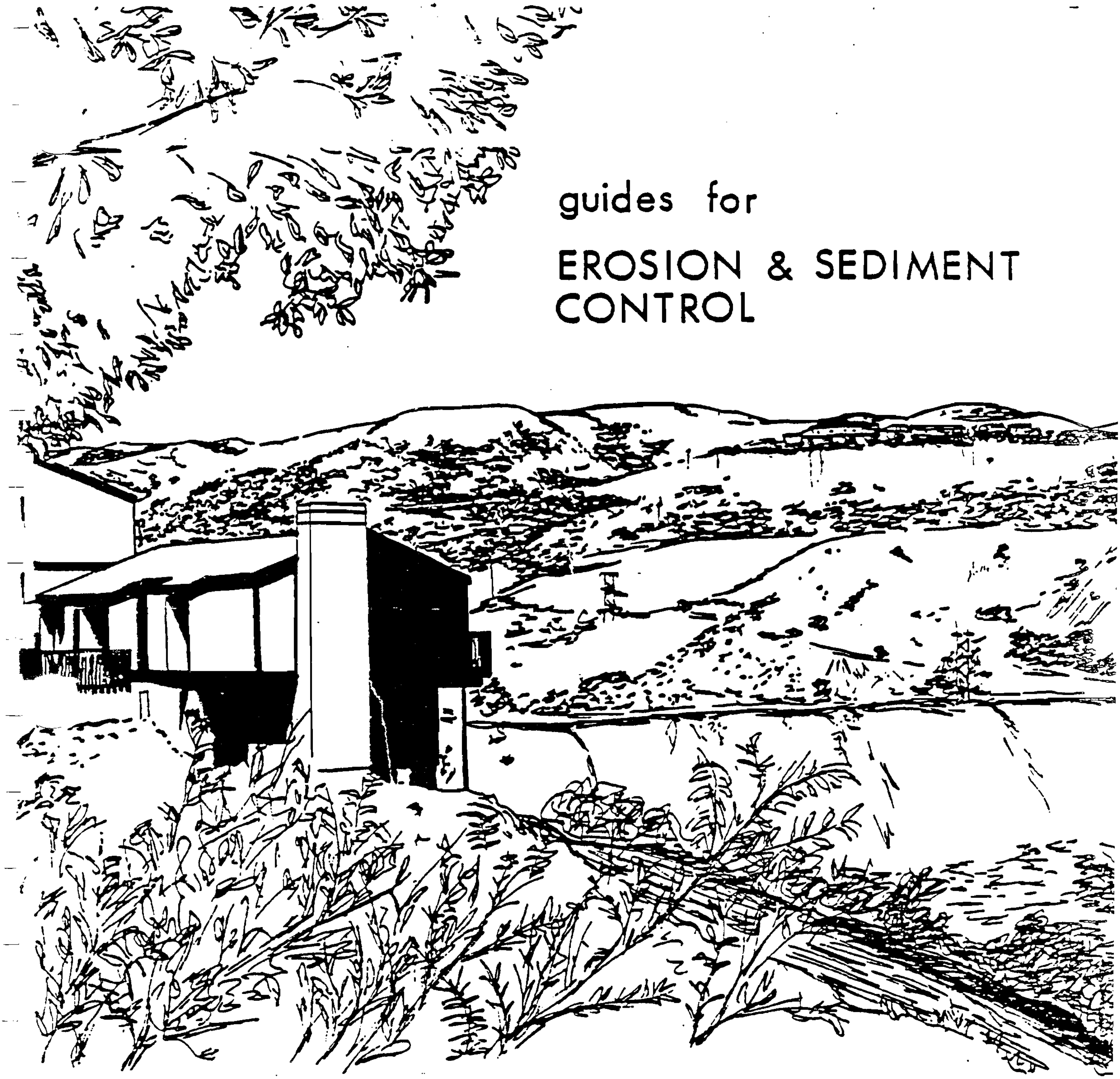
guides for

EROSION & SEDIMENT CONTROL



USDA Soil Conservation Service
Davis, California

GUIDES FOR EROSION AND SEDIMENT CONTROL IN CALIFORNIA

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
DAVIS, CALIFORNIA

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PREFACE

This is a revision of the publication first issued in January 1975 which is now superseded. The material it contains is in essence the same as in the first issue with changes limited only to minor editorial corrections and updating of references.

The purpose of this publication is to set forth guidelines for the quantitative treatment of problems related to erosion and sedimentation in the State of California.

