ABSTRACT

The Universal Soil Loss Equation (USLE) predicts soil erosion by water. It has factors that take into account the climatic, the physical, and the topographical characteristics of an area. Among these factors are the crop management (C) and the conservation practice (P) factors, which are not tabulated for forest sites. This two factors may be quantified as a combined CP factor by using the USLE together with the measured soil losses over a year.

Once the CP factors are known, the Modified Universal Soil Loss Equation may be used to predict soil losses that are caused by single rainfall storm events. This may then be used as a managerial tool to evaluate the major factors controlling erosion in forests. Any action may be taken from this point to preserve the water quality of the streams leaving the forests. For example, detention or filtration

ponds may be designed to control runoff water, if there is the economical incentive.

The calculation of a CP factor to represent a forest site and certain treatment conditions enables an evaluation of the site preparations practiced. For three watersheds that were sheared and windrowed, the CP average value found is 0.0014156 for 1981. While for three watersheds that received the roller chopped treatment, the CP value obtained is of 0.00003577 also for 1981. This means that the latter treatment resulted in lower soil losses.

As time advances from the period of treatment, the differences between treatments diminish, resulting in CP factors that are closer together. For 1984, the sheared and windrowed watersheds averaged a CP value of 0.0001368, while the roller chopped gave a value of 0.0000243. This both treatments compared to the lower values resulting from the control watersheds.

When more CP factor values are obtained through research, they may be used in tabular form, as the existing data for agricultural areas, for the practical prediction of soil losses in places where these are not measured directly. Quantified CP factors may then be used when similar forest site preparations are practiced. The CP factor may be used to predict annual soil losses with the Universal Soil Loss Equation or single storm soil erosion with the Modified Universal Soil Loss Equation. Even though more attention is given to the CP factor in this paper, carefull evaluation of the other factors is very important to be able to predict soil losses accurately.

DEDICATION

This Undergraduate Thesis is dedicated to Rolando and Nuria Lopez, the most wonderful parents of the world.

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I wish to thank Dr. John L. Nieber, advisor, for his guidance, friendship, help, and advice throughout the Undergraduate Fellows Program. I also want to thank him very much for giving me the opportunity to work with him while going to school, and for sharing his knowledge with me.

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CHAPTER I

INTRODUCTION

Statement of Purpose

The soil losses, erosion, influenced by mankind lower the productivity levels of soils. The soil moves from places where it will support the growth of plants wanted by man to undesired locations. Soils high in nutrient value become a waste when reaching stream banks, lakes, or others. This soil sediments fill the lakes wanted for water storage, hence reducing the capacity of reservoirs to store water. Nutrients, like nitrogen, held by soil particles pollute waters, contributing to the growth of unwanted water plants, and lowering the water quality.

The Universal Soil Loss Equation (USLE) predicts soil losses from a field. This equation has factors that take into account the rainfall amount, the soil type, the topography, the crop management, and the conservation practice. Even though the USLE was developed to quantify erosion in agricultural lands, some work is being done to adapt its use to forested watersheds, areas. While for agricultural lands there are tables to quantify the crop management and the conservation practice factors, for forest lands there are no tabulated values that may be readily used. Hence, the use of the

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The journal used as a pattern for format and style was <u>Transactions of the American Society of Agricultural Engineers</u>.

equation on the field presents complications. It cannot be easily used to help decide the management practices that are best suited to harvest the woods and prepare the site for the next generation of trees.

Background

Austin W. Zingg, 1940, presented one of the first mathematical expressions to quantify erosion. He considered the effect of land slope, horizontal length and some soil characteristics in the prediction of soil erosion.

Dwight D. Smith (1941) made the distinction between uncontrollable (rainfall amount and intensity, soil type, temperature, degree of slope) and controllable variables (soil moisture, crop rotation, crop residues, length of slope). Smith introduced the crop management and conservation practice factors, as well as the concept of soil loss limit.

W.D. Ellison worked extensively in soil erosion and quantified the rainfall energy that affects erosion, for it is the raindrop splash that detaches the soil particles that are transported.

G.W. Musgrave (1947) published the results of a workshop in Cincinnati in 1946, where soil conservationists analyzed the factors affecting erosion, and added a rainfall factor.

Finally, the Universal Soil Loss Equation (USLE) was developed by

Walter H. Wischmeier and Dwight D. Smith. The most elaborated work was titled: "Predicting Rainfall-Erosion Losses from Cropland East of the Rocky Mountains-Guide for the Selection of Practices for Soil and Water Conservation." It was published in the Agriculture Handbook No. 282, 1965.

George E. Dissmeyer and George R. Foster (1980) cover with some detail the Cover-Management factor (C) for forest lands, which relates to the crop management factor used for agricultural areas. Some of the subfactors that they consider to estimate the C factor are bare soil, canopy, fine roots, and onsite depression storage. They bearly cover the conservation practice factor (P), which will vary from the values used for agricultural lands.

Scope

This paper will present a method to quantify a combined crop management and conservation practice factor (CP) to predict soil erosion with either the Universal Soil Loss Equation (USLE) or the Modified Universal Soil Loss Equation (MUSLE). The USLE gives annual estimates for soil loss, while the MUSLE quantifies single storm erosion. Since the USLE gives long range averages, this equation will be used to quantify the CP values for forests.

The data used for this paper comes from nine watersheds in East Texas located in southwest Cherokee, approximately ten miles west of Alto. County. These watersheds range in size from 6.4 to 6.8, and are located on land owned by Temple-EasTex, Inc. See figure 1 for the location. The watersheds are divided into three treatments. The control, undisturbed watersheds: 4, 6 and 8; the sheared and windrowed: 1, 2 and 3; and the roller chopped: 5, 7 and 9. Hence, the CP values obtained will better represent these kind of treatments, or any similar ones.

The CP factors will be analyzed to demonstrate their use for practical applications. These factors may suggest the optimum forest management practices, to both maintain the soil properties and prevent the pollution of water resources.

The paper consists of three basic parts. It discusses the Universal Soil Loss Equation and its factors. It presents the combined C and P factor computation, as well as its dependance and relation to management practices. And finally, this paper presents the use of the CP factor in the Modified Universal Soil Loss Equation to predict the soil losses resulting from single rainfall storm events.

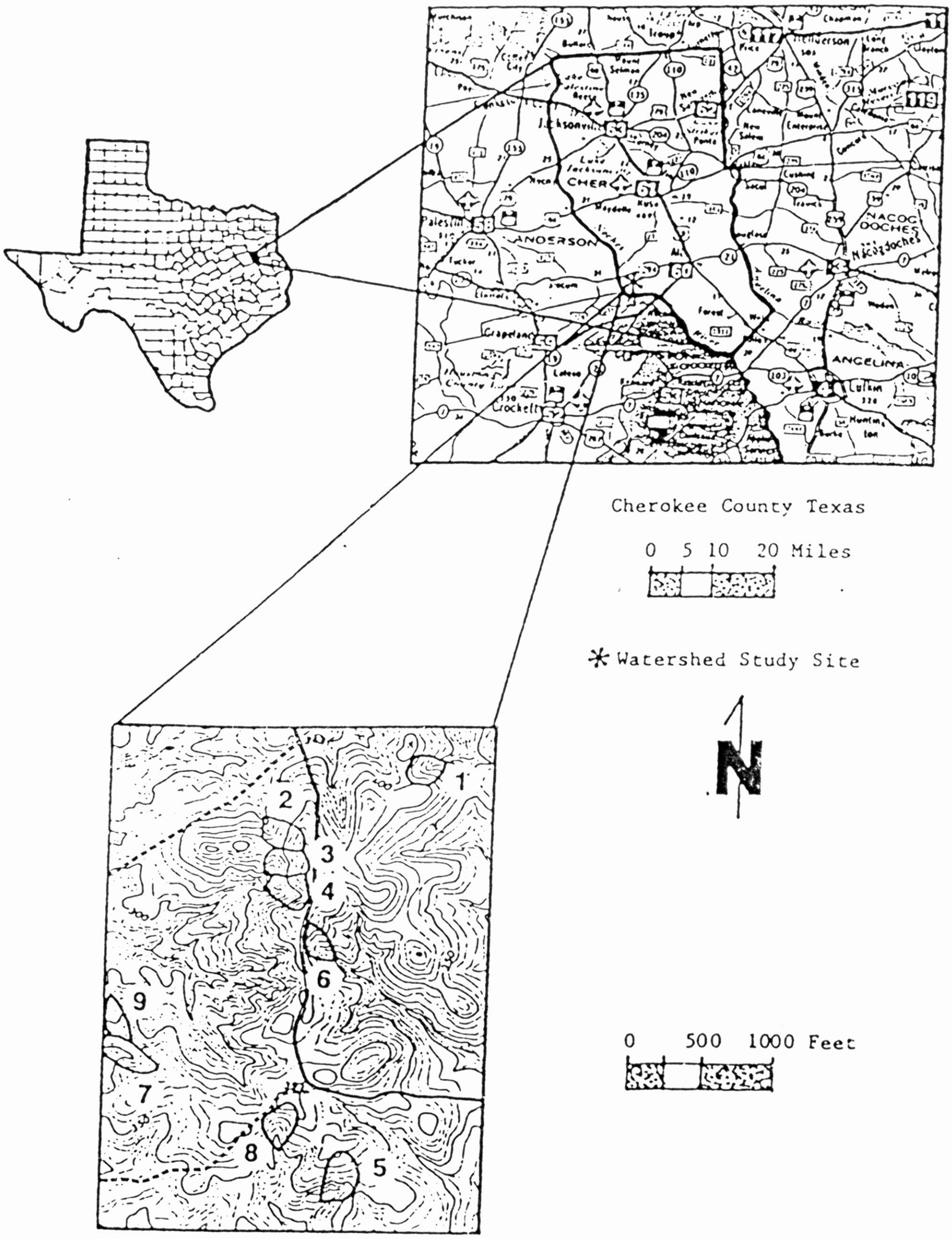

Figure 1. Study Site Location for nine Forested Watersheds

CHAPTER II

THE UNIVERSAL SOIL LOSS EQUATION (USLE)

The need to quantify the soil losses from agricultural lands urged the development of the USLE. This equation enabled conservationists to analyze the factors that affect erosion, so that by varying the controllable parameters erosion may be minimized. Productivity levels are inversely related to soil losses, therefore a reduction in erosion would increase crop and forest yields.

The Universal Soil Loss Equation is expressed as follows:

$$A = R\ K\ L\ S\ C\ P \qquad (1)$$

where A, the annual soil loss in tons per acre, is the mass of soil that is transported from one place to another. R, the rainfall factor, is the number of erosion-index units in one year of normal rain. The erosion-index (EI) measures the erosive force of the rainfall, and is calculated by multiplying the total kinetic energy of the storm to its maximum 30-minute intensity. K, the soil erodibility factor, is the erosion rate per unit of erosion index for a specific soil in cultivated continuous fallow, on a 9-percent slope that is 72.6 feet long. These specifications are the standard reference. L, the slope length factor, is the ratio of soil loss from the field slope length to that from a 72.6-foot length on the same soil type and gradient. S, the slope gradient factor, is the ratio of soil loss from the field gradient to that from a 9-percent slope.

The slope length and slope gradient factors may be combined to yield the topographic factor (LS). C, the crop management factor, is the ratio of soil loss from a field with specified cropping and management to that from the standard fallow condition on which the factor K is evaluated. P, the conservation practice factor, is the ratio of soil loss with contouring, stripcropping, or terracing to that with straight-row farming, up-and-down the slope.

This equation attempts to extrapolate limited research data to the wide range of conditions and locations of different fields. Measured soil losses are used in research to quantify conditional, dependent parameters such as crop management and conservation practice. Once the values obtained through research are tabulated, these are used for similar crop management and conservation practices where the rainfall and other uncontrollable factors may be quantified in relation to local characteristics.

The rainfall factor (R) is obtained by using either the rainfall events occuring within a year to calculate it, or the maps that provide this factor as an annual average. The soil erodibility factor (K) is determined from soil characteristics found in tables for different soil types. Both, the slope length (L) and gradient (S) factors are obtained using measurements from the field under consideration. These two factors may be quantified using contour maps of the watershed. The L and the S factor calculation for forest areas is more complex than for agricultural lands due to the irregular topography, and hence requires careful consideration. Since the crop management (C) and the conservation practice (P) factor values are different for forest lands, their computation as a combined factor will be presented after the evaluation of the other factors.

Soil Erosion Factor (A)

The sediment yield was obtained in a sampling station at the outlet of each watershed. A Coshocton wheel sampler was used to collect water samples. The suspended solids were measured out of these samples to estimate the soil loss concentration of the watershed in a given storm event. Suspended sediments were determined by filtering with vacuum each subsample of water through 0.000018 inch filters, oven drying at 220 ^{0}F and weighing. Notice that the soil loss due to the bed load of the channel are not taken into account because this is not what the Universal Soil Loss Equation predicts.

The soil loss concentration was multiplied to the total runoff yielded by the storm and to the area of the watershed in order to obtain the total weight of sediment yield resulting from a particular storm, in tons. The amount of runoff volumes were measured with 3 ft H-flumes equipped with FW-1 type water level recorders. The total runoff volume was calculated from the recorded charts.

The A factor, soil loss in tons per acre, was then calculated as the sum of the sediment yields of all the storms within a certain year, divided by the area of the watershed. This measured factor was quantified for all the years of interest, to enable the analysis of the CP factor characterizing a given year and watershed. See appendix A for the values of the measured soil losses in tons for all the watersheds and corresponding dates, and for the equations used to convert sediment concentration in grams per liter to tons.

Rainfall Factor (R)

The rainfall factor was evaluated for yearly periods. Rainfall charts generated by a recording rain gage were digitized to make a file in x-y pairs, the rainfall amount versus time. This data file was processed with a program (Stavros ASAE Paper 81-2032) to obtain the rainfall intensities, and also the erosion index corresponding to the digitized storm. Then, the R factor was calculated by summing the erosion indexes for all the storm events taking place within a year. See appendix B for program used and table of Erosion Index factors.

Soil Erodibility Factor (K)

The soil erodibility factor was calculated as a weighted average according to the soil type for each of the nine watersheds. The soil erodibility factor for each soil type was obtained from soil interpretations records, since it has already been evaluated and is a function of the soil type. A soil-erodibility nomograph may also be used to compute the K factor (Wischmeier and Smith, 1978). Watershed maps with the areas of each different soil type delineated were digitized to obtain the corresponding areas. The total area for a certain soil type was divided by the watershed area to find the weighting factor to be multiplied to the K factor representing this soil type. See appendix C for soil types and K factors.

Topographic Factor (LS)

The combined soil topografic factor was evaluated using the nine watershed contoured maps, having a five feet contour interval. Because of the irregular topografic conditions in forested watersheds a method suggested by Williams and Berndt was used to provide a better estimate of the factor.

The length of slope was approximated by dividing the total watershed area by the total length of the channels within the watershed, and then dividing the resulting value by two. This assumes that the length of the slope is constant within the watershed, making the contributing area a rectangle of which one length is given by the length of the channel, and the other by the length of the slope.

The degree of slope was calculated in intervals of ten feet of elevation. This slope was obtained by multiplying the height interval to the average of the lengths of the contour lines making the height interval. This value is divided by the area between corresponding contour lines to yield the slope for this partial area. The final degree of slope was calculated by weighting the partial slopes according to their contributing area to the total area of the watershed. In some cases the area between contour lines was divided into more partial areas to account for height differences near the boundary limits of the watershed. Most difficulties took place in the higher elevation boundaries due to the larger areas involved, and due to the irregularity on the contour lines continuity, as these were cut by boundary limits.

The length and degree of slope calculated above were used with the appropriate equation to obtain the LS factor for the Universal Soil Loss Equation (Wischmeier and Smith, 1978). Tables may also be used to find the LS factor once the two parameters are known. See appendix D for materials and equations to calculate the topographic (LS) factor.

CHAPTER III

THE COMBINED CROP MANAGEMENT AND CONSERVATION PRACTICE FACTOR (CP)

The crop management and conservation practice combined factor for forested watersheds accounts for a more diverse set of characteristics than for an agricultural watershed, which has more homogeneous factors involved. The canopy, amount of vegetative cover, in forested sites may vary widely depending on the population and the type of trees grown. The bare soil areas, where the unprotected soil erodes thanks to the raindrop impact that detaches the soil particles, should also be taken into account in the CP factor. The root density, specially close to the surface, and the logs, woods left on the field, which will hold the soil that is being washed, together with some other factors will have significant effect in the early stage of development of the emerging trees.

Use of the USLE

When the soil loss is measured, and the R, K, L and S factors are known the USLE may be used to calculate the CP factor as follows:

$$CP = \frac{A}{R\ K\ LS} \qquad (2)$$

where the CP factor would then take into account any other variables not included in the R, K, L, or S factor. A CP factor value is hence obtained to fit the characteristics of the forest site considered.

Sample Calculation

For watershed #1, for 1981 the following values were obtained:

A = 0.49808875 tons/acre/year

R = 488.85721 Erosion-index (EI) units/year

K = 0.2312 tons soil/acre/EI unit

LS = 2.70

Where A is the measured value and R is the regional value obtained by using recording rain gages for the interval considered. K is the weighed soil erodibility factor for watershed #1, and LS, the combined topographic factor, is the weighed slope length and gradient factor for the watershed, to be used regardless the period under consideration. Note however that the topography does change with time.

With these values the combined CP value is calculated as follows:

$$CP = \frac{A}{R\ K\ LS}$$

$$CP = \frac{0.49808875 \text{ tons/acre/yr}}{(488.85721 \text{ EI units/yr})(0.2312 \text{ tons/acre/EI unit})(2.70)}$$

CP = 0.0016322 (watershed #1, shear and windrow treatment)

Experimental CP Factors Obtained

The CP factor values obtained by using the Universal Soil Loss Equation for 1981, 1982, 1983, and 1984 are presented in table 1 and table 2. Where watersheds 1, 2 and 3 are sheared and windrowed (SHR); 4, 6 and 8 are undisturbed (UND); and 5, 7 and 9 are roller chopped (CHP).

Analysis of CP Factor Values

Notice the decrease in the CP factor values, specially from 1981 to 1982. The harvesting operations, similar for all watersheds, were completed in October, 1980. The site preparation period ended in February, 1981 when the loblolly pine seedlings were planted. The CP values for 1981 were closer to the treatment period, and as a result were higher than the ones for 1982. The regenerated vegetation that develops with time protects the exposed soil, and reduces the energy available to erode the soil, hence reducing the CP values as time to treatment increases. But, the difference in CP values from 1981 to 1982 may be due to the higher rainfall amount during 1981. This is reflected in the rainfall factors, 488.86 for 1981 and 299.12 for 1982.

Table 3 shows the arithmetic average of the CP values according to treatment for 1981, 1982, 1983 and 1984. The values for the sheared and windrowed treatment yields significantly larger values than the roller chopped treatment or the control watersheds. The

Table 1. All factors for the USLE for the nine watersheds.

WS	PERIOD	A	R	K	LS	CP
1	1981	0.49808875	488.85721	0.2312	2.700	1.6321990 E-3
	1982	0.02991240	299.12387	0.2312	2.700	1.6019486 E-4
	1983	0.00713452	361.73144	0.2312	2.700	3.1595621 E-5
	1984	0.03113445	292.37817	0.2312	2.700	1.7058650 E-4
					AVG.=	4.9864399 E-4
2	1981	0.90871876	488.85721	0.2824	4.167	1.5796442 E-3
	1982	0.04445267	299.12387	0.2824	4.167	1.2628698 E-4
	1983	0.01719210	361.73144	0.2824	4.167	4.0388198 E-5
	1984	0.02115035	292.37817	0.2824	4.167	6.9480788 E-4
					AVG.=	4.7917207 E-4
3	1981	0.44461396	488.85721	0.2287	3.843	1.0348193 E-3
	1982	0.00664976	299.12387	0.2287	3.843	2.5294048 E-5
	1983	0.00522519	361.73144	0.2287	3.843	1.6435362 E-5
	1984	0.01785444	292.37817	0.2287	3.843	6.9480788 E-5
					AVG.=	2.8650737 E-4
4	1981	0.00321472	488.85721	0.2584	4.896	5.1978915 E-6
	1982	0.00070338	299.12387	0.2584	4.896	1.8586817 E-6
	1983	0.00103336	361.73144	0.2584	4.896	2.2580391 E-6
	1984	0.00250351	292.37817	0.2584	4.896	6.7681576 E-6
					AVG.=	4.0206924 E-6
6	1981	0.03877380	488.85721	0.2994	3.578	7.4039625 E-5
	1982	0.00605195	299.12387	0.2994	3.578	1.8886528 E-5
	1983	0.00494488	361.73144	0.2994	3.578	1.2760784 E-5
	1984	0.02115035	292.37817	0.2994	3.578	6.7527470 E-5
					AVG.=	4.3303851 E-5
8	1981	0.00192271	488.85721	0.2619	2.519	5.9616722 E-6
	1982	0.00007756	299.12387	0.2619	2.519	3.9302761 E-7
	1983	0.00049950	361.73144	0.2619	2.519	2.0930787 E-6
	1984	0.00101522	292.37817	0.2619	2.519	5.2632203 E-6
					AVG.=	3.4277497 E-6
5	1981	0.00916291	488.85721	0.2233	2.274	3.6912394 E-5
	1982	0.00121127	299.12387	0.2233	2.274	7.9746330 E-6

	1983	0.00080691	361.73144	0.2233	2.274	4.3929843 E-6
	1984	0.00368349	292.37817	0.2233	2.274	2.4810491 E-5
					AVG.=	1.8522625 E-5
7	1981	0.01089761	488.85721	0.3110	2.644	2.7109867 E-5
	1982	0.00106057	299.12387	0.3110	2.644	4.3118776 E-6
	1983	0.00217115	361.73144	0.3110	2.644	7.2993087 E-6
	1984	0.00364199	292.37817	0.3110	2.644	1.5148581 E-5
					AVG.=	1.3467408 E-5
9	1981	0.01732591	488.85721	0.3107	2.634	4.3306891 E-5
	1982	0.00505556	299.12387	0.3107	2.634	2.0651955 E-5
	1983	0.00419954	361.73144	0.3107	2.634	1.4185900 E-5
	1984	0.00788893	292.37817	0.3107	2.634	3.2969786 E-5
					AVG.=	2.7778633 E-5

Table 2. Summary of the CP Factors.