The publication adopts the Soil Loss Equation, developed by the Agricultural Research Service as the basic tool for predicting erosion rates at a site under a given set of conditions. In view of the relatively small amount of data underlying the adaptation of the equation to the western regions of the United States the predictions obtained from it may not be as accurate as elsewhere in the country. We expect, however, that after a period of testing and adjustment the accuracy of results and hence reliability of the equation will increase.

The publication describes pertinent factors of the equation, discusses merits and shortcomings, explains how governing factors are evaluated and demonstrates how the equation can be used in resource conservation activities in California.

The material in this issue as in the previous one deals only with water induced erosion and primarily with sheet and rill erosion. Other aspects of water erosion as well as erosion induced by wind, gravity or other processes will be included in subsequent revisions of this publication.

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INTRODUCTION

I. Erosion Control

Soil erosion is a serious problem in two distinct, but closely related aspects. On the one hand it depletes a very valuable national resource and on the other it produces sediment which is one of the most damaging factors to the economy and the environment.

Soil erosion may result from natural causes such as rainstorms, windstorms and geologic disturbances or from man's activities. These activities can be direct, as for instance earth moving projects that involve excavation and disposal of large quantities of soil, or indirect. Agriculture is such an acitvity that does not involve massive removal of soil, but disturbs its protective cover and increases its susceptibility to erosion by natural or other causes.

One of the major objectives of the Soil Conservation Service is the development and implementation of programs that provide protection to the agricultural land and enchance its ability to resist erosion. Such programs have been used on a large scale during the last four decades and proved fairly successful.

Their main limitation was that they treated the problem of erosion only in a qualitative way. What they did in a given situation was to recommend the application of one or several conservation practices considered the most suitable for the site. The cost of installation was easily determined, but in general the benefit from it could not be predicted. Recognition of this limitation motivated the Agricultural Research Service to develop the Universal Soil Loss Equation (USLE) which is recommended for use, when applicable, to predict erosion rates.

The purpose of this publication is to describe briefly pertinent factors of the Universal Soil Loss Equation, discuss its merits and limitations, explain how terms are evaluated at different locations in California and demonstrate how the equation can be used to rate erosion and sediment control alternatives concerning either agricultural lands or construction sites.

Gully erosion results when overland flow waters come together and forms a concentrated flow and is discussed in Appendix F.

Ephemeral gully erosion occurs on arable lands where overland flow waters come together and form concentrated flows. The resulting channels are removed by the next tillage operation. See Appendix G for more information.

1. Rainfall Erosion

THE UNIVERSAL SOIL LOSS EQUATION

The equation as orignally developed predicted soil losses from agricultural lands induced by rainfall.

The general form of the equation is:

$$A = R * K * LS * C * P \qquad (9)*$$

The terms are defined as follows:

A	computed soil loss per acre per year
R	rainfall and runoff factor
K	soil erodibility factor
LS	topographic factor derived from the slope gradient and slope length
C	cover and management factor
P	support practice factor

THE RAINFALL FACTOR (R), represents the intensity of the mechanism responsible for the detachment of the soil particles by rainfall. considered on a yearly basis its value is equal to the total number of erosion-index units in a normal year's rain. The definintion of erosion-index and the method of its computation is described in reference 8.

See Appendix A for "R" values in California.

* Numbers in parenthesis refer to list of references in page 26.

THE SOIL ERODIBILITY FACTOR (K) The soil erodibility factor K used in the universal soil loss equation is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. It is a value determined experimentally for selected benchmark soils. Based on a knowledge of the behavior of soil properties and their interactions, these data are synthesized and values assigned to other kinds of soil.

A single K value can be given the dominant textural phase of a soil series if the erosion potential is about the same for all horizons and textural phases of that series. Where horizons or textural phases of a series differ greatly in erosion potential, say two or more K value classes, more than one K value needs to be assigned to the named kind of soil.

K values that have been obtained experimentally range from .02 to .69. For ease of use in the Service, twelve K value classes are used as follows:

.10, .15, .17, .20, .24, .28, .32, .37, .43, .49, .55, and .64.

Soil scientists, working closely with other specialists who have a knowledge of soils and their behavior, will assign one of these K value classes to each kind of soil and as needed to each major soil layer within a series. Once assigned, the K values are coordinated between states and regions in accordance with Service policy.

K factor values will be recorded on forms SCS-SOILS 5 for soils currently mapped in California. This record will be retrievable from computer storage. The Form 5 will be part of the Soils Handbook and Technical Guide in all Field Offices and the information will be available to the public and other agencies. Priority for developing values for K will be given to soils mapped in survey areas that are scheduled for completion within three years. A list of soil series with K factor values assigned to significant layers will be issued by the State Office as the data becomes available. The list will be updated periodically until values for all series and significant phases are developed.

In developing K values for soils, use all applicable data. In addition, consider the following soil properties that have been found to affect soil erodibility:

1. Soil Texture, especially percent of silt plus very fine sand.
2. Percent of sand greater than 0.10mm.
3. Soil organic matter content.
4. Soil structure (type, grade).
5. Soil permeability.
6. Clay mineralogy.
7. Coarse fragments in soil layer being evaluated.

The Agricultural Research Service has developed a nomograph which shows the influence of various selected soil properties on K values. (reference 10) ~~A copy of this nomograph is attached for information and guidance(figure 4)~~ See Figure 3 in Agriculture Handbook Number 537.

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When using the nomograph, care should be taken to select those soil properties that are most representative of the horizon being considered. For horizons having organic matter in excess of 4 percent, do not extrapolate—use the 4 percent curve.

The K values derived from the nomograph must be adjusted for coarse fragments. K values for soils high in coarse fragments (gravelly, chanery, shaly, slatey, cobbly, or flaggy) are reduced by one or two classes. Soils that are very gravelly, very chanery, very shaly, very slaty, very cherty, very cobbly, or very flaggy are reduced by two or three classes.

Soil scientists using the ARS nomograph have noted that for some soils, the K values obtained from the nomograph differ from those they have been using for many years. The nomograph commonly gives higher K values for silty soils and lower values for soils high in clay and in sand than values now in use. Where these values differ more than two K value classes, there is need to study the soils carefully and see how they behave under field conditions. For some soils the best value may be somewhere between these two values. For other soils, the original estimated value may be more representative; in others the nomograph value may be more representative. The nomograph is based on a limited number of different kinds of soil and experience with its use is limited. Therefore, it should be used as a guide and adjusted by field testing, observation and experimental evidence.

California will need to use the nomograph and other guides to make their first approximation of K values for California Soils. The K values derived from this approximation can then be adjusted where local experience shows a need to do so. It may also be helpful to look at the K values of soils having similar properties that occur in other states. As more data becomes available for specific soils the K values of these soils and of similar soils can be adjusted.

In Appendix B is an aid for estimating significant soil properties that have been found to affect soil erodibility, and a procedural outline and chart for estimating values for the K factor. Also included is the "textural; triangle method" proposed by Utah that could be tried and tested for use in California.

THE SLOPE LENGTH-GRADIENT FACTOR (LS) describes the combined effect of the geometric features of the site. It is defined as the expected ratio of soil loss per unit width on a field slope to corresponding loss from the basic 9 percent slope, 72.6 feet long.

The two components (S) and (L) have little influence, if any at all, on the particle dislodging mechanism which derives its energy directly from rainfall. On the other hand, they influence strongly the transport mechanism which has runoff as its source of energy. In flat areas where the effect of (LS) is negligible there is little systematic movement away from the site and consequently no soil loss, even though large amounts of soil particles may be detached and splashed around by the raindrops.

~~The value of the factor (LS) for a given site may be determined from the curves in figures 5 and 6 that relate it to given values of (L) and (S). Selection of the proper set of curves is done according to soil moisture, soil temperature regime indicated on the map in figure 3.~~

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Three different LS relationships are used in California. Figure 1 shows their general areas, and they are defined by Major Land Resource Areas (MLRA) as follows:

LS Area 1 includes MLRAs 21 and 23
LS Area 2 includes MLRAs 26, 29, 30, and 31
LS Area 3 includes MLRAs 4, 5, 14, 15, 16, 17, 18, 19, 20, and 22