Sheared and windrowed:

WS	1981	1982	1983	1984
1	1.6321990 E-3	1.6019486 E-4	3.1595621 E-5	1.7058650 E-4
2	1.5796442 E-3	1.2628698 E-4	4.0388198 E-5	6.9480788 E-5
3	1.0348193 E-3	2.5294048 E-5	1.6435362 E-5	6.9480788 E-5
AVG.	1.4155542 E-3	1.0392396 E-4	2.9473960 E-5	1.3681220 E-4

TREATMENT AVERAGE= 4.2144108 E-4

Undisturbed, control:

WS	1981	1982	1983	1984
4	5.1978915 E-6	1.8586817 E-6	2.2580391 E-6	6.7681576 E-6
6	7.4039625 E-5	1.8886528 E-5	1.2760784 E-5	6.7527470 E-5
8	5.9616722 E-6	3.9302761 E-7	2.0930787 E-6	5.2632203 E-6
AVG.	2.8399730 E-5	7.0460791 E-6	5.7039672 E-6	2.6519620 E-5

TREATMENT AVERAGE= 1.69173491 E-5

Roller chopped:

WS	1981	1982	1983	1984
5	3.6912394 E-5	7.9746330 E-6	4.3929843 E-6	2.4810491 E-5
7	2.7109867 E-5	4.3118776 E-6	7.2993087 E-6	1.5148581 E-5
9	4.3306891 E-5	2.0651955 E-5	1.4185900 E-5	3.2969786 E-5
AVG.	3.5776384 E-5	1.0979489 E-5	8.6260645 E-5	2.4309619 E-5

TREATMENT AVERAGE= 3.93315343 E-5

average CP values for four years were 0.0004214 for the shearedand windrowed, 0.0000169 for the control, and 0.0000393 for the roller chopped. This compares to C factor values ranging from 0.0001 to 0.001 for forests (Wischmeier and Smith, 1978). Assuming a value of 0.5 for P, quite common, the CP factor would range from 0.00005 to 0.0005.

Table 3. Average treatment CP values

TREATMENT	1981	1982	1983	1984
Sheared	1.4155542 E-3	1.0392396 E-4	2.9473960 E-5	1.3681220 E-4
Control	2.8399730 E-5	7.0460791 E-6	5.7039672 E-6	2.6519620 E-5
Chopped	3.5776384 E-5	1.0979489 E-5	8.6260645 E-5	2.4309619 E-5

See figures 2 to 5 for a graphical representation of the CP values according to treatment and year. The CP value for the sheared and windrowed treatment for 1981 really shows to be significantly different from the other two. Only the value for 1983 for the roller chopped treatment resulted in being larger than the sheared one, but both being very close to each other.

A lower CP value results in a lower soil loss. The soil loss is directly proportional to the CP factor, as presented by the USLE. This means that comparing CP factors shows the areas that yield larger soil losses. Therefore, from the values derived here, the undisturbed watersheds tend to yield the lowest soil loss and CP factor values. The sheared and windrowed treatment yields more soil loss than the roller chopped treatment, which appears to be a better treatment method from the soil conservation point of view.

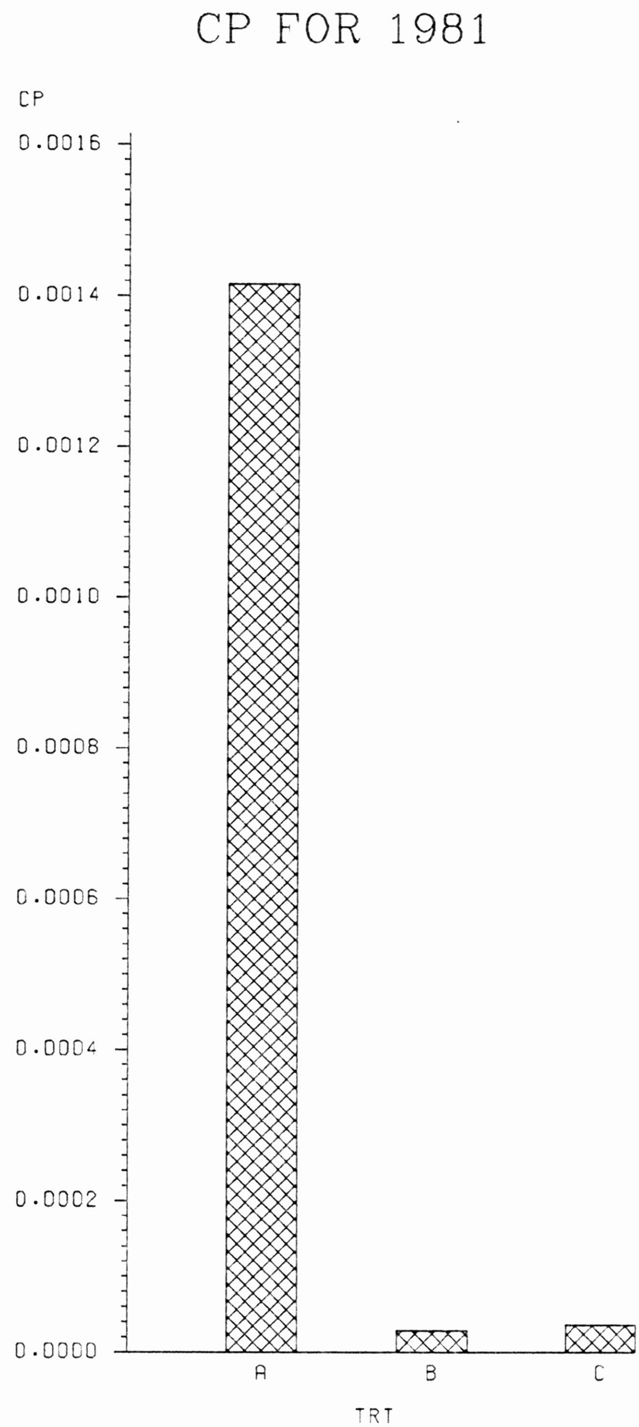

Figure 2. 1981 CP combined factor values for three treatments A = sheared and windrowed, B = control, C = roller chopped

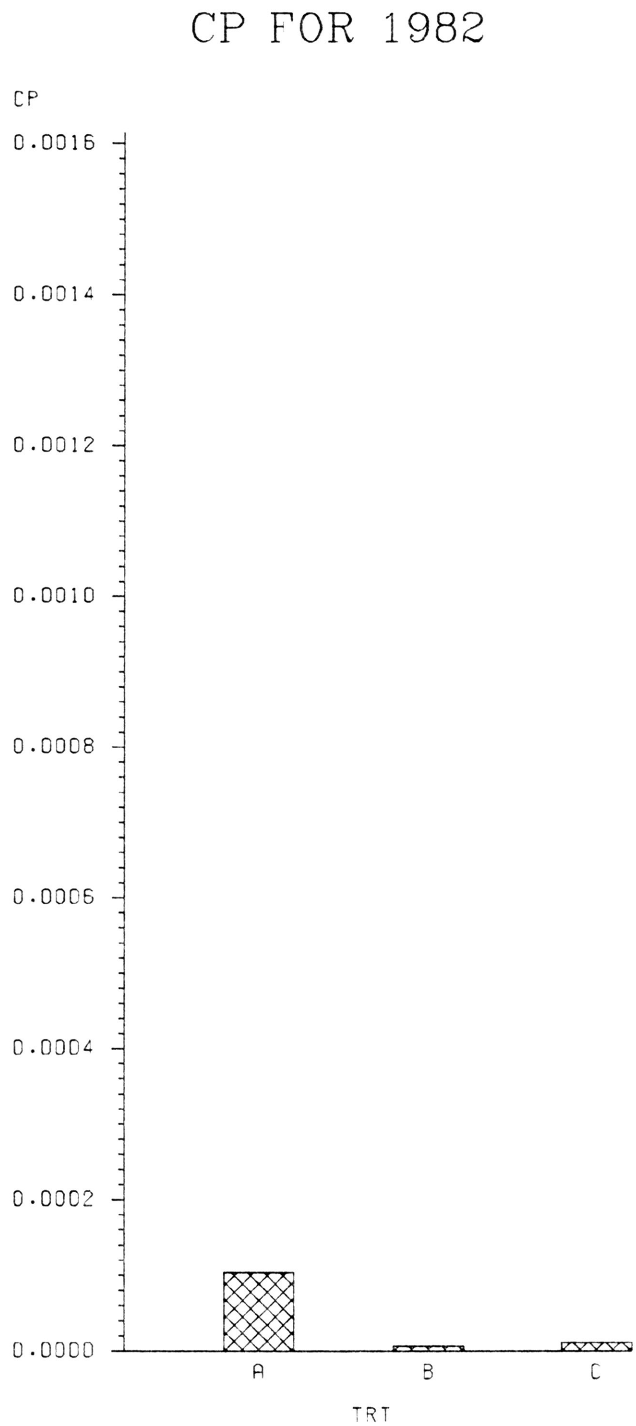

Figure 3. 1982 CP combined factor values for three treatments A = sheared and windrowed, B = control, C = roller chopped

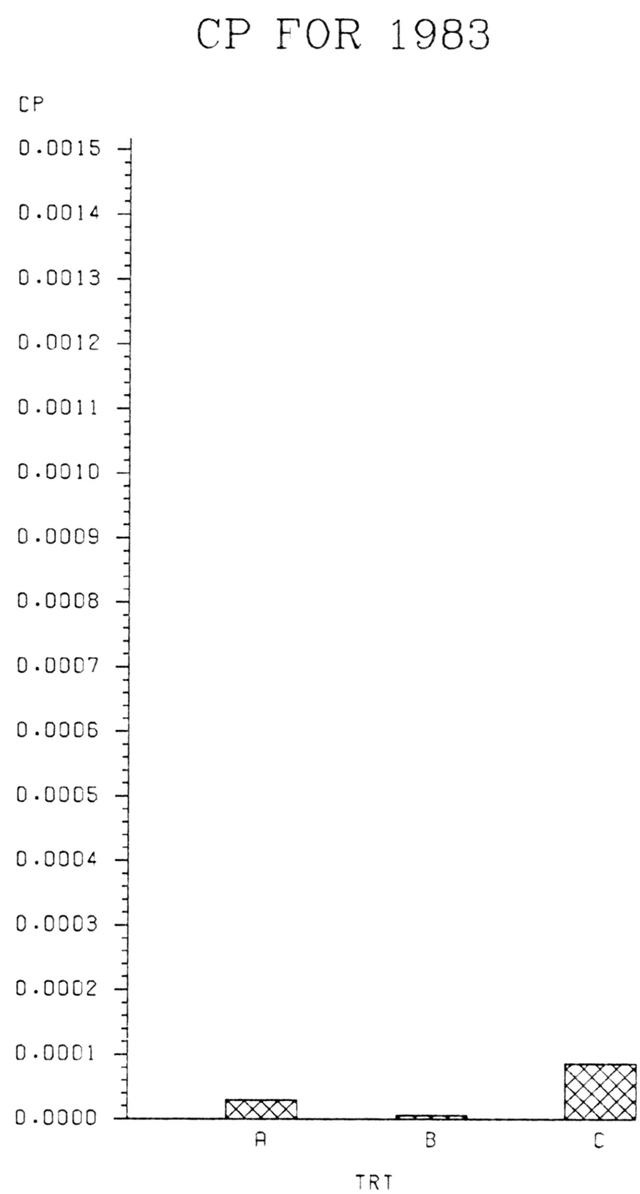

Figure 4. 1983 CP combined factor values for three treatments A = sheared and windrowed, B = control, C = roller chopped

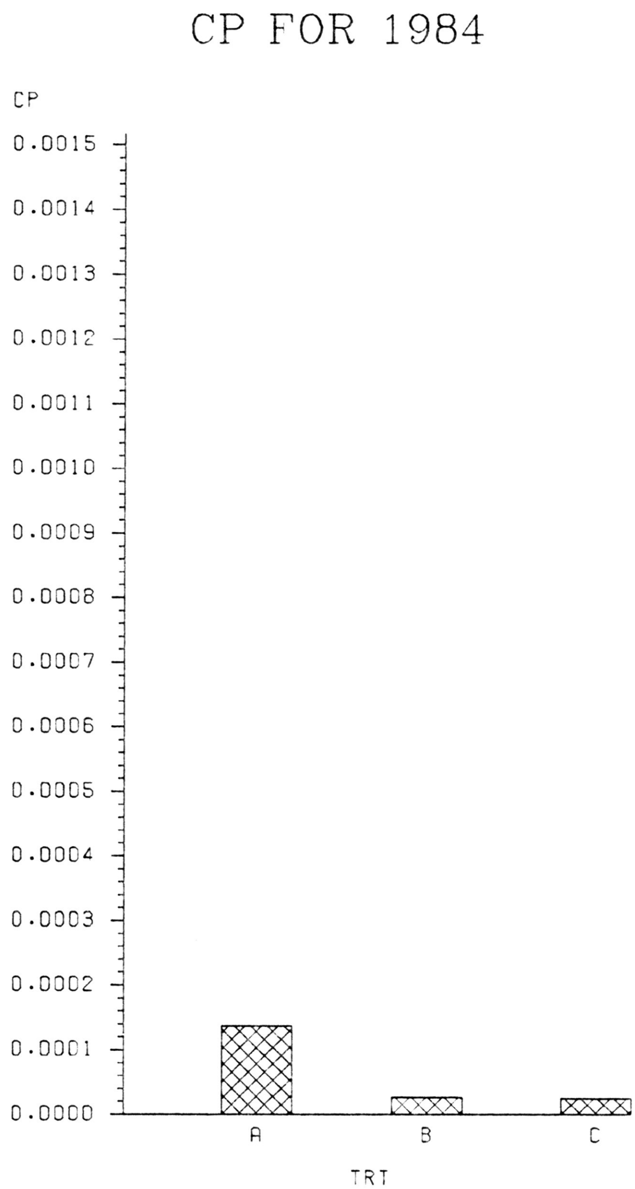

Figure 5. 1984 CP combined factor values for three treatments A = sheared and windrowed, B = control, C = roller chopped

CHAPTER IV

THE MODIFIED UNIVERSAL SOIL LOSS EQUATION (MUSLE)

Once the factors used in the USLE are quantified, the MUSLE may be used to predict the soil loss generated by a single rainfall storm. One form of the MUSLE states as follows:

$$y = 56\ (Q\ q)^{0.56}\ K\ L\ S\ C\ P \quad (5)$$

where y is the soil loss (tons), Q is the runoff volume (acre-ft), q is the peak runoff rate (cfs), K is the soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is the crop management factor, and P is the conservation practice factor.

The R factor of the USLE is replaced in this equation by the resulting runoff volume and peak rate of a rainfall event, which are directly proportional to the soil loss. A large runoff volume or high peak runoff rate yields a large soil loss.

Table 4 has some calculated values for sediment yields that represent the three treatments. The CP average factor values for each treatment for the four years considered were used to estimate the sediment yields. These calculated values appeared to be smaller than the measured ones most of the times.

This method for evaluating sediment yields for single storm events would not be possible at every forest, because flumes would have to be built, and instrumentation bought to be able to quantify runoff

Table 4. Calculated and Measured Sediment Yields, in tons

DATE	WS	Q (ac-in)	q (cfs)	SEDIMENT YIELDS CALCULATED	SEDIMENT YIELDS MEASURED
05/15/80	6	1.350422	11.2266	0.0046517	0.2004483
05/16/81	3	0.098317	1.5123	0.0071340	0.1551244
06/04/81	7	0.483147	1.1282	0.0012832	0.0107687
10/14/81	1	2.004735	16.5520	0.1047091	0.7035130
10/14/81	8	0.286583	1.1214	0.0003099	0.0100913
05/13/82	2	0.303432	0.6784	0.0114604	0.0306408
02/05/83	9	0.611539	0.7955	0.0010394	0.0051604
11/19/83	3	0.008392	0.0946	0.0003808	0.0000000
03/04/84	9	0.822356	2.7698	0.0024675	0.0270942

CP Values used:

Sheared and windrowed (1,2,3): 4.21441 E-4

Undisturbed, control (4,6,8): 1.69173 E-5

Roller chopped (5,7,9): 3.93315 E-5

volumes and peaks. But, this method may provide a tool to evaluate and analyze sediment losses generated by the different types of storms.

CHAPTER V

CONCLUSIONS

The crop management and conservation practice factors used in the Universal Soil Loss Equation may be quantified for forest sites, using measured soil loss values. The evaluated CP combined factor characterizes the conditions of the soil. These depend on the treatment practiced in preparing harvested sites in forest areas. Site preparations distribute the small woods, litter through the soil in different patterns, which relate to a CP factor. As a result, similar treatments may be represented by a common CP factor to estimate the soil losses that take place in forested watersheds. This factor may be used in locations where the soil loss is not measured, but where forest practices are similar. All other factors need to be evaluated for the particular location.

The use of the USLE and the measured soil loss to compute the CP factor is quite simple, but other factors also come into play. Gully (channel) erosion may add soil sediments to the measured soil loss that are not actually being contributed by the watershed top soil. The result is a higher CP factor. On the other hand, soil particles are transported within the watershed, and they even reach the channels, but not all to the outlet where the soil loss is measured. This reduces the actual soil erosion taking place, and yields a lower CP factor than the true one.

Once the CP factor is computed with the USLE, the Modified Universal Soil Loss Equation may be used to predict soil losses produced by a single rainfall event. The factors used in the USLE may be applied to this equation, excluding the R factor. The runoff volume and peak runoff rate replace the R factor, and therefore need to be measured.

The CP factor is a function of forest treatment. The type of site preparation practiced will control the protective cover left to reduce soil erosion. Hence, the CP factor will be related to the protective cover that reduces the impact of the raindrop energy on the exposed soil. The CP factor will not only depend on this factor, but it will also be a function of depressions generated by the treatment, soil aggregate stability, additional pathways for runoff water to reach the main channel faster, and many others. The CP factor as a result is to account for any variable not considered by the rainfall, the soil erodibility and the topographic factors.

The CP combined factor values obtained with this method may be used in other locations where the forest practices are similar. When more values are obtained through research to enable a good statistical representation for the different treatments practiced, these CP factors will become very practical in predicting soil losses.

This method for calculating soil erosion might ease the burden of having to evaluate factors to account for root density, canopy, bare soil, organic content of soils, onsite storage, and other factors. These factors could not be practically and economically evaluated on every forest site to predict soil losses that may aid in forest management practices.

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APPENDIX A

SOIL EROSION FACTOR (A)

" A " FACTOR CALCULATION FOR USLE

$$Y_i = RO(in) * DA(acres) * SED(g/l) * 0.113394303$$

$$A = \frac{\sum Y_i}{DA}$$

WHERE:

Y_i = ith MEASURED SEDIMENT YIELD, TONS

RO = RUNOFF VOLUME, INCHES

DA = TOTAL AREA OF THE WATERSHED, ACRES

SED = SEDIMENT CONCENTRATION, g/l

MEASURED SOIL LOSSES (tons)

WATERSHED	PERIOD		SUM	T/ACRE
1	1/ 1/80	12/30/80	0.10040275	0.01554222
1	12/31/80	12/30/81	3.21765327	0.49808875
1	12/31/81	12/30/82	0.19323413	0.02991240
1	12/31/82	12/30/83	0.04608898	0.00713452
1	12/31/83	12/31/84	0.20112856	0.03113445
2	1/ 1/80	12/30/80	1.21401405	0.19058305
2	12/31/80	12/30/81	5.78853846	0.90871876
2	12/31/81	12/30/82	0.28316349	0.04445267
2	12/31/82	12/30/83	0.10951369	0.01719210
2	12/31/83	12/31/84	0.37339133	0.05861716
3	1/ 1/80	12/30/80	0.09207520	0.01412196
3	12/31/80	12/30/81	2.89888310	0.44461396
3	12/31/81	12/30/82	0.04335643	0.00664976
3	12/31/82	12/30/83	0.03406825	0.00522519
3	12/31/83	12/31/84	0.11641092	0.01785444
4	1/ 1/80	12/30/80	0.26662648	0.04052074
4	12/31/80	12/30/81	0.02115283	0.00321472
4	12/31/81	12/30/82	0.00462826	0.00070338
4	12/31/82	12/30/83	0.00679949	0.00103336
4	12/31/83	12/31/84	0.01647310	0.00250351
5	1/ 1/80	12/30/80	0.03975867	0.00593413
5	12/31/80	12/30/81	0.06139148	0.00916291
5	12/31/81	12/30/82	0.00811553	0.00121127
5	12/31/82	12/30/83	0.00540630	0.00080691
5	12/31/83	12/31/84	0.02467936	0.00368349
6	1/ 1/80	12/30/80	0.22704642	0.03450553
6	12/31/80	12/30/81	0.25513157	0.03877380
6	12/31/81	12/30/82	0.03982181	0.00605195
6	12/31/82	12/30/83	0.03253732	0.00494488
6	12/31/83	12/31/84	0.13916929	0.02115035
7	1/ 1/80	12/30/80	0.08759829	0.01292010
7	12/31/80	12/30/81	0.07388578	0.01089761
7	12/31/81	12/30/82	0.00719069	0.00106057
7	12/31/82	12/30/83	0.01472043	0.00217115
7	12/31/83	12/31/84	0.02469266	0.00364199
8	1/ 1/80	12/30/80	0.07365389	0.01140153
8	12/31/80	12/30/81	0.01242069	0.00192271
8	12/31/81	12/30/82	0.00050105	0.00007756
8	12/31/82	12/30/83	0.00322677	0.00049950
8	12/31/83	12/31/84	0.00655830	0.00101522
9	1/ 1/80	12/30/80	0.17355525	0.02567385
9	12/31/80	12/30/81	0.11712314	0.01732591
9	12/31/81	12/30/82	0.03417555	0.00505556
9	12/31/82	12/30/83	0.02838891	0.00419954
9	12/31/83	12/31/84	0.05332914	0.00788893

MEASURED SOIL LOSSES (tons)

ws	date	y
1	12080	0.00000000
1	12180	0.00217999
1	2 880	0.00000000
1	41380	0.00135371
1	51580	0.09686905
1	21081	0.00000000
1	3 181	0.00000000
1	3 381	0.98624772
1	32981	0.00000000
1	5 481	0.00000000
1	5 981	0.14038542
1	51681	0.07061244
1	52481	0.00000000
1	53081	0.23608683
1	6 281	0.00000000
1	6 381	0.09039060
1	6 481	0.50956172
1	61281	0.15366974
1	61681	0.00000000
1	62381	0.00000000
1	7 781	0.24166791
1	7 881	0.00000000
1	91581	0.00000000
1	10 981	0.03099458
1	101481	0.70351297
1	101881	0.00000000
1	11 181	0.05204441
1	11 881	0.00247886
1	13082	0.00219977
1	41782	0.00000000
1	41982	0.08454798
1	42182	0.00161448
1	42482	0.00000000
1	42882	0.06399335
1	51382	0.01645543
1	51782	0.00000000
1	52382	0.00000000
1	52482	0.00000000
1	61682	0.00000000
1	63082	0.00000000
1	102882	0.00000000
1	11 282	0.00000000
1	112682	0.01489369
1	121182	0.00000000
1	121482	0.00029301
1	122382	0.00223493
1	122482	0.00122625
1	122582	0.00000000
1	122682	0.00416660
1	122682	0.00160862
1	1 183	0.00000000
1	13183	0.00381059
1	2 583	0.00451235
1	2 983	0.00308979
1	22083	0.00000000
1	3 483	0.00135371
1	32383	0.00615321
1	32683	0.00328171
1	51883	0.00000000
1	51983	0.00221515
1	52083	0.00000000
1	52183	0.01427324
1	6 683	0.00043146
1	121083	0.00696777
1	21284	0.00000000
1	3 484	0.07795234
1	31284	0.02181751
1	102084	0.00024320
1	102184	0.04061409
1	102284	0.01359566
1	102384	0.02617164
1	102884	0.00662129
1	11 184	0.00863793
1	112684	0.00120134
1	12 584	0.00000000
1	121384	0.00035161
1	121684	0.00029008
1	123084	0.00363186
2	12180	0.01525538
2	2 880	0.00982643
2	32780	0.00000000
2	41380	0.01639737
2	51380	0.00765947
2	51480	0.00000000
2	51580	1.16487539
2	21081	0.03498914
2	3 181	0.00000000
2	3 381	0.19274580
2	3 781	0.00000000
2	32981	0.00000000
2	5 481	0.00000000
2	5 981	0.75794393
2	51681	0.09030433
2	52481	0.00437509
2	53081	1.07941067
2	6 281	0.00000000
2	6 381	0.11448469
2	6 481	0.76942295
2	61081	0.00259602
2	61181	0.00000000
2	61281	0.08089685
2	61681	0.00000000
2	62381	0.01167773
2	7 581	0.00000000
2	7 781	0.27594396
2	7 881	0.09907185
2	91581	0.00000000
2	91681	0.00000000
2	10 981	0.56297916
2	101481	1.63062763
2	101881	0.01141842
2	11 181	0.05940064
2	11 881	0.01024971
2	13082	0.00650737
2	41782	0.00000000
2	41982	0.11974318
2	42182	0.02404745
2	42482	0.01794241
2	42882	0.03376553
2	5 682	0.00000000
2	51382	0.03064078
2	51782	0.01921369
2	52382	0.00000000
2	52482	0.00000000
2	61682	0.00000000
2	63082	0.00000000
2	102882	0.00000000
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2	112682	0.01734505
2	121182	0.00017552
2	121482	0.00060675
2	122382	0.00091879

ws	date	y
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2	122582	0.00000000
2	122682	0.00031782
2	1 183	0.00000000
2	13183	0.00759807
2	2 583	0.00278526
2	2 983	0.00339346
2	22083	0.00251367
2	3 483	0.00323743
2	32383	0.01307687
2	32683	0.00273037
2	51883	0.00000000
2	51983	0.00873284
2	52083	0.00000000
2	52183	0.03901101
2	53183	0.00000000
2	6 683	0.00385718
2	71683	0.00000000
2	8 983	0.00000000
2	81883	0.00000000
2	111983	0.00000000
2	12 383	0.00000000
2	121083	0.02257753
2	22684	0.00000000
2	3 484	0.16586976
2	31084	0.00000000
2	31284	0.04261322
2	102084	0.00075844
2	102184	0.08380707
2	102284	0.00373439
2	102384	0.00777432
2	102884	0.01819161
2	11 184	0.00873717
2	112684	0.02548342
2	12 584	0.00000000
2	121384	0.00491899
2	121684	0.00000000
2	123084	0.01150293
3	12180	0.00727499
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3	41380	0.00271038
3	51380	0.00000000
3	51480	0.00000000
3	51580	0.08208983
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3	21081	0.00000000
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3	3 381	0.22113603
3	3 781	0.00000000
3	32981	0.00000000
3	42381	0.00000000
3	5 481	0.00000000
3	5 981	0.20357551
3	51681	0.15512435
3	52481	0.00000000
3	53081	0.47765410
3	6 281	0.00000000
3	6 381	0.08520018
3	6 481	0.56632984
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3	61181	0.00000000
3	61281	0.07879391
3	61681	0.00000000
3	62381	0.00503335
3	7 581	0.00000000
3	7 781	0.28244185

ws	date	y
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3	72681	0.00000000
3	91581	0.00000000
3	91681	0.00000000
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3	101481	0.65980607
3	101881	0.00502743
3	11 181	0.01617576
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3	13082	0.00000000
3	41982	0.00645434
3	42182	0.00230670
3	42482	0.00109347
3	42882	0.00282276
3	51382	0.00951515
3	51782	0.00000000
3	52482	0.00000000
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3	122382	0.00000000
3	122482	0.00536752
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3	122682	0.00468438
3	13183	0.00156516
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3	22083	0.00000000
3	3 483	0.00000000
3	32383	0.00650609
3	32683	0.00227713
3	51883	0.00000000
3	51983	0.00986560
3	52083	0.00000000
3	52183	0.00866862
3	53183	0.00000000
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3	11 683	0.00000000
3	111983	0.00000000
3	121083	0.00518565
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3	31284	0.00550060
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4	6 381	0.00000000
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4	61281	0.00000000
4	7 781	0.00000000
4	101481	0.01776838
4	101881	0.00000000

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4	11 881	0.00000000
4	13082	0.00000000
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4	13183	0.00000000
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4	2 983	0.00000000
4	3 483	0.00000000
4	32383	0.00176684
4	32683	0.00000000
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4	121083	0.00000000
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4	102184	0.00198770
4	102284	0.00109458
4	102384	0.00243239
4	102884	0.00205186
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4	112684	0.00000000
4	121384	0.00000000
4	121684	0.00000000
4	123084	0.00000000
5	12180	0.00829635
5	2 880	0.00000000
5	51580	0.03146232
5	3 381	0.00257400
5	5 981	0.00333829
5	51681	0.00000000
5	53081	0.00246155
5	6 381	0.00079317
5	6 481	0.00623822
5	61281	0.00053182
5	101481	0.04545443
5	101881	0.00000000
5	11 181	0.00000000
5	11 881	0.00000000
5	41982	0.00293335
5	42182	0.00000000
5	42482	0.00000000
5	42882	0.00000000
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5	112682	0.00205130
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5	122582	0.00000000
5	122682	0.00197608
5	2 583	0.00131739
5	2 983	0.00000000
5	22083	0.00000000
5	3 483	0.00000000
5	32383	0.00040266
5	32683	0.00000000

ws	date	y
5	51983	0.00057740
5	52083	0.00000000
5	52183	0.00310885
5	6 683	0.00000000
5	3 484	0.00144730
5	31084	0.00000000
5	31284	0.00206649
5	102184	0.00342794
5	102284	0.00099982
5	102384	0.00781088
5	102884	0.00892693
5	11 184	0.00000000
5	112684	0.00000000
5	12 584	0.00000000
5	121384	0.00000000
5	121684	0.00000000
5	123084	0.00000000
6	12180	0.01489876
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6	32780	0.00000000
6	41380	0.00565866
6	51380	0.00000000
6	51480	0.00000000
6	51580	0.20044832
6	21081	0.00000000
6	3 381	0.00435592
6	5 981	0.00221153
6	53081	0.00289499
6	6 381	0.00229212
6	6 481	0.00933038
6	61281	0.00000000
6	7 781	0.00000000
6	10 981	0.00000000
6	101481	0.23404664
6	11 181	0.00000000
6	11 881	0.00000000
6	41982	0.02299280
6	42182	0.00000000
6	42482	0.00000000
6	42882	0.00441412
6	51382	0.00573999
6	51782	0.00000000
6	112682	0.00163851
6	121482	0.00000000
6	122382	0.00000000
6	122482	0.00331730
6	122682	0.00171909
6	13183	0.00000000
6	2 583	0.00706736
6	2 983	0.00232793
6	22083	0.00000000
6	3 483	0.00114830
6	32383	0.00572656
6	32683	0.00261146
6	51983	0.00000000
6	52083	0.00000000
6	52183	0.00950647
6	6 683	0.00000000
6	81883	0.00000000
6	121083	0.00414924
6	3 484	0.11121693
6	31284	0.00413805
6	102184	0.00816567
6	102284	0.00140646
6	102384	0.00183922
6	102884	0.00333073

ws	date	y
6	11 184	0.00907222
6	112684	0.00000000
6	121384	0.00000000
6	123084	0.00000000
7	12180	0.00714071
7	2 880	0.00000000
7	41380	0.00000000
7	51480	0.00000000
7	51580	0.08045758
7	3 381	0.00604746
7	5 981	0.00755587
7	51681	0.00000000
7	53081	0.00632654
7	6 381	0.00256168
7	6 481	0.01076873
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7	101881	0.00000000
7	11 181	0.00216190
7	11 881	0.00000000
7	41982	0.00071115
7	42182	0.00000000
7	42482	0.00000000
7	42882	0.00103328
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7	51782	0.00000000
7	112682	0.00071961
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7	121482	0.00000000
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7	122482	0.00000000
7	122582	0.00000000
7	122682	0.00168831
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7	13183	0.00115322
7	2 583	0.00201121
7	2 983	0.00000000
7	22083	0.00000000
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7	32683	0.00109940
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7	52083	0.00000000
7	52183	0.00460133
7	53183	0.00000000
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7	31284	0.00149918
7	102184	0.00429996
7	102284	0.00064657
7	102384	0.00098100
7	102884	0.00411929
7	11 184	0.00000000
7	112684	0.00000000
7	121384	0.00000000
7	121684	0.00000000
7	123084	0.00000000
8	12180	0.00079113
8	2 880	0.00000000
8	51580	0.07286276
8	3 381	0.00000000
8	5 981	0.00000000
8	53081	0.00000000

ws	date	y
8	6 381	0.00000000
8	6 481	0.00232943
8	101481	0.01009126
8	41982	0.00000000
8	51382	0.00000000
8	122682	0.00050105
8	2 583	0.00034282
8	32383	0.00000000
8	32683	0.00000000
8	51983	0.00000000
8	52183	0.00288395
8	6 683	0.00000000
8	121083	0.00000000
8	3 484	0.00455118
8	31284	0.00000000
8	102184	0.00200712
8	102284	0.00000000
8	102384	0.00000000
8	102884	0.00000000
8	112684	0.00000000
8	121384	0.00000000
8	123084	0.00000000
9	12180	0.00520636
9	2 880	0.00358742
9	32780	0.00005212
9	41380	0.00244757
9	51380	0.00000000
9	51480	0.00000000
9	51580	0.16226178
9	3 381	0.01032073
9	5 481	0.00000000
9	5 981	0.01412278
9	51681	0.00165573
9	52481	0.00000000
9	53081	0.01549183
9	6 381	0.00643896
9	6 481	0.01518675
9	61081	0.00000000
9	61281	0.00725150
9	7 781	0.00238242
9	10 981	0.00000000
9	101481	0.03559518
9	101881	0.00000000
9	11 181	0.00612621
9	11 881	0.00255105
9	13082	0.00000000
9	41782	0.00000000
9	41982	0.01862316
9	42182	0.00000000
9	42482	0.00000000
9	42882	0.00559883
9	5 682	0.00000000
9	51382	0.00602426
9	51782	0.00000000
9	52382	0.00000000
9	52482	0.00000000
9	61682	0.00000000
9	112682	0.00098424
9	121182	0.00000000
9	121482	0.00000000
9	122382	0.00086006
9	122482	0.00208500
9	122582	0.00000000
9	122682	0.00000000
9	1 183	0.00000000
9	13183	0.00148709

ws	date	y
9	2 583	0.00516037
9	2 983	0.00000000
9	22083	0.00105553
9	3 483	0.00075121
9	32383	0.00671491
9	32683	0.00184584
9	51183	0.00000000
9	51883	0.00000000
9	51983	0.00409794
9	52083	0.00000000
9	52183	0.00335439
9	53183	0.00000000
9	6 683	0.00284387
9	71683	0.00000000
9	81883	0.00000000
9	121083	0.00107776
9	21284	0.00000000
9	22684	0.00000000
9	3 484	0.02709422
9	31084	0.00000000
9	31284	0.00346631
9	102084	0.00000000
9	102184	0.00132535
9	102284	0.00058257
9	102384	0.00193169
9	102884	0.00723616
9	11 184	0.00424281
9	111884	0.00000000
9	112684	0.00199301
9	12 584	0.00000000
9	121384	0.00247900
9	121484	0.00000000
9	121684	0.00297802
9	123084	0.00185043

APPENDIX B

RAINFALL FACTOR (R)

PROGRAM OUTPUT

FOR STORM OF 11/ 8/81 AT
R2 ALTO
STORM BEGAN AT 0.1208E+02 HOURS
STORM DEPTH: 1.102 IN.
DURATION: 3.01HRS.

→ EROSION INDEX= 0.6598E+01 100 FT-TONS-INCH/ACRE-HOUR
TABLE OF TIME VS. MASS AND TIME VS. INTENSITY

OBS NO.	TIME (HRS)	DELTA T (HRS)	MASS (INCHES)	DELTA M (INCHES)	INTENSITY (IPH)
1	11.994	0.230	0.009	0.009	0.0388
2	12.076	0.082	0.051	0.042	0.5165
3	12.133	0.057	0.095	0.043	0.7560
4	12.166	0.033	0.132	0.037	1.1215
5	12.225	0.059	0.143	0.011	0.1943
6	12.260	0.035	0.208	0.065	1.8722
7	12.352	0.092	0.299	0.091	0.9918
8	12.491	0.139	0.369	0.070	0.5017
9	12.580	0.089	0.431	0.062	0.7028
10	12.631	0.051	0.449	0.017	0.3380
11	12.722	0.091	0.504	0.055	0.6092
12	12.931	0.209	0.566	0.062	0.2986
13	13.114	0.183	0.639	0.072	0.3950
14	13.287	0.174	0.674	0.035	0.2033
15	13.510	0.223	0.719	0.045	0.2008
16	13.677	0.167	0.748	0.029	0.1752
17	13.844	0.167	0.807	0.059	0.3536
18	14.001	0.157	0.864	0.057	0.3640
19	14.066	0.064	0.868	0.004	0.0549
20	14.299	0.234	0.918	0.051	0.2173
21	14.550	0.250	0.931	0.012	0.0484
22	14.689	0.140	0.959	0.028	0.2009
23	14.815	0.125	1.000	0.041	0.3265
24	14.969	0.154	1.062	0.062	0.4031
25	15.085	0.116	1.094	0.033	0.2833
26	15.359	0.274	1.102	0.007	0.0267
27	16.051	0.692	1.102	0.000	0.0000
28	17.166	1.115	1.102	0.001	0.0006

SUMMARY OF EROSION INDEX VALUES

date	ei
010681	1.847
011981	0.833
013181	1.008
020481	0.7162
020981	11.44
022181	3.503
022881	7.061
030381	23.59
030781	1.072
031381	0.09639
032981	7.44
040481	0.2736
042381	4.366
050381	0.1949
050481	5.532
050981	56.06
051381	0.6934
051581	10.88
052481	6.581
052581	53.49
060281	4.07
060381	4.613
060481	18.03
061081	5.847
061181	13.49
061481	0.8316
062381	9.313
070281	0.3484
070581	4.332
070781	22.02
070881	0.9409
071181	1.681
072681	9.784
082781	1.819
083081	2.601
090181	0.1126
090381	0.5119
091481	10.32
100681	6.760
100981	47.50
101281	95.63
101481	0.2403
101881	10.70
103081	12.47
110881	6.598
112981	1.554
120581	0.0039
121281	0.04295
123081	0.01513
010382	0.6807
011182	1.359
012082	13.01
012282	0.2625
012982	10.71
020282	2.341
020582	0.1895
020882	1.409
022582	1.263
030582	0.7664
032182	1.572
032382	0.151
032782	0.6657
041082	0.1597
041682	5.798
041982	31.06
042082	4.909

date	ei
042182	2.245
042482	1.056
042882	14.34
050182	0.05458
050682	3.689
051382	12.98
051782	5.557
052382	5.579
061682	19.53
062082	0.3195
062182	0.728
062482	1.375
062782	1.871
063082	14.12
072182	0.7675
072582	0.6376
080882	2.498
081782	1.532
091982	19.96
100682	9.371
100982	15.85
101782	0.0816
102082	2.49
102882	5.895
110282	29.69
111282	0.3097
111682	1.238
112682	16.80
120282	2.028
120482	0.1358
121082	2.63
121482	1.365
122382	4.601
122482	9.645
122682	5.924
122682	5.924
011983	0.3185
012283	2.662
013183	12.34
020483	6.38
020983	3.583
022083	3.775
031683	3.207
032383	6.309
032683	4.033
033083	6.340
050283	0.000
051583	64.44
052083	22.24
053083	16.76
060683	37.23
061583	0.8005
062383	8.395
062983	3.446
070183	0.0
071583	19.94
071383	1.476
080283	13.77
080783	33.32
081883	18.49
082783	0.8944
090783	3.523
091883	15.23
101183	10.03
102083	3.078
110683	8.266

date	ei
112283	2.450
112583	0.5280
112983	4.662
121083	22.57
121683	1.245
010984	1.816
011484	0.2526
012384	0.7325
012984	3.292
021184	2.005
022684	5.360
030484	39.85
031084	16.05
031884	0.04263
032384	1.473
040284	0.2778
040784	0.0
050284	0.1978
051083	10.24
051884	10.40
060584	6.569
060984	0.0
062784	0.0289
070184	9.786
070584	68.47
080484	0.3036
082284	0.8663
083084	0.0
090284	2.472
092384	2.696
100884	25.96
101284	3.522
101984	3.305
102184	53.63
110184	3.742
111584	4.89
112584	12.66
120484	1.488
121384	2.933