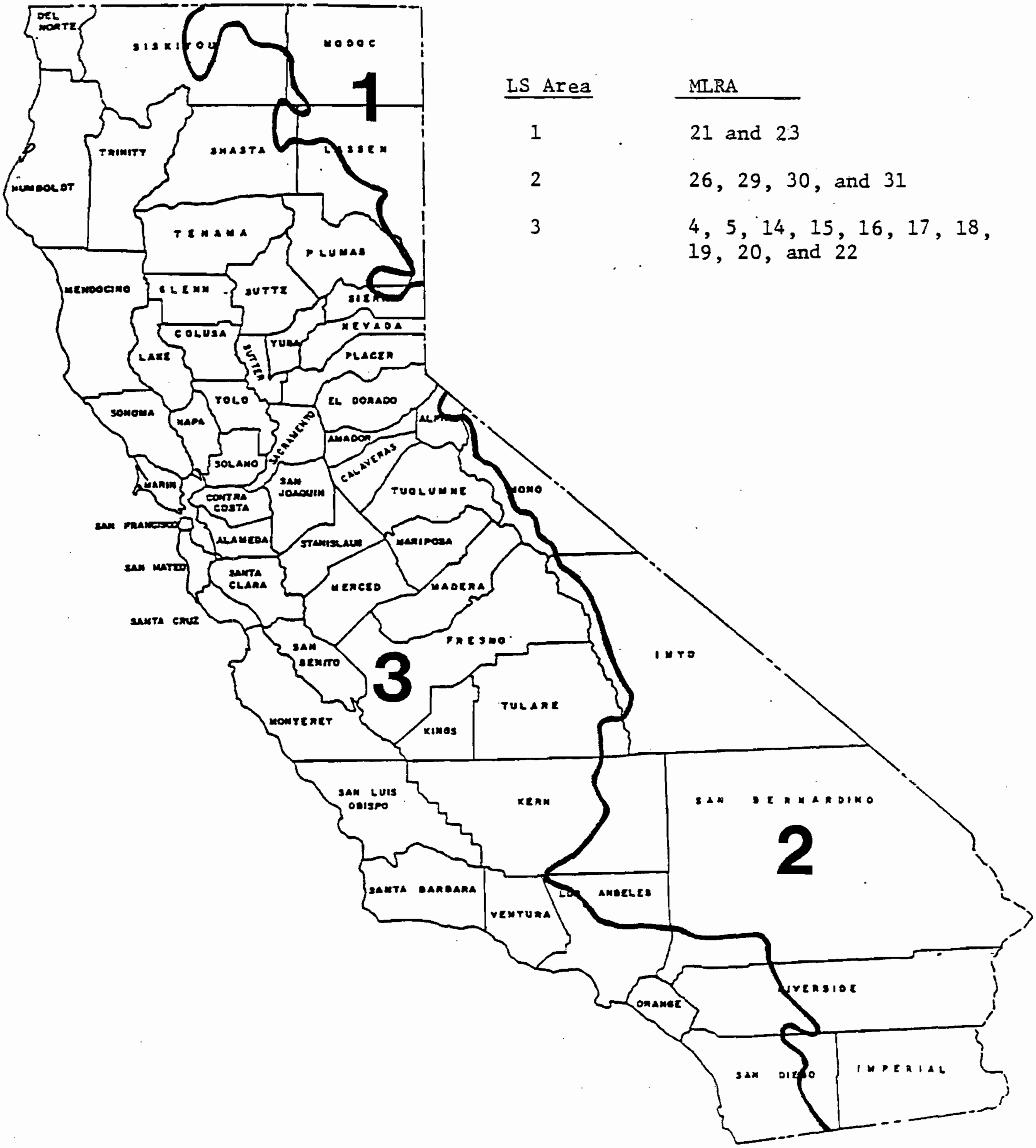
LS values in California will be obtained in

LS Area 1 using Table 1
LS Area 2 using Table 2 or Figure 4 in USDA Agriculture Handbook Number 537
LS Area 3 using Table 3

Procedures for adjusting LS values for segmented slopes are presented in USDA Agriculture Handbook Number 537.

Differences in the LS relationships between Areas can be seen in the LS equations shown on each Table.

Figure 1: LS Areas in California.



LS Area	MLRA
1	21 and 23
2	26, 29, 30, and 31
3	4, 5, 14, 15, 16, 17, 18, 19, 20, and 22

TABLE 1. LS Values for LS Area 1

MLRA: 21 and 23

$$LS = \left[\left(\frac{\ell}{72.6}\right)\cos(\tan^{-1}s)\right]^{0.50}\left[\frac{\sin(\tan^{-1}s)}{\sin 5.143}\right]^{0.70}$$