PROGRAM

```
FORTRAN IV      V02.6           THU 18-APR-85 01:16:33          PAGE 001
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

      C
      C
      C      THIS PROGRAM CONVERTS RAINCHART DATA (INPUT IN DIGITIZER) FROM
      C      CURVILINEAR CHARTS TO A TIME VS. INTENSITY TYPE BREAKPOINT DATA
      C      SET. FOR MORE INFO, SEE STAVROS ASAE PAPER 81-2032
      C
      C
      C    NOTE: TO LINK TYPE: LINK/OPTIONS RAINCT,DL:[1,1]DIGLIB/LIBRARY
      C            OPTION?? ACTFIL=5
      C
      C        DATFIL = OUTPUT FILE
      C        INFIL  = FILE THAT RAW DATA IS IN (5 IF ENTERED FROM SCREEN)
      C        LOGNAM = TEMPORARY STORAGE OF DATFIL AND INFIL
      C
      C
      C      T=VECTOR OF HOURS FROM START OF DATA
      C      T1=VECTOR OF HOURS FROM START OF STORM
      C      TIME=VECTOR OF MILITARY CLOCK TIME IN HOURS
      C      M4=VECTOR OF MASS CORRECTED FOR CHART REVERSAL AND EVAPORATION
      C      M1=VECTOR OF MASS RE-INDEXED TO COINCIDE WITH T1 AND TIME
      C
      C-----------------------------------------------------------------------
0001         DIMENSION R1(250),T(250),T1(250),X(250),Y(250),DIFF(250)
0002         LOGICAL *1 FNAME(14),DATFIL(14)
0003         REAL*8 LEGEND(10)
0004         REAL M(5),M1(250),M2,M4(250),M7,M9,DELTAT(250),TIME(250),
            *     MASS,OUTFIL(4)
0005         INTEGER D,D0(12),F1,Z(5),Y0,IDAY(250),MON(250),IYR(250)
0006         DATA D0/31,28,31,30,31,30,31,31,30,31,30,31/
0007         WRITE(5,113)
0008     113 FORMAT(2X,'ENTER DATA FILE NAME')
0009         READ(5,114) DATFIL
0010     114 FORMAT(14A1)
0011         IUNIT =2
0012         IOUT = 1
0013         CALL ASSIGN(IUNIT,DATFIL)
0014         CALL CDGUSR(IUNIT,IOUT)
0015         REWIND 1
0016         REWIND 2
0017         IUNIT = 1
0018         IOUT =2
0019         WRITE(5,105)
0020     105 FORMAT('$',4X,'ENTER OUTPUT FILE: ')
0021         READ(5,114) FNAME
0022         CALL ASSIGN(IOUT,FNAME)
      C       WRITE(5,201)
      C  201 FORMAT(2X,'DO YOU WISH THE INPUT TO BE ECHOED? (Y/N)')
      C       READ(5,116) IECHO
0023         IECHO='N'
0024         S=0.5866
0025         Y3=6.0
0026         T5=2.0833
0027         S1=6.7708
      C
```

```
FORTRAN IV      V02.6          THU 18-APR-85 01:16:33          PAGE 002
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

      C      INTERACTIVE SECTION
      C
             WRITE(5,100)
         100 FORMAT(2X,'ENTER LEGEND AND DATE'/)
             READ(5,200) (LEGEND(I),I=1,10)
         200 FORMAT(10A8)
             READ(5,*) MO,D,YO
      C       TYPE 7
      C     7 FORMAT('$','ENTER CORRECTION FACTOR FOR Y (*.***):  ')
      C       ACCEPT 9,CORREC
      C     9 FORMAT(F5.3)
             CORREC=0.
         118 CONTINUE
      C       WRITE(5,115)
      C  115 FORMAT(2X,'INITIAL DATA IS SET FOR A ONE DAY CHART'/
      C      *2X' DO YOU WANT TO CHANGE S, Y3, T5, OR S1? (Y/N)'/)
      C       READ(5,116) IANS
      C  116 FORMAT(A1)
             IANS='N'
             IF(IANS.EQ.'N') GO TO 117
             IF(IANS.NE.'Y') GO TO 118
             WRITE(5,101)
         101 FORMAT(2X,'FOR RAINCHART, ENTER S,Y3,T5, AND S1'/
            *2X,'WHERE: T5=HOURS/INCH OF CHART'/9X,'S1=MILITARY TIME AT'
            *,' ORIGIN OF CHART'/)
             READ(5,*) S,Y3,T5,S1
      C
      C      FOR AN 8 DAY CHART, S=0.5866, Y3=6.0, T5=16.696, AND S1=20.43
      C      FOR A 1 DAY CHART, S=0.5866, Y3=6.0, T5=2.0833, AND S1=6.7708
      C
      C      INITIALIZE VALUES
      C
         117 I=0
             IST=0
             X3=0.00
             X1=0.0
             START=0.0
             END=0.0
             T0=7.0
             E1=0.0
             D1=0.0
             OFFSET=0.0
             DO 10 L=1,5
                T(L)=0.0
          10    M(L)=0.0
             Z(1)=5
             Z(2)=15
             Z(3)=30
             Z(4)=60
             Z(5)=180
             F1=0
             WRITE(IOUT,109)
         109 FORMAT(1H1//)
             IF(IECHO.EQ.'Y') WRITE(IOUT,202)
```

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FORTRAN IV      V02.6           THU 18-APR-85 01:16:33           PAGE 003
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

0066      202 FORMAT(2X,'RAW DATA')
        C
        C      CALCULATE ARC RADIUS ON CHART
        C
0067          R=(S**2+(Y3/2.0)**2)/(S*2.0)
        C
        C      DATA INPUT
        C
        C       WRITE(5,102)
0068      102 FORMAT(2X,'INPUT DIGITIZER DATA, ENTER -99 WHEN FINISHED'/)
0069      440 I=I+1
0070          X2=X1
0071          READ(IUNIT,*) X1,YY
0072          Y(I)=YY+CORREC
0073          IF(IECHO.EQ.'Y') WRITE(IOUT,*) X1,Y(I)
        C       IF(IECHO.EQ.'Y') WRITE(5,*) X1,Y(I)
0075          IF(X1.EQ.-99) GO TO 650
        C
        C      CORRECT X(I) FOR CURVILINEAR NATURE OF CHART
        C
0077          X1=X1+(SQRT(R**2-(Y3/2.0-Y(I))**2)-(R-S))
0078          IF(X1+.02.LT.X2) GO TO 483
0080          GO TO 484
0081      483 X3=X3+11.5
0082      484 X(I)=X3+X1
        C
        C      CREATE VECTOR T(I)=HOURS FROM ORIGIN
        C
0083          T(I)=X(I)*T5
        C
        C      TEST FOR DECREASE NEAR 6"
        C      TEST FOR ERROR
        C
0084          IF(F1.EQ.1) GO TO 580
0086          IF(Y(I).GT.Y3-0.25) GO TO 620
0088          IF(Y(I).GE.Y(I-1)) GO TO 570
        C
        C      SECTION TO HANDLE EVAPORATION OFFSET
        C
0090          OFFSET=OFFSET+Y(I-1)-Y(I)
0091      570 M4(I)=Y(I)+OFFSET
0092          GO TO 440
        C
        C      SECTION TO HANDLE FLUCTUATIONS NEAR TOP OF CHART AND CHART REVERSALS
        C
0093      580 IF(Y(I).LT.Y(I-1)) GO TO 600
0095          Y(I)=Y(I-1)
0096      600 M4(I)=Y(I-1)+ABS(Y(I)-Y(I-1))+OFFSET
0097          GO TO 440
        C
        C      F1=1 MEANS THERE HAS (PROBOBLY) BEEN A CHART REVERSAL
        C
0098      620 F1=1
0099          GO TO 580
```

```
FORTRAN IV      V02.6           THU 18-APR-85 01:16:33          PAGE 004
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

      C
      C      END OF INPUT AND TEST PHASE
      C
0100     650 I=I-1
      C
      C      LOOP TO START TIME JUST PRIOR TO RAIN
      C
0101         DO 690 J=1,I
0102     690  IF(M4(J).GT.0.01) GO TO 720
0104         WRITE(5,103)
0105     103 FORMAT(2X,'ERROR, NO Y VALUE GREATER THAN 0.01"'/)
0106         STOP
0107     720 J=J-1
0108         IJJ=J
      C       DO 9852 K=1,I
      C 9852 TYPE *,T(K),M4(K)
      C
      C      CREATE M1 VECTOR OF MASS,RE-WORK T VECTOR, CALCULATE DELTA T
      C
0109         E=0.00
0110         TO=T(J)+S1
0111         DO 910 L=J,I
0112            LL=L-J+1
0113            M1(LL)=M4(L)
0114            T1(LL)=T(L)-T(J)
0115            TIME(LL)=T1(LL)+TO
      C
      C      STORM IS CONSIDERED TO START WHEN 0.01" OF RAIN HAS FALLEN
      C
0116            IF(IST.EQ.0.AND.M4(L).GT.0.01) GO TO 820
      C
      C      STORM IS CONSIDERED ENDED WHEN LESS THAN 0.01" FALLS
      C
0118          IF(M4(L)-M4(L-1).GT.0.01) END=T(L)
0120     790  IF(M4(L).LE.0.0) GO TO 910
0122            DELTAT(LL)=T(L)-T(L-1)
0123     810  IF(DELTAT(LL).LT.0.0) GO TO 830
0125            GO TO 880
0126     820  IST=1
0127            START=T(L)
0128            ISTI=L-J+1
0129            GO TO 790
0130     830  DELTAT(LL)=DELTAT(LL)+24.0
0131            GO TO 810
0132     880  ILL=L-J
0133            DIFF(LL)=M1(LL)-M1(ILL)
      C          TYPE *,L,LL,ILL,M1(LL),M1(ILL)
0134            IF(DELTAT(LL).EQ.0.)GO TO 910
0136            R1(LL)=DIFF(LL)/DELTAT(LL)
0137            RI=R1(LL)
0138            IF(R1(LL).LE.0.)GO TO 910
0140            IF(R1(LL).GT.3.0)RI=3.0
0142            E=E+(916.+331.*ALOG10(RI))*DIFF(LL)
      C
```

```
      C      R1=INTENSITY    NOTE: THERE WILL BE NO R1(1)
      C
0143    910  CONTINUE
      C      WRITE(5,1235)
0144   1235 FORMAT(' ','REACHED 910')
      C
      C      LOOP OVER EVERY KNOT
      C
      C      I=TOTAL NUMBER OF KNOTS
      C      N=INDEX FOR KNOTS
      C      K=INDEX FOR MINUTES
      C      J=# OF USELESS KNOTS
      C
0145   1030 ND=I-J+1
0146        DO 1160 N=1,ND
0147           IDAY(N)=D
0148           MON(N)=MO
0149           IYR(N)=YO
0150   1040  IF(TIME(N).LE.24.0) GO TO 1060
0152           TIME(N)=TIME(N)-24.0
0153           IDAY(N)=IDAY(N)+1
0154           IF(DO(MON(N)).GT.IDAY(N)) GO TO 1040
0156           MON(N)=MON(N)+1
0157           IDAY(N)=IDAY(N)-DO(MON(N)-1)
0158           IF(MON(N).LE.12) GO TO 1040
0160           IYR(N)=IYR(N)+1
0161           IDAY(N)=1
0162           MON(N)=1
0163           GO TO 1040
0164   1060   MASS=M1(N)
0165           DO 1160 L=1,5
0166               TARGET=T1(N)+Z(L)/60.0
0167               IF(TARGET.GT.T1(ND)) GO TO 1100
0169               CALL SEARCH(M1,T1,ND,TARGET,RESULT)
0170               TENS=(RESULT-MASS)/Z(L)*60.0
0171               IF(TENS.LE.M(L)) GO TO 1100
0173               M(L)=TENS
0174   1100        TARGET=T1(N)-Z(L)/60.0
0175               IF(TARGET.LT.T1(1)) GO TO 1160
0177               CALL SEARCH(M1,T1,ND,TARGET,RESULT)
0178               TENS=(MASS-RESULT)/Z(L)*60.0
0179               IF(TENS.LE.M(L)) GO TO 1160
0181               M(L)=TENS
0182   1160     CONTINUE
0183        WRITE(IOUT,109)
0184        WRITE(3,107) MO,D,YO,(LEGEND(IK),IK=1,10)
0185        WRITE(4,107) MO,D,YO,(LEGEND(IK),IK=1,10)
0186        WRITE(3,300)
0187    300 FORMAT(2X,'TIME VS MASS')
0188        WRITE(4,301)
0189    301 FORMAT(2X,'TIME VS INTENSITY')
0190  C      WRITE(5,107) MO,D,YO,(LEGEND(IK),IK=1,10)
***** K
0191        WRITE(IOUT,107) MO,D,YO,(LEGEND(IK),IK=1,10)
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FORTRAN IV        V02.6              THU 18-APR-85 01:16:33              PAGE 006
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

0192       107 FORMAT(2X,'FOR STORM OF ',I2,2('/',I2),5X,'AT'/2X,10A8)
0193           WRITE(IOUT,110) TIME(ISTI)
        C       WRITE(5,110) TIME(ISTI)
0194       110 FORMAT(2X,'STORM BEGAN AT ',E11.4,' HOURS')
0195           DURATN=END-START
0196           WRITE(IOUT,108) M4(I),DURATN
        C       WRITE(5,108) M4(I),DURATN
0197       108 FORMAT(2X,'STORM DEPTH: ',F10.3,' IN. '/2X,'DURATION: ',
             +          F10.2,'HRS. '/)
0198       111 FORMAT(1X,I3,2(3X,F7.3),2X,2(3X,F7.3),5X,F8.4)
0199           RI30=M(3)
0200           IF(M(3).GT.2.5) RI30=2.5
0202           EI=E*RI30*0.01
0203           WRITE(IOUT,106) EI
        C       WRITE(5,106) EI
0204       106 FORMAT(2X,'EROSION INDEX=',E13.4,' 100 FT-TONS-INCH/ACRE-HOUR')
0205           WRITE(IOUT,206)
        C       WRITE(5,206)
0206       206 FORMAT(' ','TABLE OF TIME VS. MASS AND TIME VS. INTENSITY')
        CN 1270   WRITE(IOUT,121)
        CN  121    FORMAT(3X,'MAXIMUM',9X,'STARTING',8X,'DATE OF'/3X,'INTENSITY',
        CN         *7X,'TIME OF',9X,'BURST')
        CN      DO 1520 L=1,5
        CN 1510     WRITE(5,112) M(L),T(L),MO,D,YO
        CN 1520     WRITE(IOUT,112) M(L),T(L),MO,D,YO
        CN  112    FORMAT(2X,2(F10.4,5X),2X,I2,2('/',I2))
0207           WRITE(IOUT,205)
0208       205 FORMAT(//' OBS',4X,'TIME',5X,'DELTA T',5X,'MASS',6X,'DELTA M',5X,
              *'INTENSITY'/' NO. ',2(4X,'(HRS)'),5X,2(2X,'(INCHES)'),4X,'(IPH)'/
              *1X,3('='),2(3X,7('=')),2X,2(3X,7('=')),5X,8('='))
0209           DO 1400 L=IJJ,I
0210              LL=L-IJJ+1
0211              WRITE(3,*) TIME(I2),M1(I2)
0212              WRITE(4,*) TIME(I2),R1(I2)
        C          WRITE(5,111) LL,TIME(LL),DELTAT(LL),M1(LL),DIFF(LL),R1(LL)
0213     1400     WRITE(IOUT,111)  LL,TIME(LL),DELTAT(LL),M1(LL),DIFF(LL),R1(LL)
0214           STOP '4=HYETO 3=MASS'
0215           END
```

```
FORTRAN IV      V02.6           THU 18-APR-85 01:16:44          PAGE 001
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

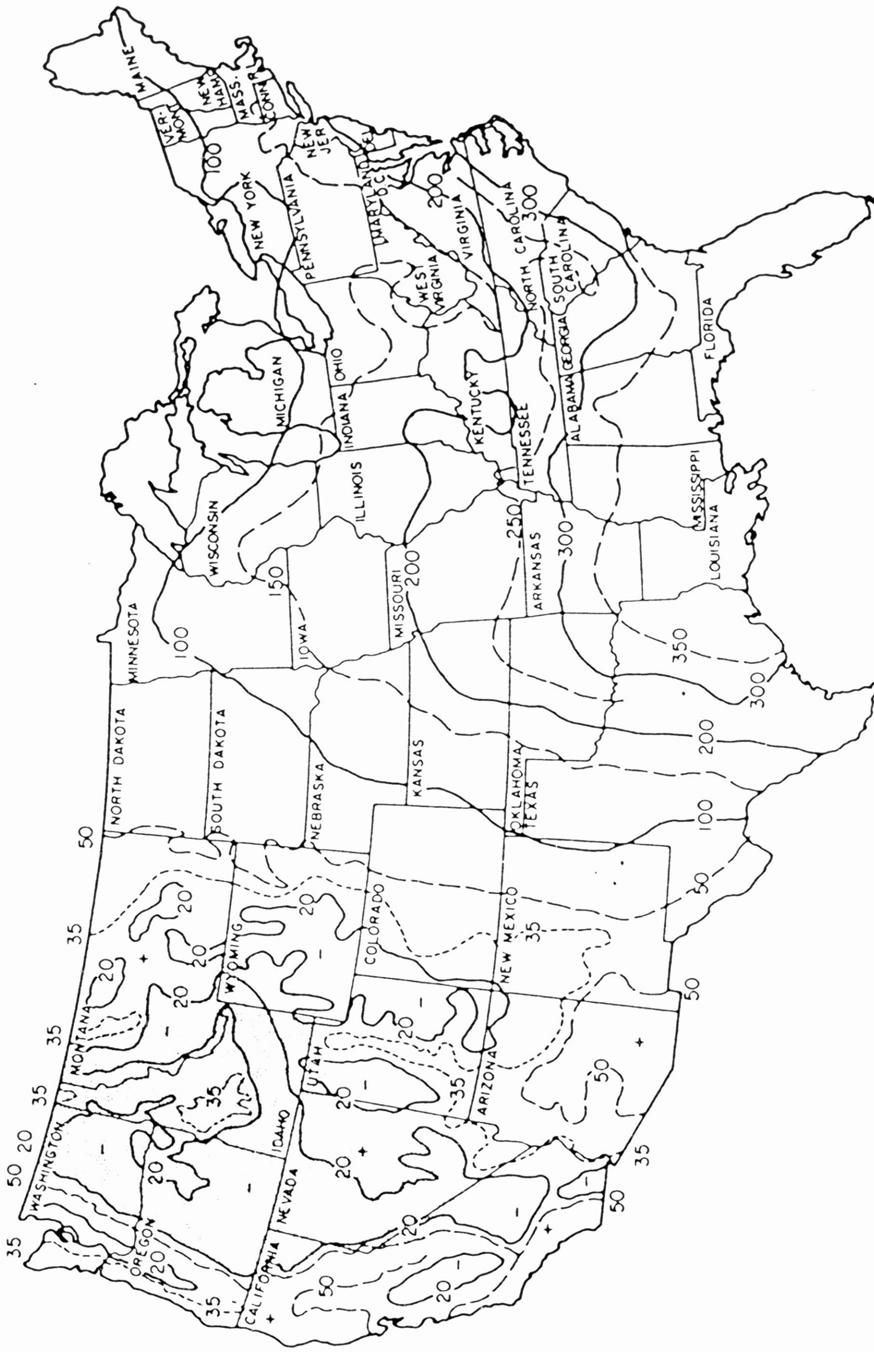
      C
            SUBROUTINE SEARCH(Y,T,N,TARGET,RESULT)
      C
      C     THIS SUBROUTINE FINDS A Y VALUE FOR A GIVEN TARGET VALUE
      C     IN THE T DOMAIN
      C     IT IS ASSUMED THAT VECTOR T IS SORTED
      C     THE LINEARLY INTERPOLATED Y VALUE IS OUTPUT AS RESULT
      C
            REAL Y(N),T(N)
            MIN=0
            MAX=N+1
            IF(TARGET.LT.T(1)) GO TO 60
            IF(TARGET.GT.T(N)) GO TO 70
            DO 10 K=1,N
               IF(MAX-MIN.GT.1) GO TO 20
      C
      C     LINEAR INTERPOLATION SECTION
      C
               T1=T(MIN)
               T2=T(MAX)
               Y1=Y(MIN)
               Y2=Y(MAX)
               SLOPE=(Y2-Y1)/(T2-T1)
               B=Y1-SLOPE*T1
               RESULT=SLOPE*TARGET+B
               RETURN
      C
      C     BINARY SEARCH SECTION
      C
         20    J=(MAX+MIN)/2
               IF(T(J).EQ.TARGET) GO TO 40
               IF(T(J)-TARGET.GT.0.0) GO TO 30
               MIN=J
               GO TO 10
         30    MAX=J
         10    CONTINUE
            STOP 'ERROR'
      C
      C     CASE OF EXACT MATCH
      C
         40 RESULT=Y(J)
            RETURN
         60 RESULT=Y(1)
      C      WRITE(5,101) RESULT
        101 FORMAT(2X,'TARGET IS LESS THAN T(1)'/2X,'Y=',E15.5,
          +           ' WILL BE USED')
            RETURN
         70 RESULT=Y(N)
      C      WRITE(5,102) RESULT
        102 FORMAT(2X,'TARGET IS BEYOND T(N)'/2X,'Y=',E15.5,' WILL BE USED')
            RETURN
            END
```

```
FORTRAN IV      V02.6           THU 18-APR-85 01:16:46          PAGE 001
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

            SUBROUTINE CDGUSR(IUNIT,IOUT)
      C
      C     SUBROUTINE TO CONVERT DATA IN FILE IUNIT FROM DIGITIZER FORMAT
      C     TO X-Y PAIRS IN USER COORDINATES
      C
      C     PROGRAM ASSUMES THAT  BOTH UNIT "IUNIT" AND "IOUT" HAVE BEEN
      C     CREATED AND ARE CURRENTLY CLOSED
      C
      C     SUBROUTINES USED: RDIST, ANGLER, COS,SIN
      C
            DIMENSION XLINE(9),YLINE(9),IBTN(9)
            REWIND IUNIT
            REWIND IOUT
      C
      C     READ OFFSET INFORMATION
      C
            READ(IUNIT,200) XSCALE,XOFF,YSCALE,YOFF,ANGLE,XROUND,YROUND
        200 FORMAT(1X,7F11.5)
      C
      C     READ A LINE OF DIGITIZED DATA
      C
          1 READ(IUNIT,201,END=60,ERR=99) (IBTN(I),XLINE(I),YLINE(I),I=1,9)
        201 FORMAT((1X,9(A1,2F6.3)))
            DO 10 I=1,9
        203    FORMAT(2X,A2,2X,F6.3,2X,F6.3,5X,2(F15.5,2X))
      C
      C     CALCULATE THE DISTANCE BETWEEN THE USER ORIGIN AND THE
      C     DIGITIZED POINT
      C
               DISTU=RDIST(XOFF,YOFF,XLINE(I),YLINE(I))
      C
      C     CALCULATE THE ANGLE BETWEEN THE USER ORIGIN AND THE
      C     DIGITIZED POINT
      C
               ANGU=ANGLER(XOFF,YOFF,XLINE(I),YLINE(I))-ANGLE
      C
      C     CALCULATE X AND Y COORDINATES IN USER REAL UNITS FROM CURRENT SCALE
      C     FACTORS
      C
               X=DISTU*COS(ANGU)*XSCALE
               Y=DISTU*SIN(ANGU)*YSCALE
      C
      C     WRITE X AND Y COORDINATES TO FILE"IOUT'
      C
      D     WRITE(3,203) IBTN(I),XLINE(I),YLINE(I),X,Y
      D     WRITE(5,203) IBTN(I),XLINE(I),YLINE(I),X,Y
               IF(IBTN(I).EQ.':') GO TO 60
               WRITE(IOUT,*) X,Y
         10    CONTINUE
            GO TO 1
      C
      C     ERROR IN READ MESSAGE
      C
         99 WRITE(5,202) IUNIT
```