Where: ℓ = length in feet along slope

s = slope in %/100

SLOPE LENGTH IN FEET

Percent Slope	25	50	75	100	125	150	200	250	300	350	400	450	500	550	600	700	800	1000	1200
0.5	0.08	0.11	0.13	0.16	0.17	0.19	0.22	0.25	0.27	0.29	0.31	0.33	0.35	0.36	0.38	0.41	0.44	0.49	0.54
1.0	0.13	0.18	0.22	0.25	0.28	0.31	0.36	0.40	0.44	0.47	0.51	0.54	0.57	0.59	0.62	0.67	0.71	0.80	0.88
2.0	0.21	0.29	0.36	0.41	0.46	0.50	0.58	0.65	0.71	0.77	0.82	0.87	0.92	0.96	1.01	1.09	1.16	1.30	1.42
3.0	0.27	0.39	0.47	0.55	0.61	0.67	0.77	0.86	0.94	1.02	1.09	1.16	1.22	1.28	1.34	1.44	1.54	1.72	1.89
4.0	0.33	0.47	0.58	0.67	0.75	0.82	0.94	1.05	1.15	1.25	1.33	1.41	1.49	1.56	1.63	1.76	1.89	2.11	2.31
5.0	0.39	0.55	0.67	0.78	0.87	0.95	1.10	1.23	1.35	1.46	1.56	1.65	1.74	1.83	1.91	2.06	2.20	2.46	2.70
6.0	0.44	0.63	0.77	0.88	0.99	1.08	1.25	1.40	1.53	1.65	1.77	1.88	1.98	2.07	2.17	2.34	2.50	2.80	3.06
7.0	0.49	0.70	0.85	0.98	1.10	1.21	1.39	1.56	1.70	1.84	1.97	2.09	2.20	2.31	2.41	2.60	2.78	3.11	3.41
8.0	0.54	0.76	0.93	1.08	1.21	1.32	1.53	1.71	1.87	2.02	2.16	2.29	2.41	2.53	2.64	2.86	3.05	3.41	3.74
9.0	0.59	0.83	1.01	1.17	1.31	1.43	1.66	1.85	2.03	2.19	2.34	2.48	2.62	2.75	2.87	3.10	3.31	3.70	4.06
10.0	0.63	0.89	1.09	1.26	1.41	1.54	1.78	1.99	2.18	2.36	2.52	2.67	2.82	2.95	3.09	3.33	3.56	3.98	4.36
12.0	0.71	1.01	1.24	1.43	1.60	1.75	2.02	2.26	2.47	2.67	2.85	3.03	3.19	3.35	3.50	3.78	4.04	4.51	4.94
14.0	0.79	1.12	1.37	1.58	1.77	1.94	2.24	2.51	2.75	2.97	3.17	3.36	3.54	3.72	3.88	4.19	4.48	5.01	5.49
16.0	0.87	1.23	1.50	1.73	1.94	2.12	2.45	2.74	3.00	3.24	3.47	3.68	3.88	4.07	4.25	4.59	4.90	5.48	6.01
18.0	0.94	1.33	1.62	1.88	2.10	2.30	2.65	2.97	3.25	3.51	3.75	3.98	4.19	4.40	4.59	4.96	5.31	5.93	6.50
20.0	1.01	1.42	1.74	2.01	2.25	2.46	2.84	3.18	3.48	3.76	4.02	4.26	4.50	4.71	4.92	5.32	5.69	6.36	6.96
22.0	1.07	1.51	1.85	2.14	2.39	2.62	3.02	3.38	3.70	4.00	4.28	4.54	4.78	5.02	5.24	5.66	6.05	6.76	7.41
24.0	1.13	1.60	1.96	2.26	2.53	2.77	3.20	3.58	3.92	4.23	4.52	4.80	5.06	5.30	5.54	5.98	6.40	7.15	7.83
26.0	1.19	1.68	2.06	2.38	2.66	2.91	3.36	3.76	4.12	4.45	4.76	5.04	5.32	5.58	5.82	6.29	6.73	7.52	8.24
28.0	1.24	1.76	2.16	2.49	2.78	3.05	3.52	3.94	4.31	4.66	4.98	5.28	5.57	5.84	6.10	6.59	7.04	7.87	8.62
30.0	1.30	1.84	2.25	2.60	2.90	3.18	3.67	4.10	4.50	4.86	5.19	5.51	5.80	6.09	6.36	6.87	7.34	8.21	8.99
32.0	1.35	1.91	2.34	2.70	3.02	3.30	3.81	4.27	4.67	5.05	5.40	5.72	6.03	6.33	6.61	7.14	7.63	8.53	9.34
34.0	1.40	1.98	2.42	2.79	3.12	3.42	3.95	4.42	4.84	5.23	5.57	5.93	6.25	6.55	6.85	7.39	7.90	8.84	9.68
36.0	1.44	2.04	2.50	2.89	3.23	3.54	4.08	4.56	5.00	5.40	5.77	6.12	6.46	6.77	7.07	7.64	8.17	9.13	10.0
38.0	1.49	2.10	2.58	2.97	3.33	3.64	4.21	4.70	5.15	5.57	5.95	6.31	6.65	6.98	7.29	7.87	8.41	9.41	10.3
40.0	1.53	2.16	2.65	3.06	3.42	3.75	4.33	4.84	5.30	5.72	6.12	6.49	6.84	7.17	7.49	8.09	8.65	9.67	10.6
45.0	1.63	2.30	2.82	3.25	3.63	3.98	4.60	5.14	5.63	6.08	6.50	6.90	7.27	7.62	7.96	8.60	9.19	10.3	11.3
50.0	1.71	2.42	2.96	3.42	3.82	4.19	4.84	5.41	5.92	6.40	6.84	7.25	7.65	8.02	8.37	9.05	9.67	10.8	11.8
55.0	1.78	2.52	3.09	3.57	3.99	4.37	5.04	5.64	6.18	6.67	7.13	7.56	7.97	8.36	8.73	9.43	10.1	11.3	12.4
60.0	1.85	2.61	3.20	3.69	4.13	4.52	5.22	5.84	6.40	6.91	7.39	7.83	8.26	8.66	9.05	9.77	10.4	11.7	12.8

TABLE 2. LS Values for LS Area 2

MLRA: 26, 29, 30, and 31

$$LS = \left[\left(\frac{\ell}{72.6}\cos(\tan^{-1}s)\right)\right]^m \left[65.41\sin^2(\tan^{-1}s) + 4.56\sin(\tan^{-1}s) + 0.065\right]$$

WHERE: ℓ = length in feet along slope
s = slope in %/100
m = 0.2 for s <0.01
m = 0.3 for s of 0.01 to 0.035
m = 0.4 for s of 0.036 to 0.045
m = 0.5 for s >0.045

SLOPE LENGTH IN FEET

PERCENT SLOPE	25	50	75	100	110	130	150	200	250	300	350	400	450	500	550	600	700	800	1000	120
.50	.07	.08	.09	.10	.10	.10	.10	.11	.11	.12	.12	.13	.13	.13	.13	.14	.14	.14	.15	.1
1.00	.09	.10	.12	.13	.13	.14	.15	.16	.17	.18	.19	.20	.20	.21	.22	.22	.23	.24	.26	.2
2.00	.13	.16	.18	.20	.21	.22	.23	.25	.26	.28	.29	.30	.32	.33	.33	.34	.36	.37	.40	.4
3.00	.19	.23	.26	.29	.30	.31	.32	.35	.38	.40	.42	.43	.45	.46	.48	.49	.51	.54	.57	.6
4.00	.23	.30	.36	.40	.42	.44	.47	.53	.58	.62	.66	.70	.73	.76	.79	.82	.87	.92	1.00	1.0
5.00	.27	.38	.46	.53	.56	.61	.66	.76	.85	.93	1.00	1.07	1.13	1.20	1.25	1.31	1.42	1.51	1.69	1.8
6.00	.34	.48	.58	.67	.70	.77	.82	.95	1.06	1.16	1.26	1.34	1.43	1.50	1.58	1.65	1.78	1.90	2.13	2.3
7.00	.41	.58	.71	.82	.86	.94	1.01	1.17	1.30	1.43	1.54	1.65	1.75	1.84	1.93	2.02	2.18	2.33	2.61	2.8
8.00	.50	.70	.86	.99	1.04	1.13	1.21	1.40	1.57	1.72	1.85	1.98	2.10	2.22	2.32	2.43	2.62	2.80	3.13	3.4
9.00	.59	.83	1.02	1.17	1.23	1.34	1.44	1.66	1.85	2.03	2.19	2.35	2.49	2.62	2.75	2.87	3.10	3.32	3.71	4.0
10.00	.68	.97	1.19	1.37	1.44	1.56	1.68	1.94	2.16	2.37	2.56	2.74	2.90	3.06	3.21	3.35	3.62	3.87	4.33	4.7
12.00	.90	1.28	1.56	1.80	1.89	2.06	2.21	2.55	2.85	3.12	3.37	3.61	3.83	4.03	4.23	4.42	4.77	5.10	5.70	6.2
14.00	1.15	1.62	1.99	2.29	2.41	2.62	2.81	3.24	3.63	3.97	4.29	4.59	4.87	5.13	5.38	5.62	6.07	6.49	7.25	7.9
16.00	1.42	2.01	2.46	2.84	2.98	3.24	3.48	4.01	4.49	4.92	5.31	5.68	6.02	6.35	6.66	6.95	7.51	8.03	8.97	9.8
18.00	1.72	2.43	2.97	3.43	3.60	3.91	4.21	4.86	5.43	5.95	6.42	6.87	7.28	7.68	8.05	8.41	9.08	9.71	10.86	11.8
20.00	2.04	2.88	3.53	4.08	4.28	4.65	5.00	5.77	6.45	7.06	7.63	8.16	8.65	9.12	9.56	9.99	10.79	11.54	12.90	14.1
22.00	2.39	3.37	4.13	4.77	5.00	5.44	5.84	6.75	7.54	8.26	8.92	9.54	10.12	10.67	11.19	11.68	12.62	13.49	15.08	16.9
24.00	2.75	3.89	4.77	5.51	5.77	6.28	6.74	7.79	8.71	9.54	10.30	11.01	11.68	12.31	12.91	13.49	14.57	15.57	17.41	19.0