```
FORTRAN IV        V02.6              THU 18-APR-85 01:16:46          PAGE 002
RAINCTF,RAINCTF/-SP/LI:3=RAINCTF

0021      202 FORMAT(2X,'ERROR DETECTED IN READ OF UNIT',I2/2X,'DATA PROCESSING'
             *,' IS BEING TERMINATED')
0022       60 CALL CLOSE (IUNIT)
0023          WRITE(IOUT,210)
0024      210 FORMAT(2X,'-99.0 0.0')
0025          CALL CLOSE (IOUT)
0026          RETURN
0027          END
```



Rainfall and runoff erosivity index R by geographic location. (From USDA and EPA, 1975.)

APPENDIX C

SOIL ERODIBILITY FACTOR (K)

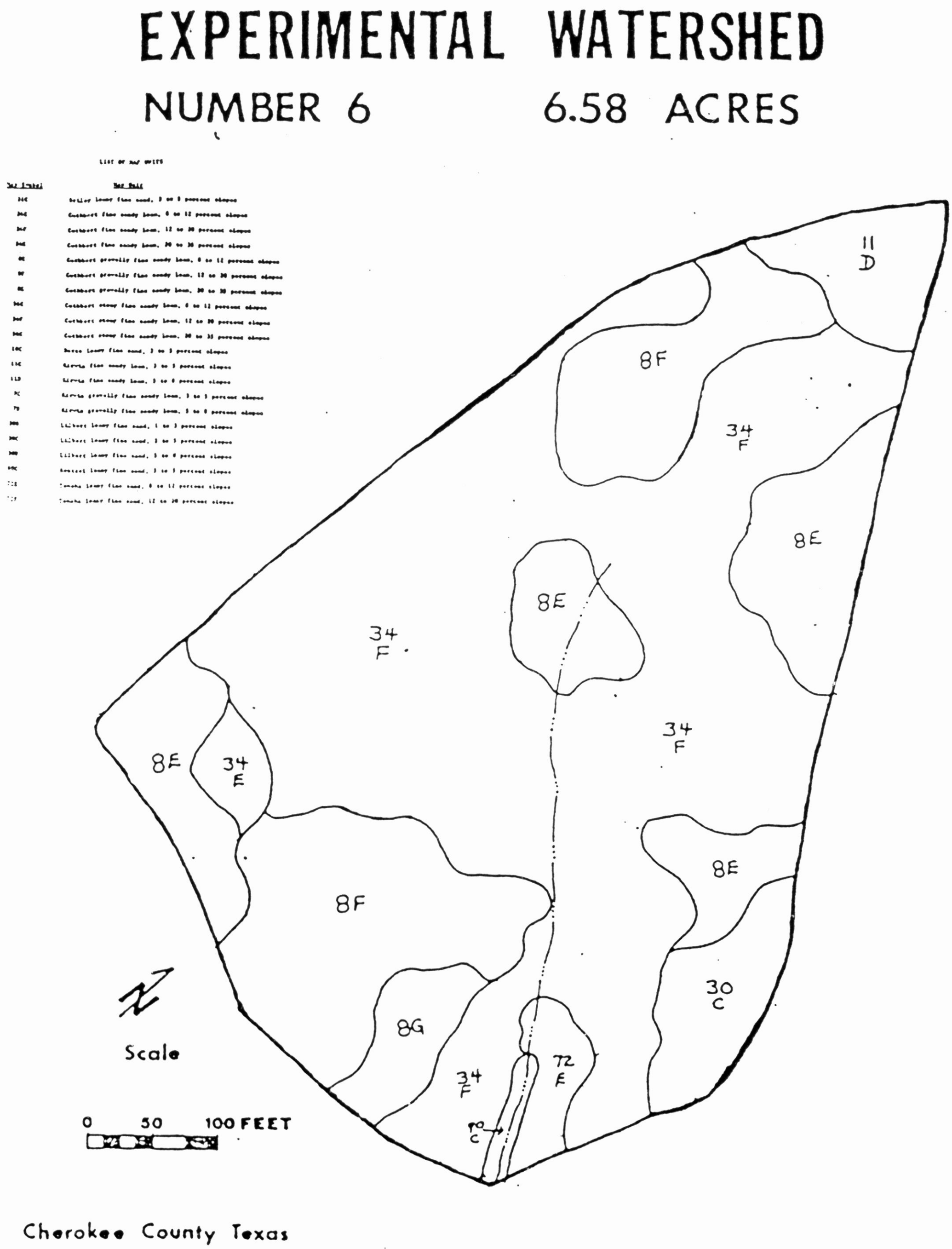


FIGURE 2. SOIL TYPE DISTRIBUTION MAP

LIST OF MAP UNITS

Map Symbol	K	Map Unit
31C	0.2	Briley loamy fine sand, 3 to 5 percent slopes
34E	0.37	0.37 for depths > 8 inches Cuthbert fine sandy loam, 8 to 12 percent slopes
34F	0.37	Cuthbert fine sandy loam, 12 to 20 percent slopes
34G	0.37	Cuthbert fine sandy loam, 20 to 35 percent slopes
8E	0.2	Cuthbert gravelly fine sandy loam, 8 to 12 percent slopes
8F	0.2	Cuthbert gravelly fine sandy loam, 12 to 20 percent slopes
8G	0.2	Cuthbert gravelly fine sandy loam, 20 to 35 percent slopes
56E	0.24	Cuthbert stony fine sandy loam, 8 to 12 percent slopes
56F	0.24	Cuthbert stony fine sandy loam, 12 to 20 percent slopes
56G	0.24	Cuthbert stony fine sandy loam, 20 to 35 percent slopes
18C	0.17	Darco loamy fine sand, 3 to 5 percent slopes
11C	0.37	Kirvin fine sandy loam, 3 to 5 percent slopes
11D	0.37	Kirvin fine sandy loam, 5 to 8 percent slopes
7C	0.20	Kirvin gravelly fine sandy loam, 3 to 5 percent slopes
7D	0.20	Kirvin gravelly fine sandy loam, 5 to 8 percent slopes
30B	0.20	Lilbert loamy fine sand, 1 to 3 percent slopes
30C	0.20	Lilbert loamy fine sand, 3 to 5 percent slopes
30D	0.20	Lilbert loamy fine sand, 5 to 8 percent slopes
90C	0.17	Rentzel loamy fine sand, 3 to 5 percent slopes
72E	0.17	Tenaha loamy fine sand, 8 to 12 percent slopes
72F	0.17	Tenaha loamy fine sand, 12 to 20 percent slopes

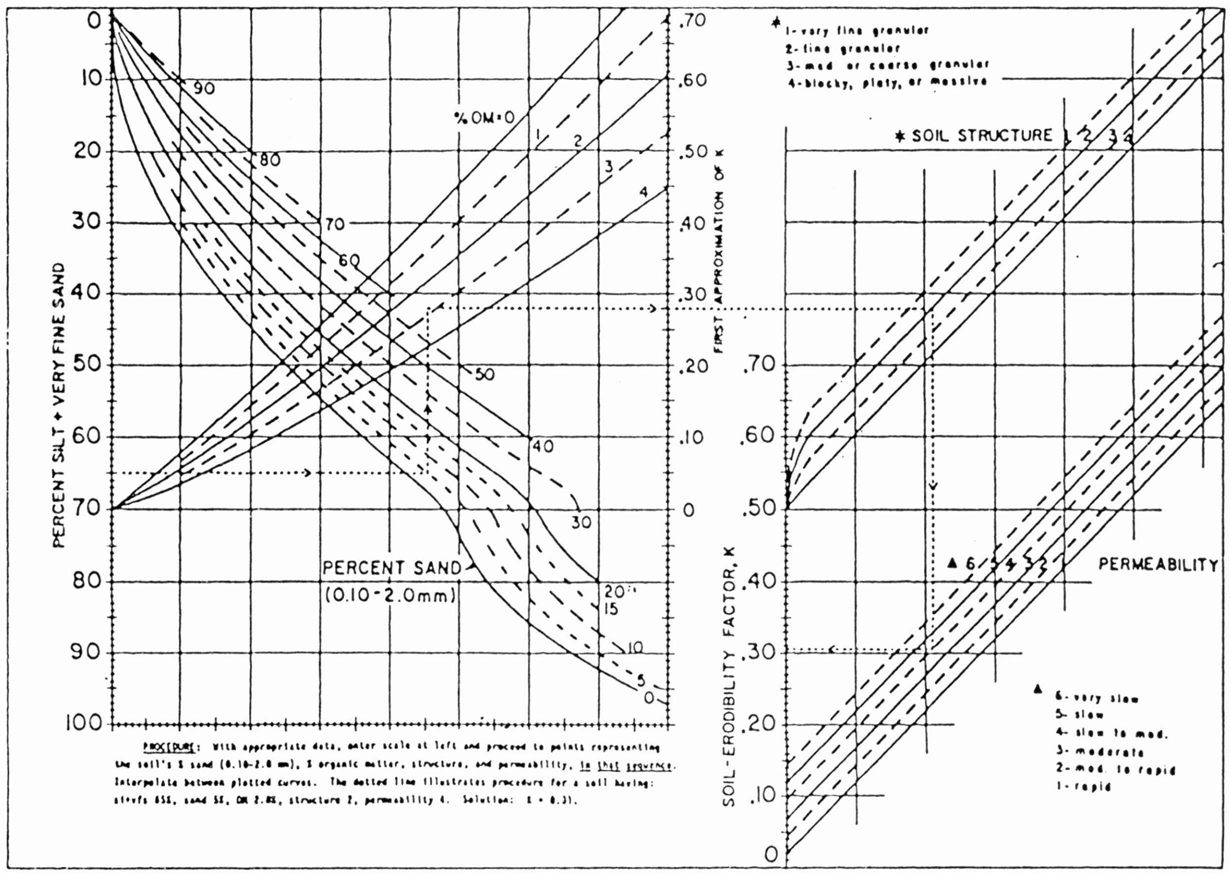


FIGURE 3.—The soil-erodibility nomograph. Where the silt fraction does not exceed 70 percent, the equation is $100\,K = 2.1\,M^{1.14}\,(10^{-4})\,(12 - a) + 3.25\,(b - 2) + 2.5\,(c - 3)$ where M = (percent si + vfs) (100 − percent c), a = percent organic matter, b = structure code, and c = profile permeability class.