26.00	3.14	4.44	5.44	6.28	6.59	7.16	7.70	8.89	9.94	10.88	11.76	12.57	13.33	14.05	14.74	15.39	16.63	17.77	19.87	21.7
28.00	3.55	5.02	6.15	7.10	7.45	8.10	8.70	10.04	11.23	12.30	13.28	14.20	15.06	15.88	16.65	17.39	18.79	20.08	22.45	24.6
30.00	3.98	5.62	6.89	7.95	8.34	9.07	9.74	11.25	12.57	13.77	14.88	15.91	16.87	17.78	18.65	19.48	21.04	22.49	25.15	27.5
32.00	4.42	6.25	7.65	8.84	9.27	10.08	10.82	12.50	13.97	15.31	16.53	17.68	18.75	19.76	20.73	21.65	23.38	25.00	27.95	30.6
34.00	4.88	6.90	8.45	9.75	10.23	11.12	11.95	13.79	15.42	16.89	18.25	19.51	20.69	21.81	22.87	23.89	25.81	27.59	30.84	33.7
36.00	5.35	7.56	9.26	10.70	11.22	12.20	13.10	15.13	16.91	18.53	20.01	21.39	22.69	23.92	25.09	26.20	28.30	30.25	33.83	37.0
38.00	5.83	8.25	10.10	11.66	12.23	13.30	14.29	16.50	18.44	20.20	21.82	23.33	24.74	26.08	27.35	28.57	30.86	32.99	36.88	40.4
40.00	6.33	8.95	10.96	12.65	13.27	14.43	15.50	17.89	20.01	21.91	23.67	25.30	26.84	28.29	29.67	30.99	33.48	35.79	40.01	43.8
42.00	6.83	9.66	11.83	13.66	14.33	15.57	16.73	19.32	21.60	23.66	25.56	27.32	28.98	30.54	32.04	33.46	36.14	38.64	43.20	47.1
44.00	7.34	10.38	12.72	14.68	15.40	16.74	17.98	20.77	23.22	25.43	27.47	29.37	31.15	32.83	34.44	35.97	38.85	41.53	46.43	50.8
46.00	7.86	11.12	13.61	15.72	16.49	17.92	19.25	22.23	24.86	27.23	29.41	31.44	33.35	35.15	36.87	38.51	41.59	44.46	49.71	54.4
48.00	8.38	11.86	14.52	16.77	17.59	19.12	20.54	23.71	26.51	29.04	31.37	33.53	35.57	37.49	39.32	41.07	44.36	47.43	53.02	58.0
50.00	8.91	12.60	15.44	17.82	18.69	20.32	21.83	25.21	28.18	30.87	33.34	35.65	37.81	39.85	41.80	43.66	47.16	50.41	56.36	61.7
52.00	9.44	13.35	16.35	18.88	19.81	21.53	23.13	26.71	29.86	32.71	35.33	37.77	40.06	42.23	44.29	46.26	49.96	53.41	59.72	65.4
54.00	9.98	14.11	17.28	19.95	20.92	22.75	24.43	28.21	31.54	34.56	37.32	39.90	42.32	44.61	46.79	48.87	52.78	56.43	63.09	69.1
56.00	10.51	14.86	18.20	21.02	22.04	23.96	25.74	29.72	33.23	36.40	39.32	42.04	44.59	47.00	49.29	51.48	55.61	59.45	66.46	72.8
58.00	11.04	15.62	19.13	22.09	23.16	25.18	27.05	31.23	34.92	38.25	41.32	44.17	46.85	49.38	51.79	54.10	58.43	62.47	69.84	76.5
60.00	11.58	16.37	20.05	23.15	24.28	26.40	28.35	32.74	36.60	40.10	43.31	46.30	49.11	51.77	54.29	56.71	61.25	65.48	73.21	80.2