APPENDIX D

TOPOGRAPHIC FACTOR (LS)

"LS" COMBINED FACTOR CALCULATION FOR USLE

$$L = \frac{0.5\ DA}{LCH}$$

$$S_i = \frac{H(LC_j + LC_{j+1})}{2\ DA_i} * 100\%$$

$$S = \sum S_i \frac{DA_i}{DA}$$

$$LS = 8.52\ (L/72.6)^{0.5}\ (0.0076 + 0.0053\ S + 0.00076\ S^2)$$

WHERE:

L = MEAN WATERSHED LENGTH, FEET

DA = TOTAL AREA OF THE WATERSHED, SQ.FT.

DA_i = AREA OF WATERSHED BETWEEN GIVEN CONTOURS, SQ.FT

LCH = LENGTH OF CHANNELS IN WATERSHED, FEET

S_i = ith SECTION PERCENT SLOPE

S = AVERAGE PERCENT SLOPE FOR THE WATERSHED

H = ELEVATION BETWEEN CONTOUR LINES, FEET

LC_j = jth CONTOUR LINE LENGTH, FEET

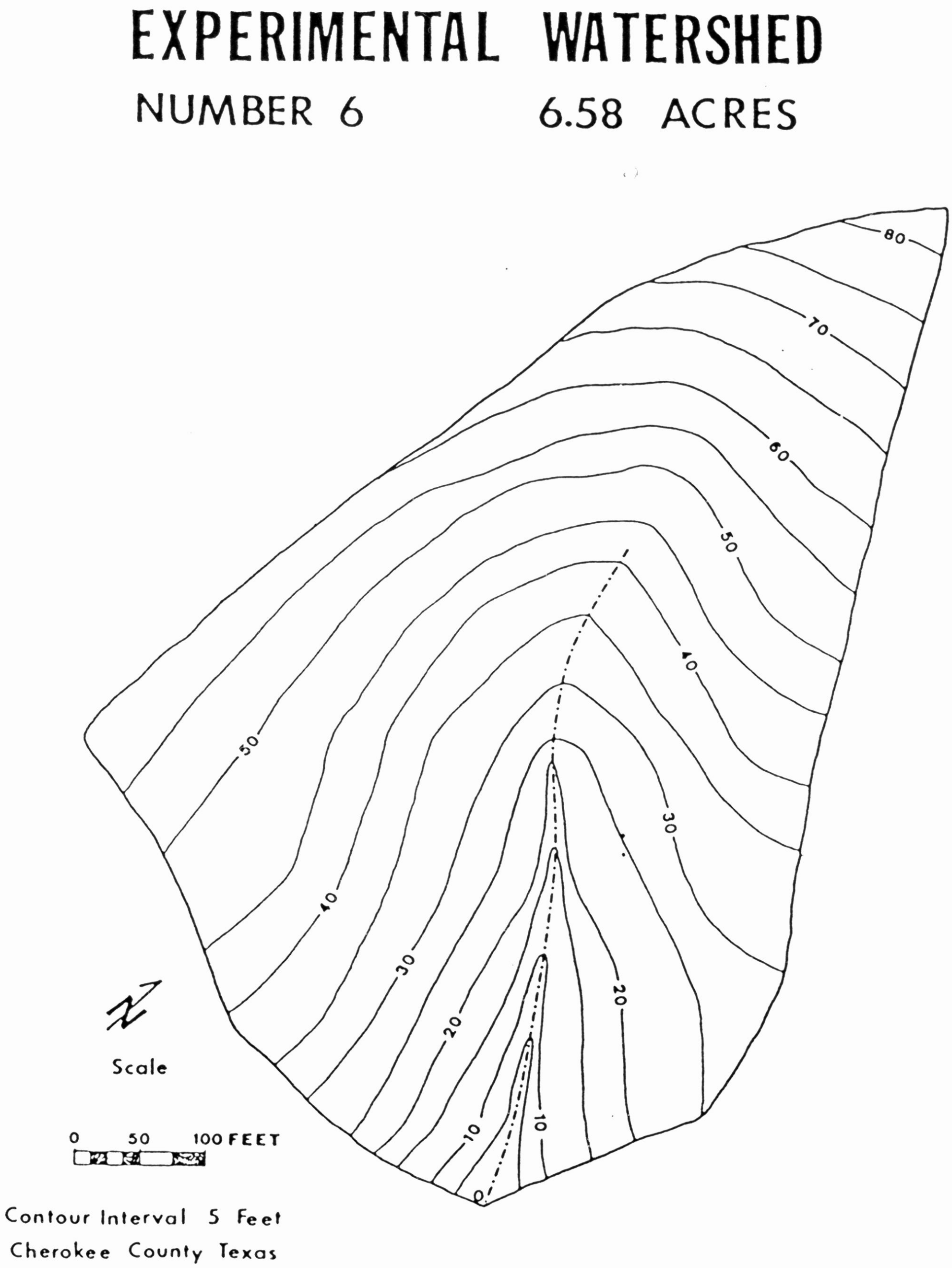


FIGURE 3. CONTOURED MAP

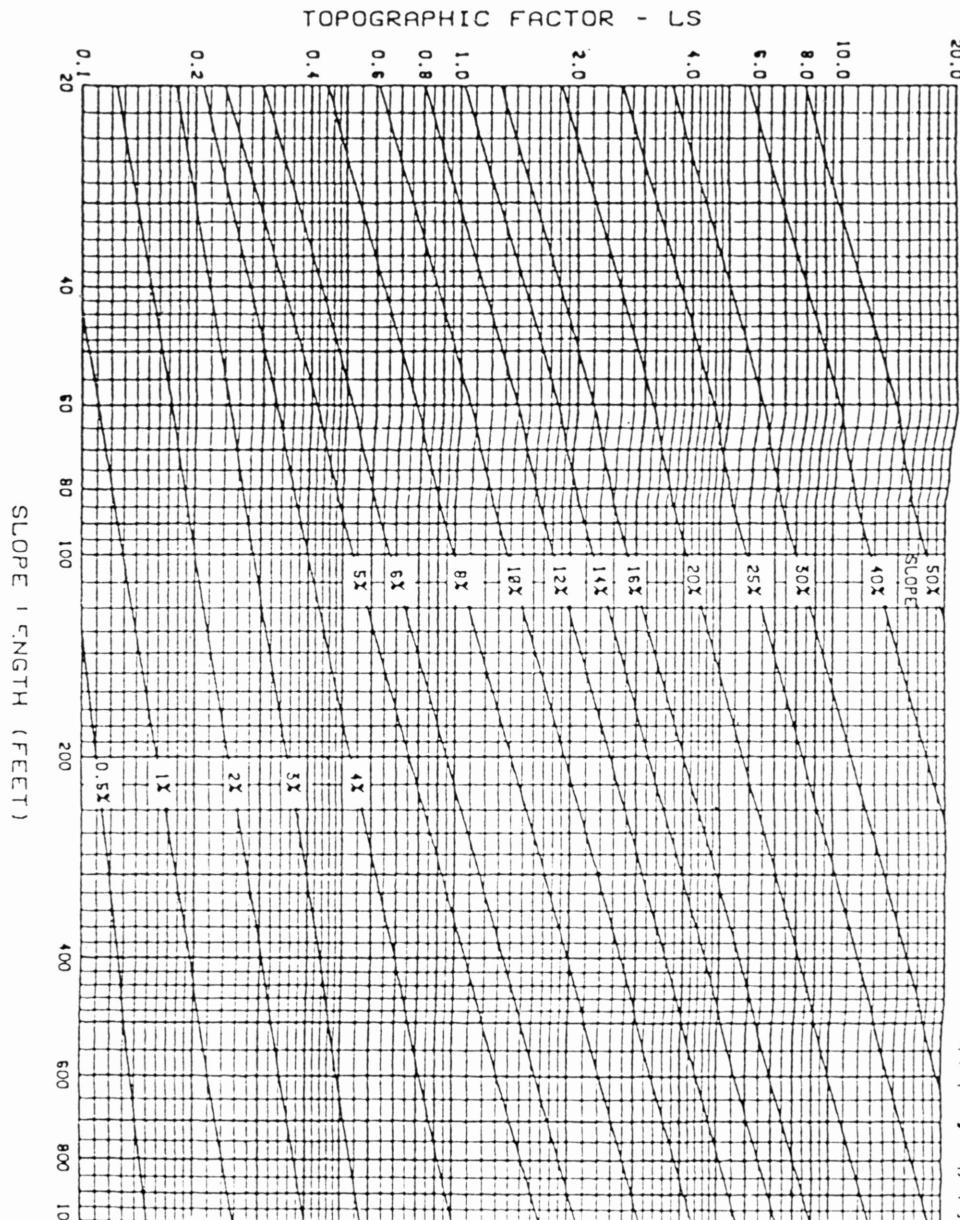


FIGURE 4.—Slope-effect chart (topographic factor, LS). $LS = (\lambda/72.6)^m (65.41 \sin^2\theta + 4.56 \sin\theta + 0.065)$ where λ = slope length in feet; θ = angle of slope; and m = 0.2 for gradients < 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, and 0.5 for slopes of 5 percent or steeper.

TOPOGRAPHIC FACTOR (LS)

Both the length and the steepness of the land slope substantially affect the rate of soil erosion by water. The two effects have been evaluated separately in research and are represented in the soil loss equation by L and S, respectively. In field applications, however, considering the two as a single topographic factor, LS, is more convenient.

Slope-Effect Chart

LS is the expected ratio of soil loss per unit area from a field slope to that from a 72.6-ft length of uniform 9-percent slope under otherwise identical conditions. This ratio for specified combinations of field slope length and uniform gradient may be obtained directly from the slope-effect chart (fig. 4). Enter on the horizontal axis with the field slope length, move vertically to the appropriate percent-slope curve, and read LS on the scale at the left. For example, the LS factor for a 300-ft length of 10-percent slope is 2.4. Those who prefer a table may use table 3 and interpolate between listed values.

To compute soil loss from slopes that are appreciably convex, concave, or complex, the chart LS values need to be adjusted as indicated in the section LS Values for Irregular Slopes. Figure 4 and table 3 assume slopes that have essentially uniform gradient. The chart and table were derived by the equation

$$LS = (\lambda/72.6)^m \ (65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065) \quad (4)$$

where λ = slope length in feet;
θ = angle of slope; and
m = 0.5 if the percent slope is 5 or more, 0.4 on slopes of 3.5 to 4.5 percent, 0.3 on slopes of 1 to 3 percent, and 0.2 on uniform gradients of less than 1 percent.

The basis for this equation is given in the subsection discussing the individual effects of slope length and steepness. However, the relationships expressed by the equation were derived from data obtained on cropland, under natural rainfall, on slopes ranging from 3 to 18 percent in steepness and about 30 to 300 ft in length. How far beyond these ranges in slope characteristics the relationships derived from the data continue to be accurate has not been determined by direct soil loss measurements.

The Palouse Region of the Northwest represents

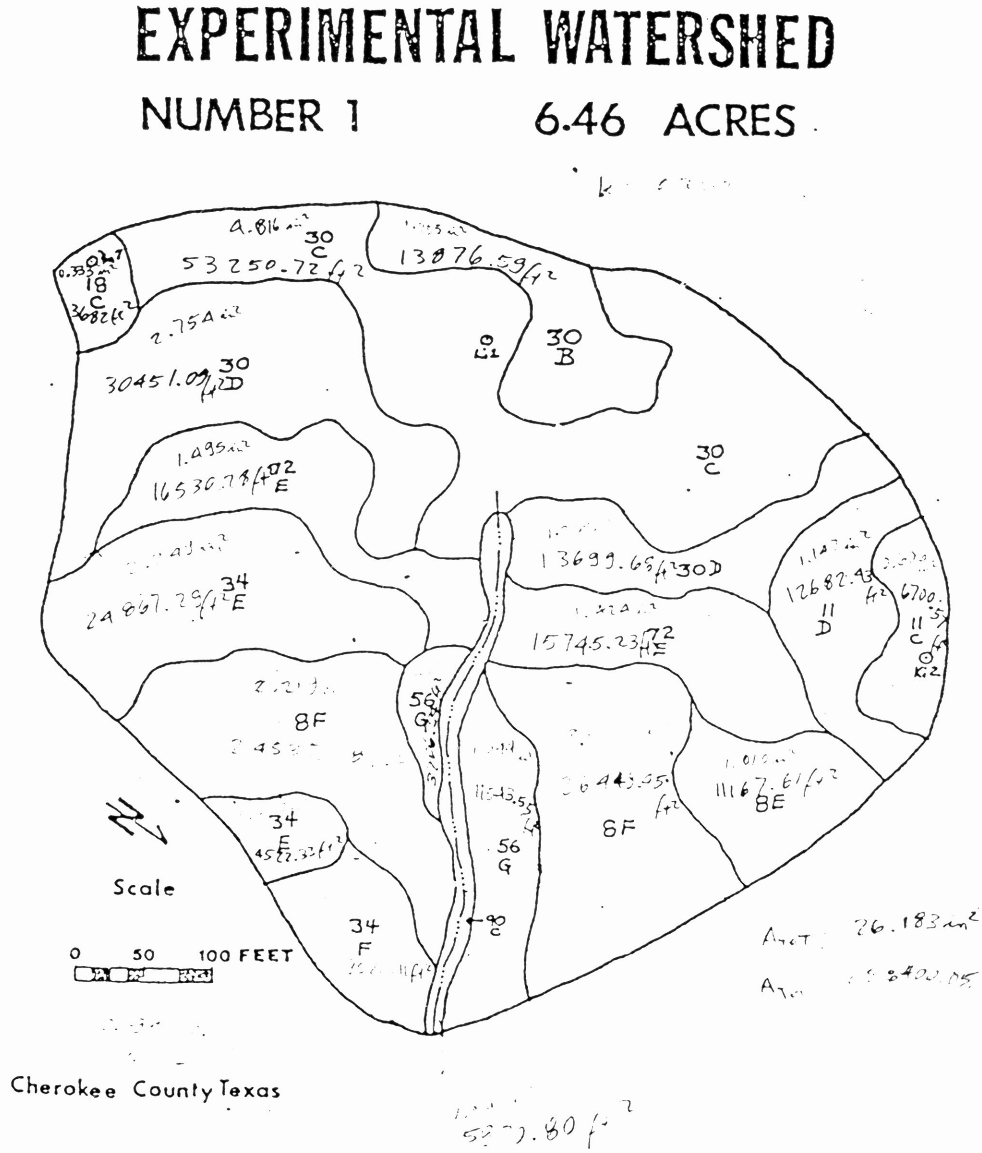
TABLE 3.—*Values of the topographic factor, LS, for specific combinations of slope length and steepness*[1]

Percent slope	Slope length (feet)											
	25	50	75	100	150	200	300	400	500	600	800	1,000
0.2	0.060	0.069	0.075	0.080	0.086	0.092	0.099	0.105	0.110	0.114	0.121	0.126
0.5	.073	.083	.090	.096	.104	.110	.119	.126	.132	.137	.145	.152
0.8	.086	.098	.107	.113	.123	.130	.141	.149	.156	.162	.171	.179
2	.133	.163	.185	.201	.227	.248	.280	.305	.326	.344	.376	.402
3	.190	.233	.264	.287	.325	.354	.400	.437	.466	.492	.536	.573
4	.230	.303	.357	.400	.471	.528	.621	.697	.762	.820	.920	1.01
5	.268	.379	.464	.536	.656	.758	.928	1.07	1.20	1.31	1.52	1.69
6	.336	.476	.583	.673	.824	.952	1.17	1.35	1.50	1.65	1.90	2.13
8	.496	.701	.859	.992	1.21	1.41	1.72	1.98	2.22	2.43	2.81	3.14
10	.685	.968	1.19	1.37	1.68	1.94	2.37	2.74	3.06	3.36	3.87	4.33
12	.903	1.28	1.56	1.80	2.21	2.55	3.13	3.61	4.04	4.42	5.11	5.71
14	1.15	1.62	1.99	2.30	2.81	3.25	3.98	4.59	5.13	5.62	6.49	7.26
16	1.42	2.01	2.46	2.84	3.48	4.01	4.92	5.68	6.35	6.95	8.03	8.98
18	1.72	2.43	2.97	3.43	4.21	3.86	5.95	6.87	7.68	8.41	9.71	10.9
20	2.04	2.88	3.53	4.08	5.00	5.77	7.07	8.16	9.12	10.0	11.5	12.9

[1] $LS = (\lambda/72.6)^m \ (65.41 \sin^2 \theta + 4.56 \sin \theta + 0.065)$ where λ = slope length in feet; m = 0.2 for gradients < 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, 0.5 for 5 percent slopes and steeper; and θ = angle of slope. (For other combinations of length and gradient, interpolate between adjacent values or see fig. 4.)

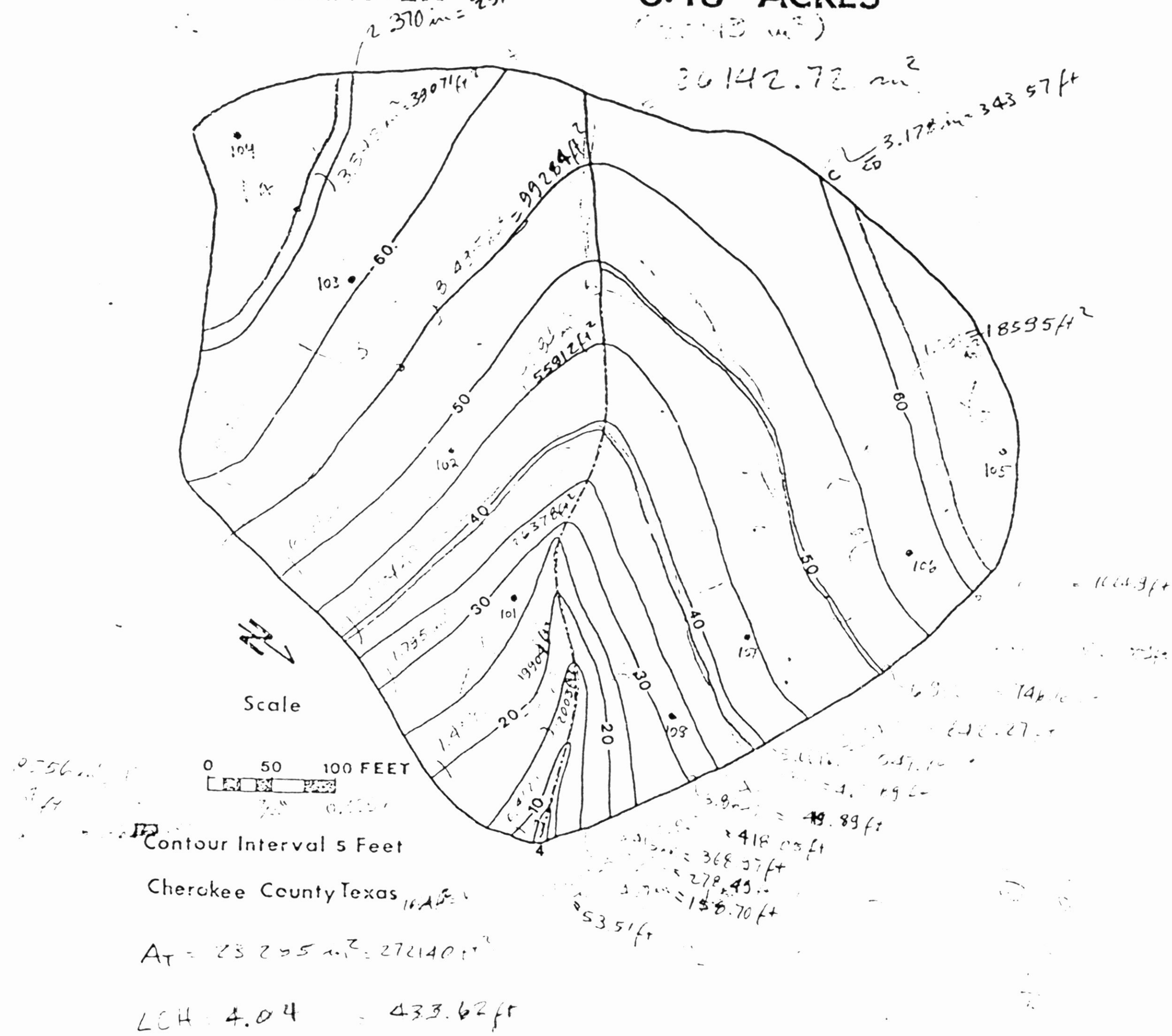
APPENDIX E

WATERSHED MAPS



EXPERIMENTAL WATERSHED

NUMBER 1 6.46 ACRES



EXPERIMENTAL WATERSHED

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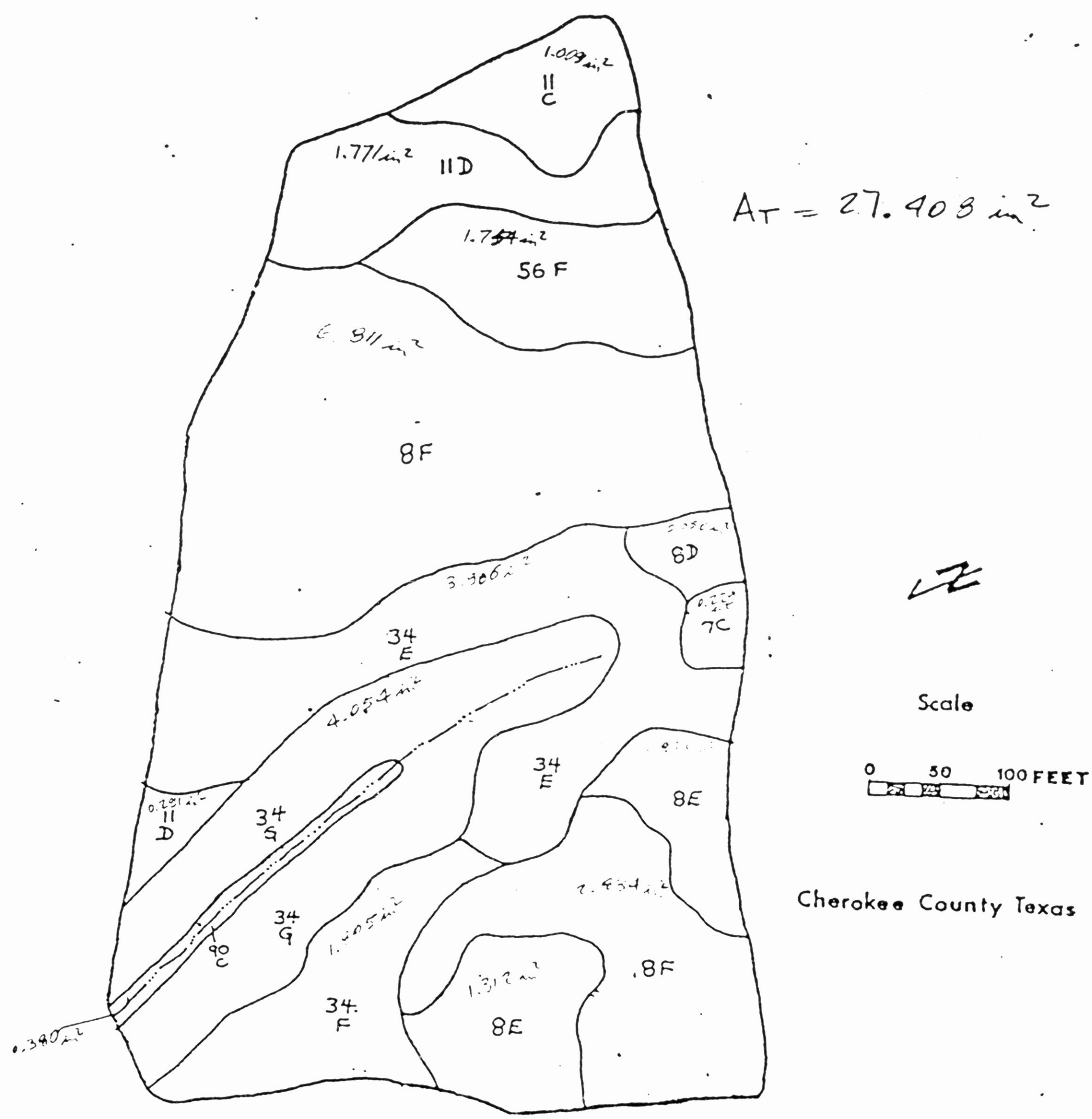

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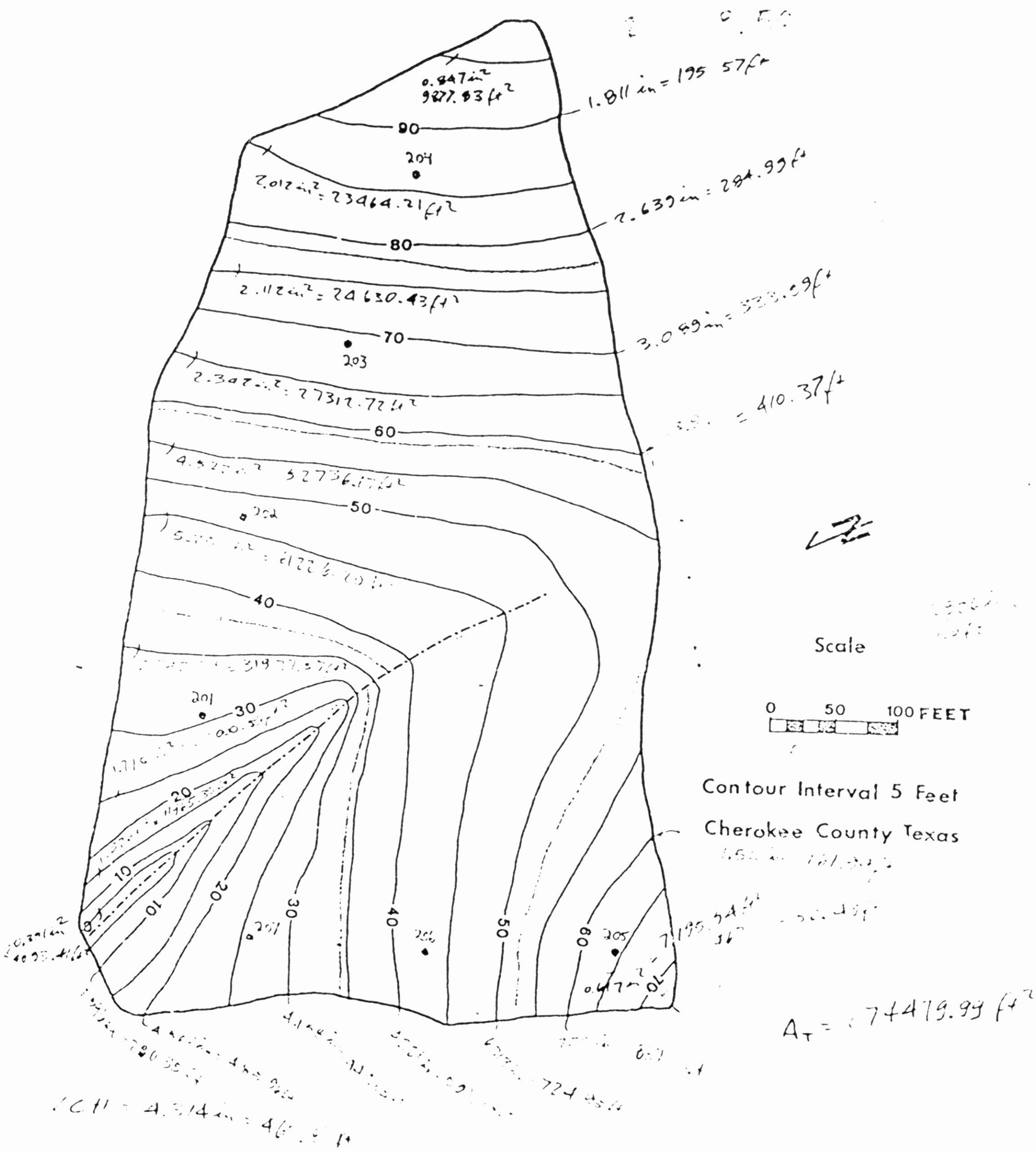
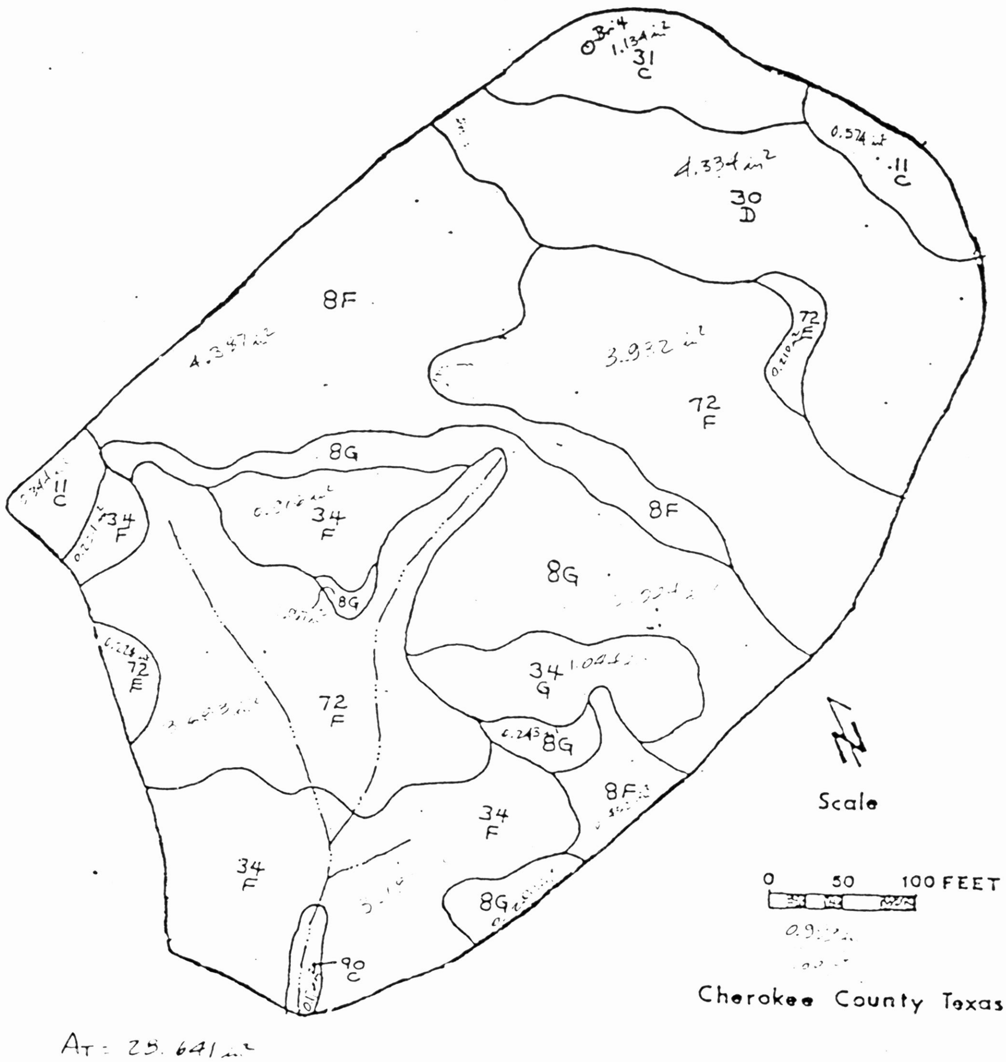


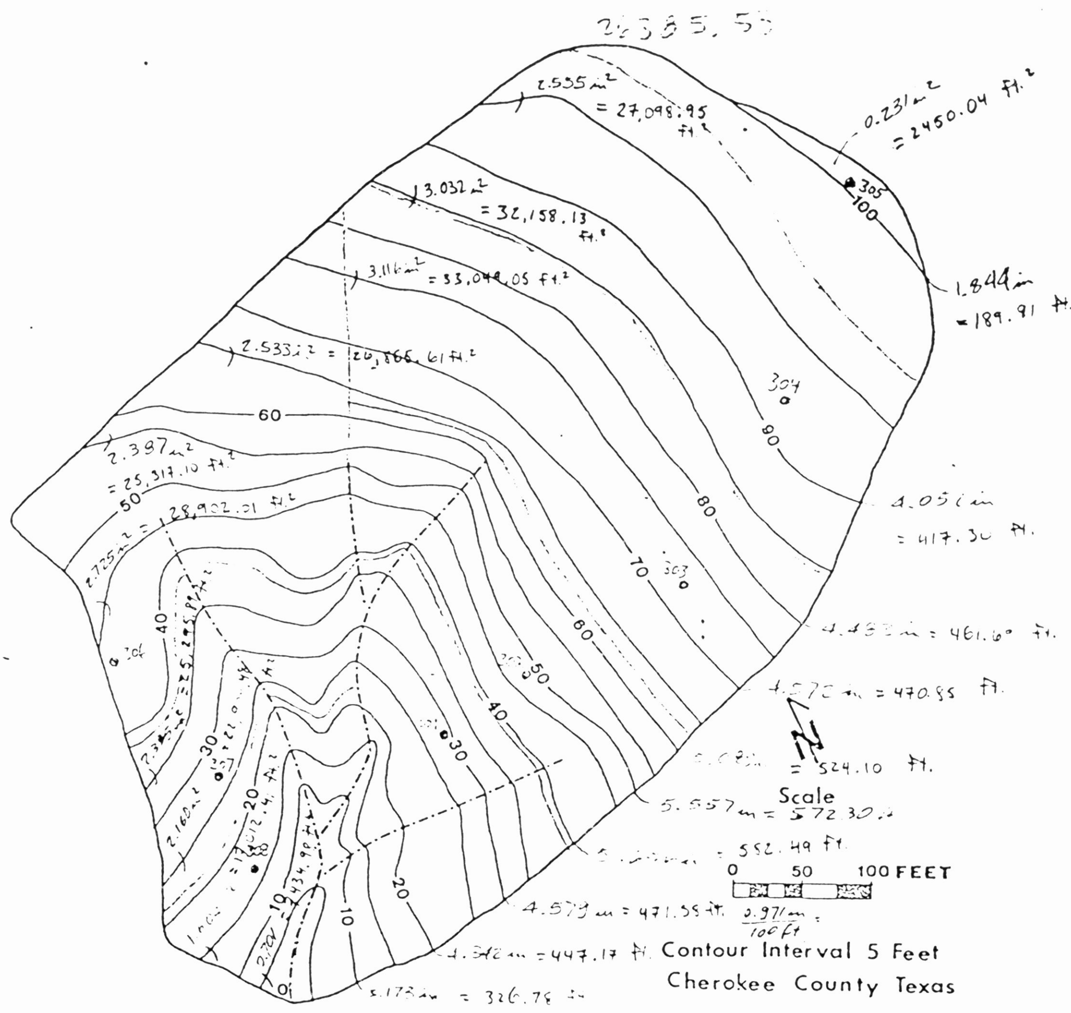
EXPERIMENTAL WATERSHED

NUMBER 3 6.52 ACRES



EXPERIMENTAL WATERSHED

NUMBER 3 6.52 ACRES

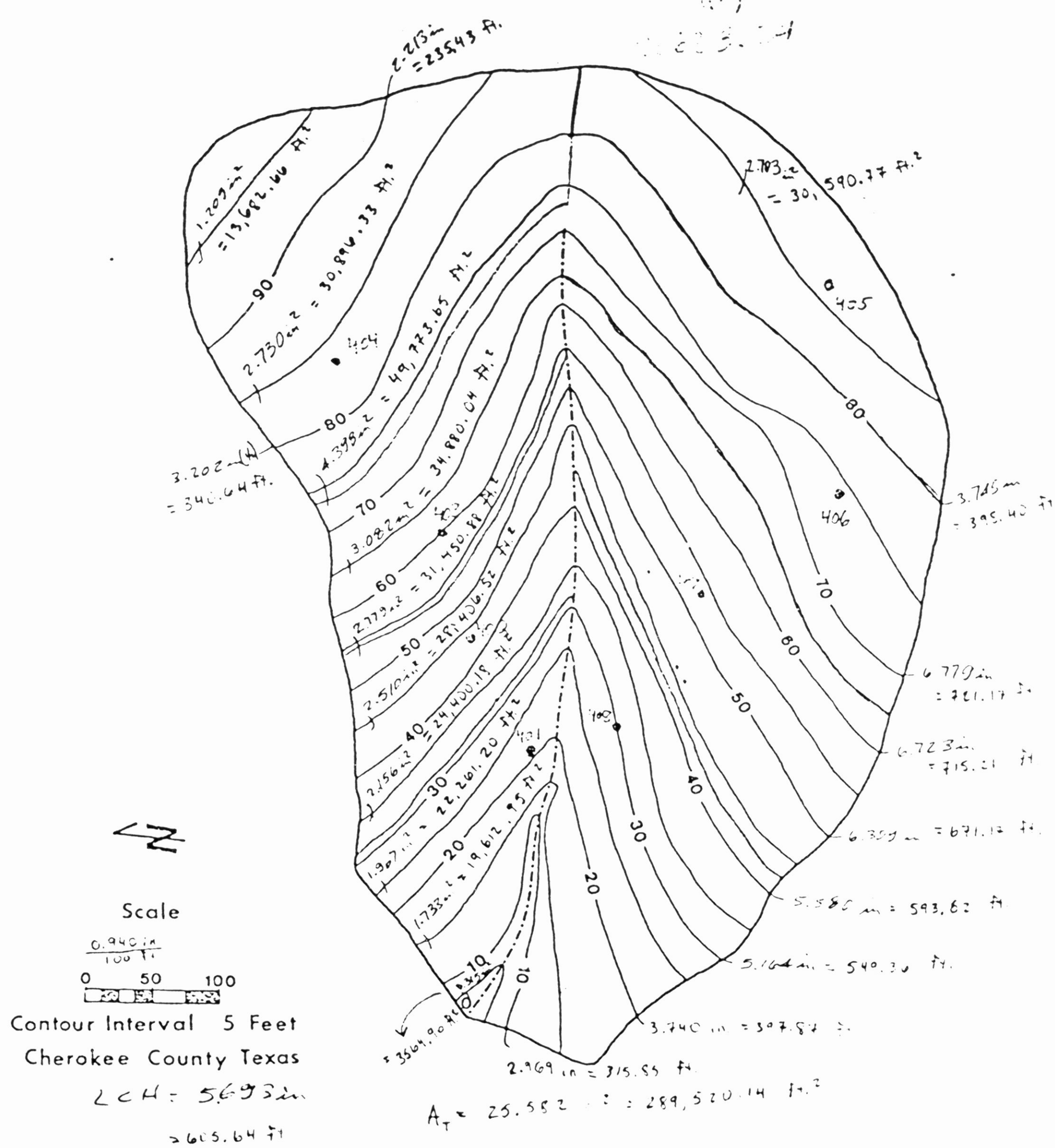


L CH: 3.683 in + 2.731 in + 1.322 in + 1.888 in = 9.624 in = 991.14 ft

A_T = 23.19 in² = 246,043.61 ft²

EXPERIMENTAL WATERSHED

NUMBER 4 6.58 ACRES



EXPERIMENTAL WATERSHED

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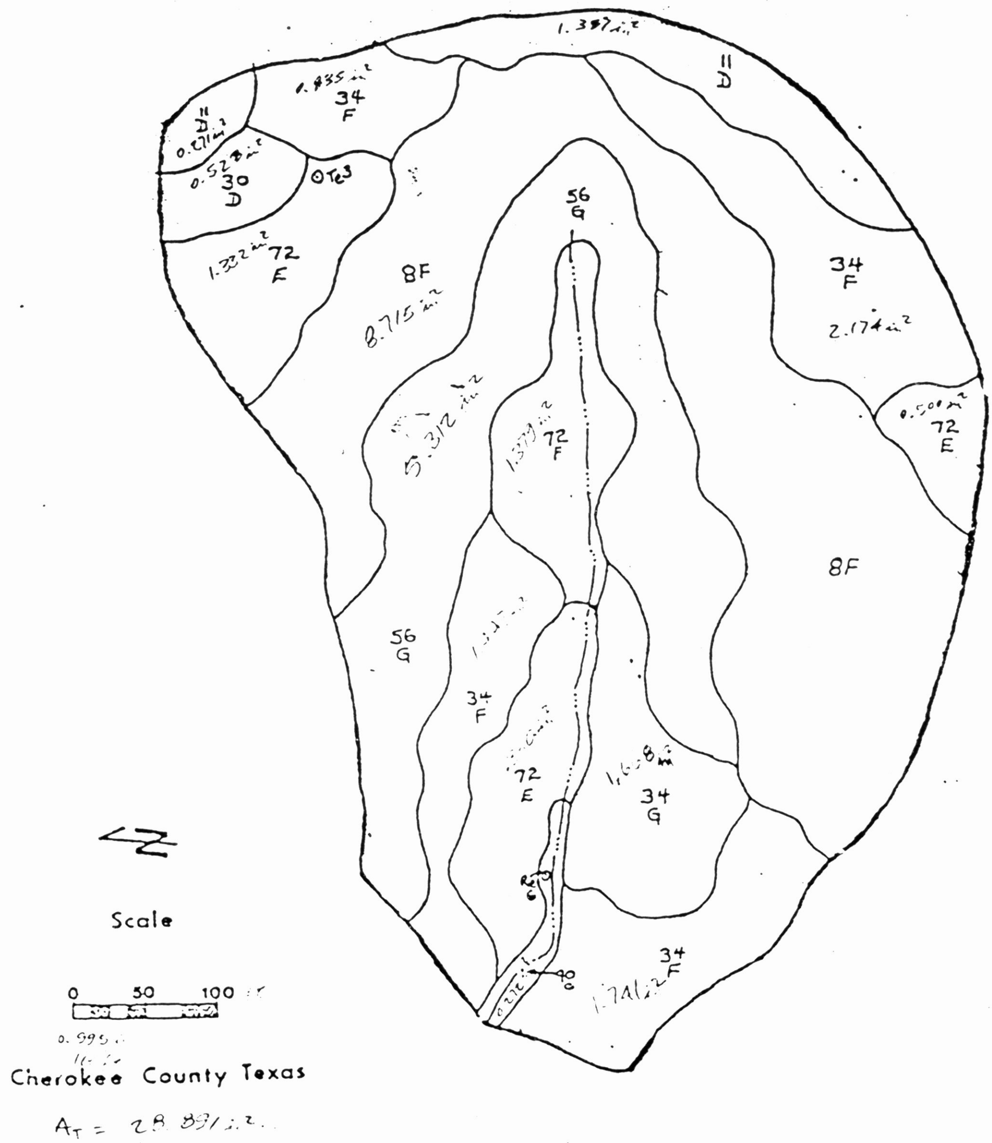
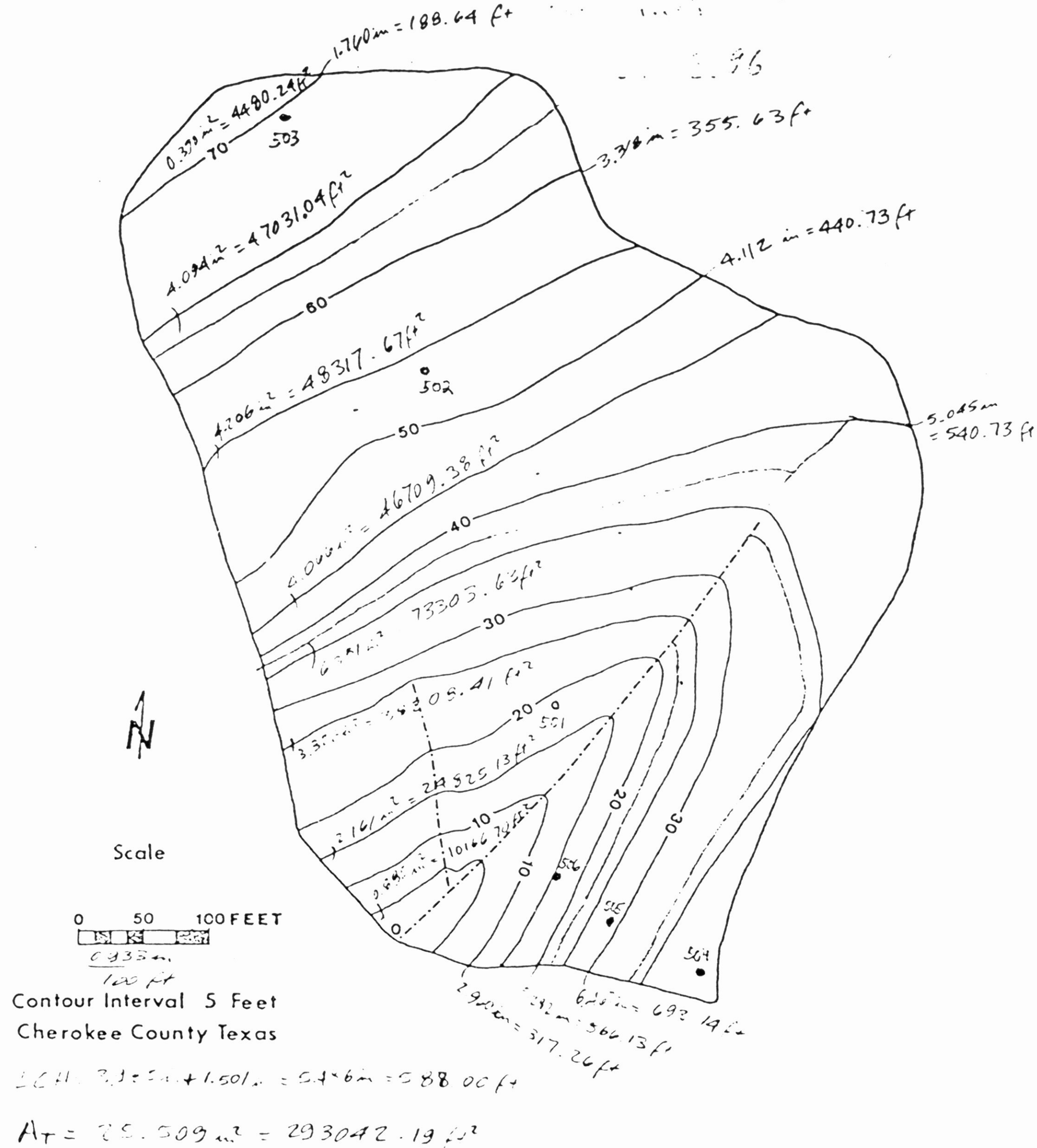


EXPERIMENTAL WATERSHED

NUMBER 5 6.70 ACRES



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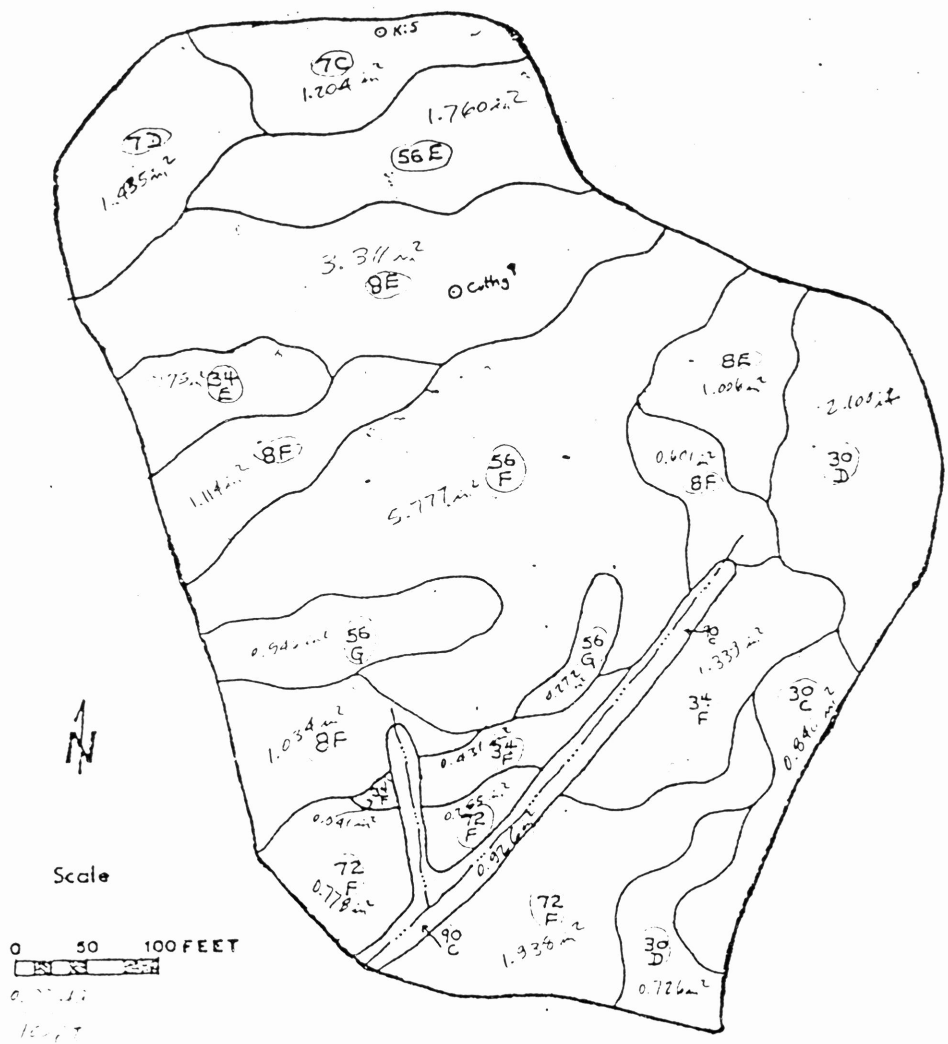
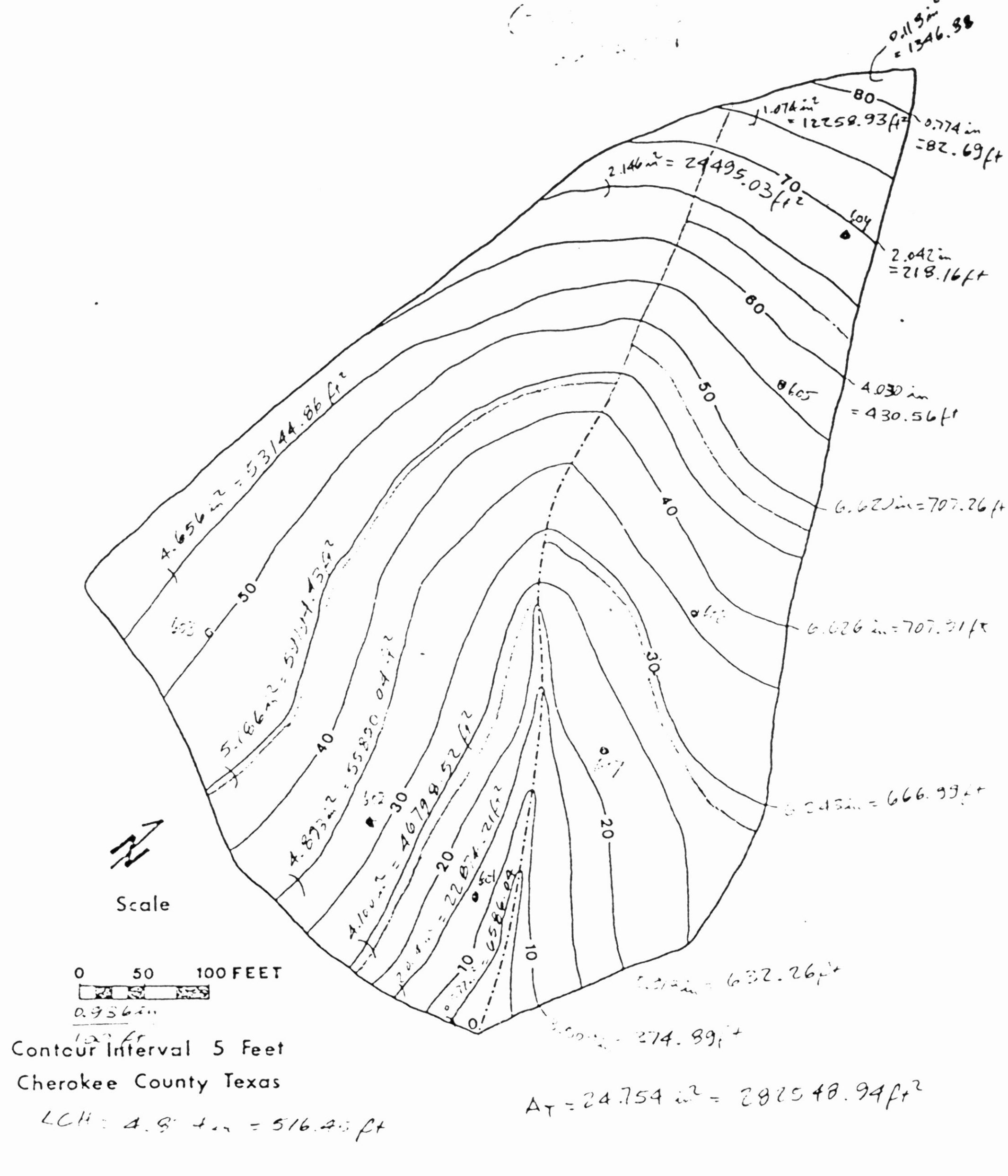


Cherokee County Texas

EXPERIMENTAL WATERSHED

NUMBER 6 6.58 ACRES



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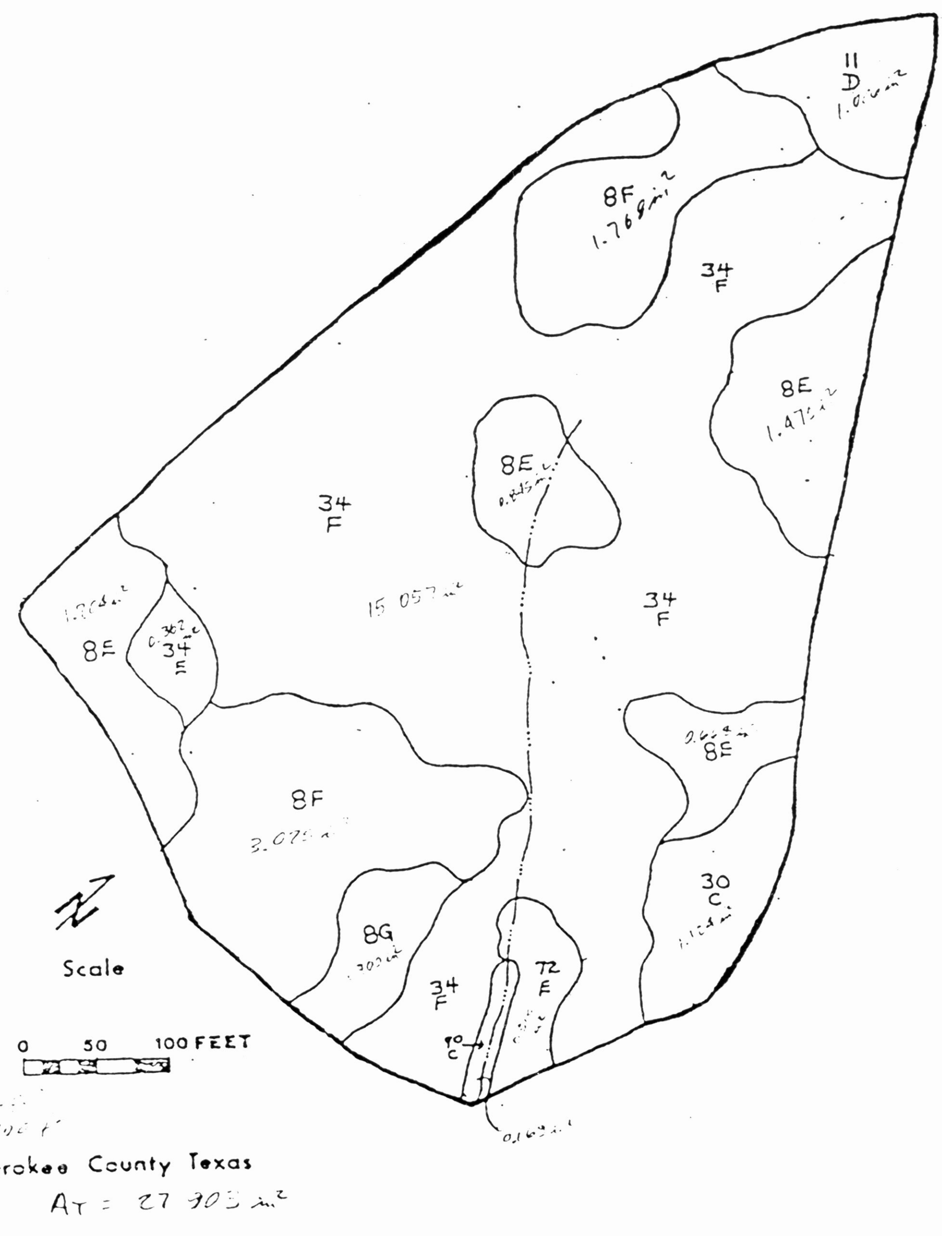
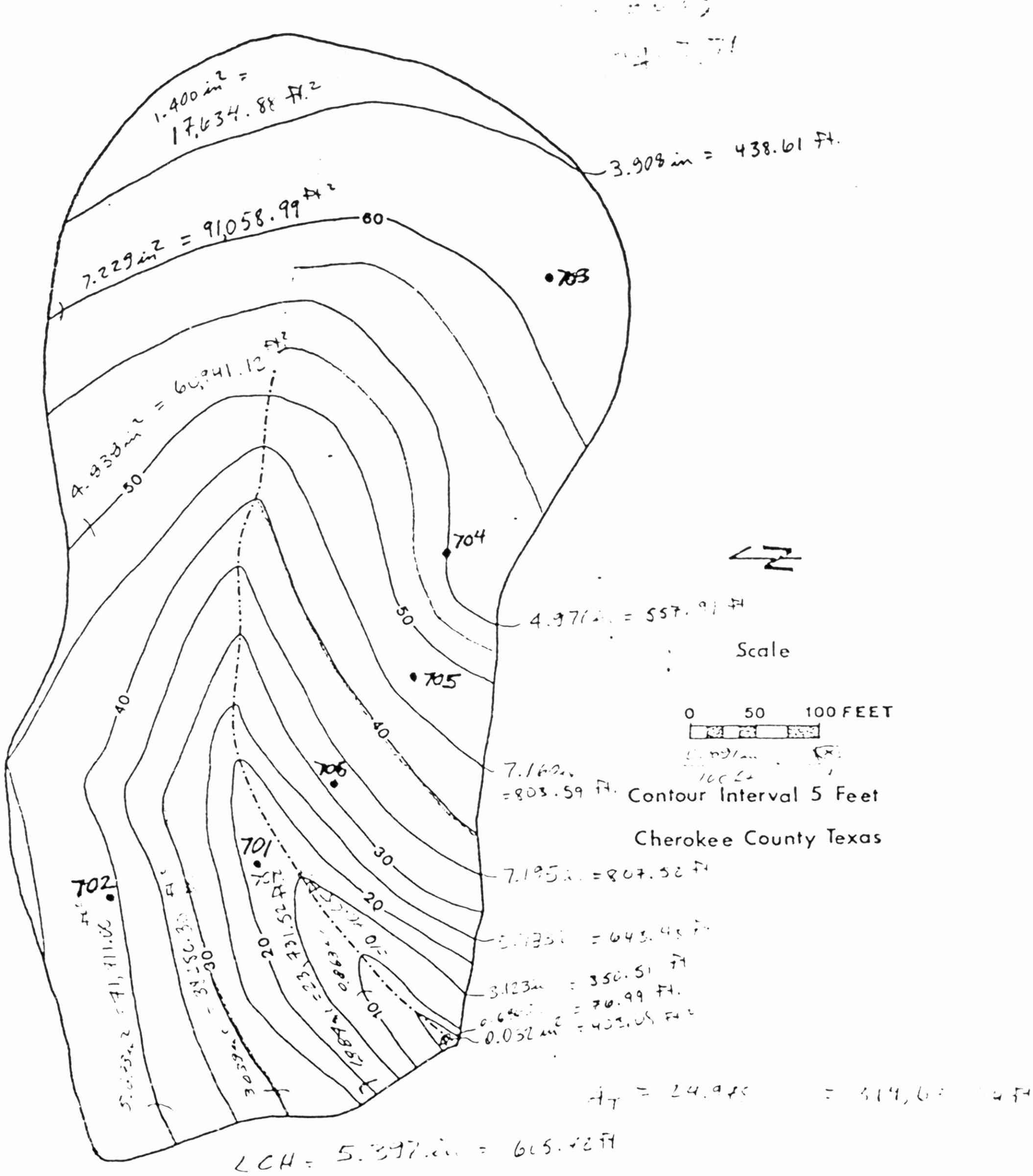


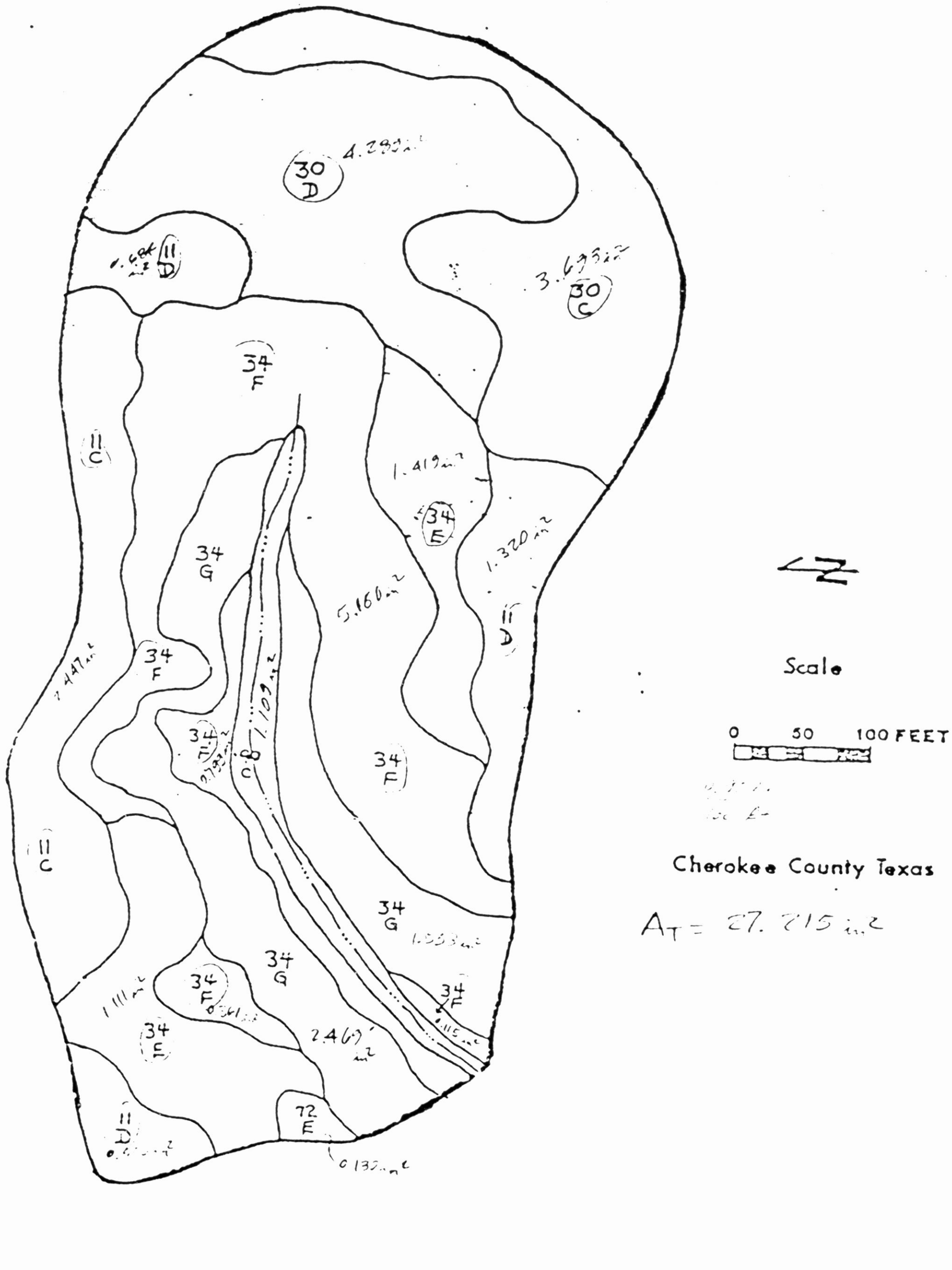
EXPERIMENTAL WATERSHED

NUMBER 7 6.78 ACRES



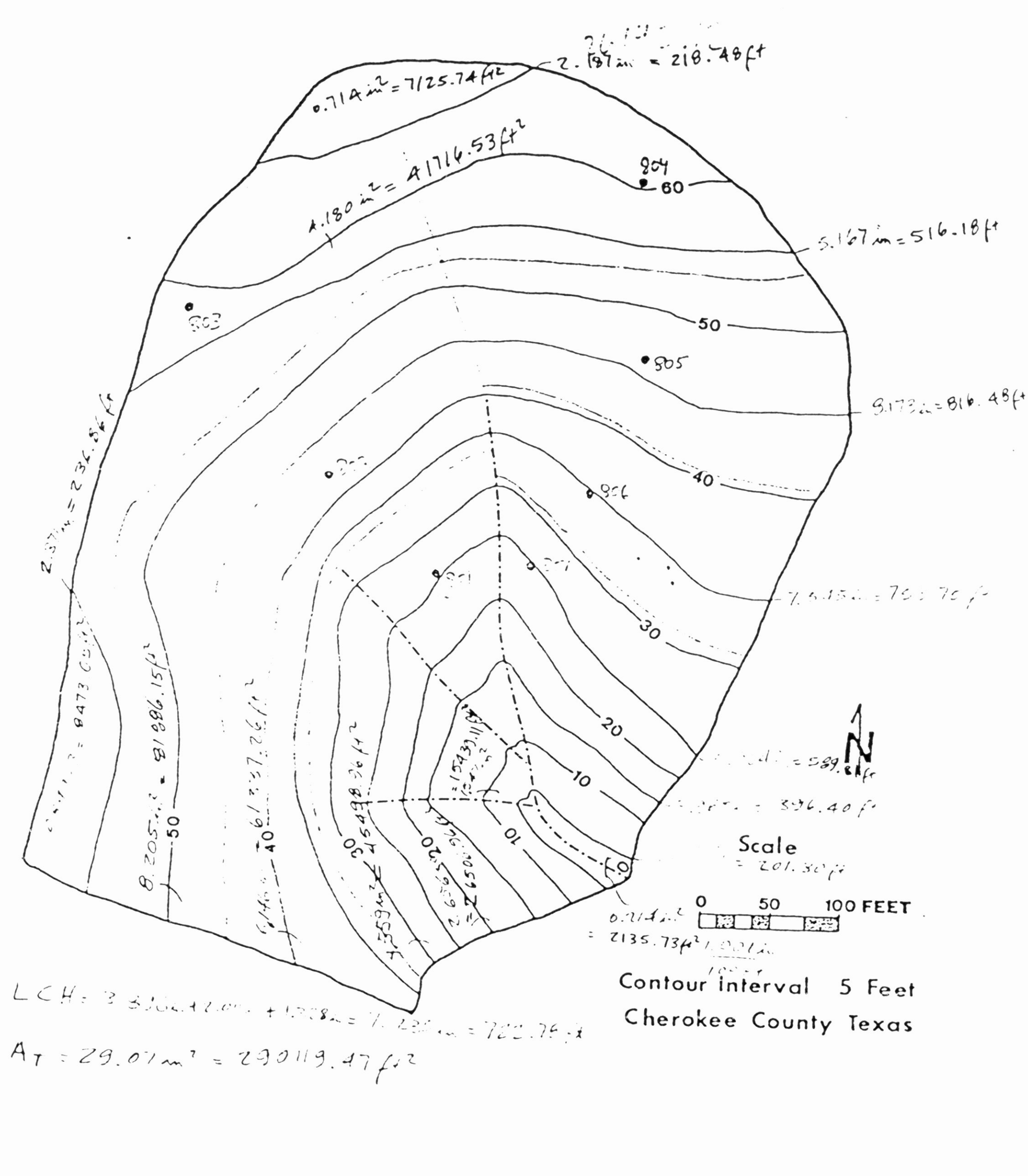
EXPERIMENTAL WATERSHED

NUMBER 7 6.78 ACRES



EXPERIMENTAL WATERSHED

NUMBER 8 6.46 ACRES



EXPERIMENTAL WATERSHED

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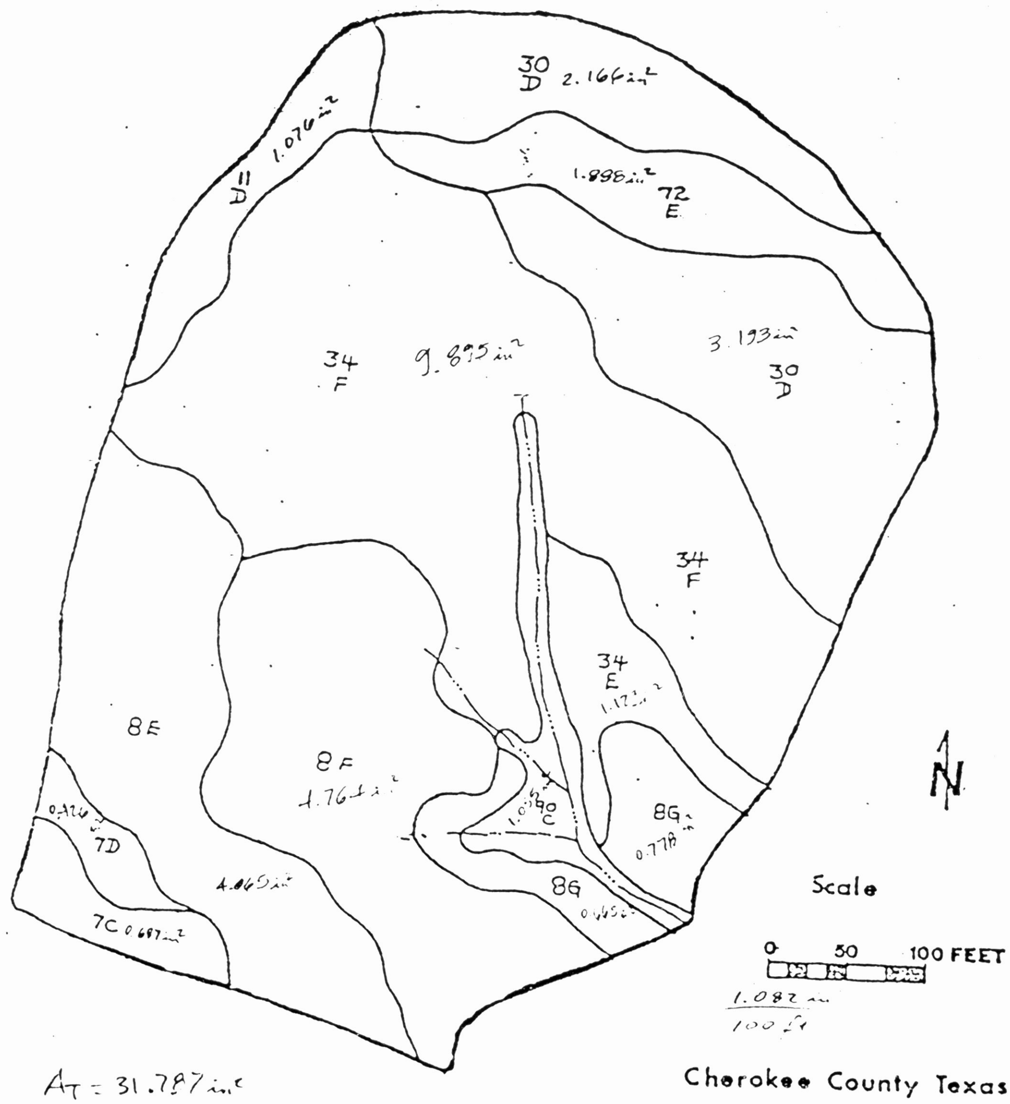
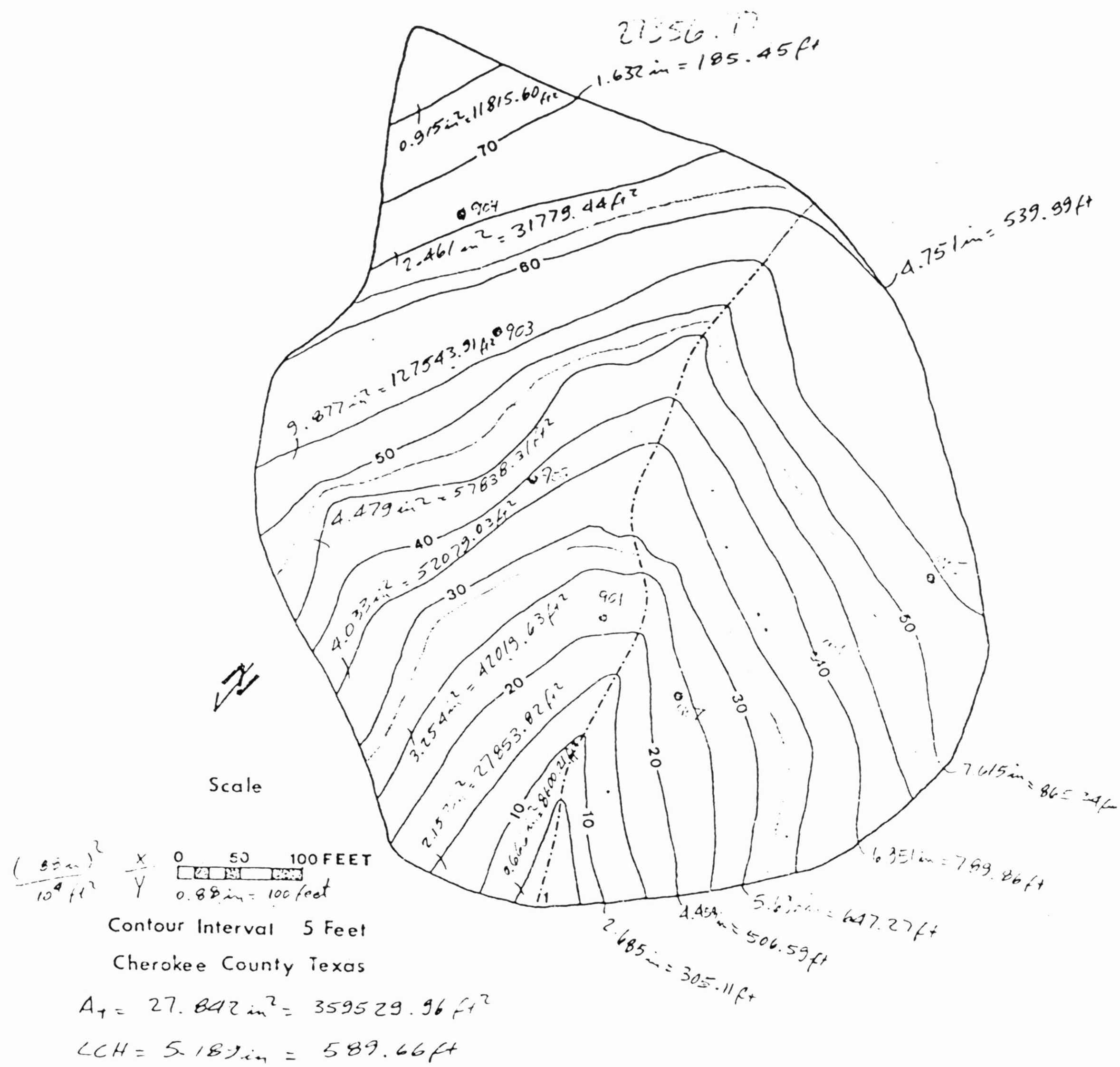


EXPERIMENTAL WATERSHED

NUMBER 9 6.76 ACRES



EXPERIMENTAL WATERSHED

NUMBER 9 6.76 ACRES