MLRA: 4, 5, 14, 15, 16,
17, 18, 19, 20, 22

WHERE: ℓ = length in feet along slope
s = slope in %/100
m = 0.2 for s <0.01
m = 0.3 for s of 0.01 to 0.035
m = 0.4 for s of 0.036 to 0.045
m = 0.5 for s >0.045

For slopes of 9% or flatter:

$$LS = [(\frac{\ell}{72.6} \cos(\tan^{-1}s)]^{m} [65.41 \sin^{2}(\tan^{-1}s) + 4.56 \sin(\tan^{-1}s) + 0.065]$$

For slopes steeper than 9%:

$$LS = [(\frac{\ell}{72.6} \cos(\tan^{-1}s)]^{0.50} [\frac{\sin(\tan^{-1}s)}{\sin 5.143}]^{1.4}$$

SLOPE LENGTH IN FEET

Percent Slope	25	50	75	100	125	150	200	250	300	350	400	450	500	550	600	700	800	1000	120
0.5	0.07	0.08	0.09	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.1
1.0	0.09	0.10	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.20	0.21	0.22	0.22	0.23	0.24	0.26	0.2
2.0	0.13	0.16	0.18	0.20	0.21	0.23	0.25	0.26	0.28	0.29	0.30	0.32	0.33	0.33	0.34	0.36	0.37	0.40	0.4
3.0	0.19	0.23	0.26	0.29	0.31	0.32	0.35	0.38	0.40	0.42	0.43	0.45	0.46	0.48	0.49	0.51	0.54	0.57	0.6
4.0	0.23	0.30	0.36	0.40	0.44	0.47	0.53	0.58	0.62	0.66	0.70	0.73	0.76	0.79	0.82	0.87	0.92	1.00	1.0
5.0	0.27	0.38	0.46	0.53	0.60	0.65	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.25	1.31	1.41	1.51	1.69	1.8
6.0	0.34	0.47	0.58	0.67	0.75	0.82	0.95	1.06	1.16	1.26	1.34	1.42	1.50	1.57	1.65	1.78	1.90	2.12	2.3
7.0	0.41	0.58	0.71	0.82	0.92	1.01	1.16	1.30	1.43	1.54	1.65	1.75	1.84	1.93	2.02	2.18	2.33	2.60	2.
8.0	0.49	0.70	0.86	0.99	1.11	1.21	1.40	1.56	1.71	1.85	1.98	2.10	2.21	2.32	2.42	2.62	2.80	3.13	3.4
9.0	0.59	0.83	1.01	1.17	1.31	1.43	1.66	1.85	2.03	2.19	2.34	2.48	2.62	2.75	2.87	3.10	3.31	3.70	4.
10.0	0.68	0.96	1.17	1.35	1.51	1.66	1.92	2.14	2.35	2.53	2.71	2.87	3.03	3.18	3.32	3.58	3.83	4.28	4.
12.0	0.87	1.23	1.51	1.74	1.95	2.13	2.46	2.75	3.02	3.26	3.48	3.69	3.89	4.08	4.27	4.61	4.93	5.51	6.0
14.0	1.08	1.52	1.86	2.15	2.40	2.63	3.04	3.40	3.73	4.02	4.30	4.56	4.81	5.04	5.27	5.69	6.08	6.80	7.4
16.0	1.29	1.82	2.23	2.58	2.88	3.16	3.65	4.08	4.47	4.82	5.16	5.47	5.77	6.05	6.32	6.82	7.29	8.15	8.9
18.0	1.51	2.14	2.62	3.02	3.38	3.70	4.27	4.78	5.23	5.65	6.04	6.41	6.76	7.09	7.40	7.99	8.55	9.56	10.
20.0	1.74	2.46	3.01	3.48	3.89	4.26	4.92	5.50	6.02	6.51	6.96	7.38	7.78	8.16	8.52	9.20	9.84	11.0	12.
22.0	1.97	2.79	3.42	3.94	4.41	4.83	5.58	6.24	6.83	7.38	7.89	8.37	8.82	9.25	9.66	10.4	11.2	12.5	13.
24.0	2.21	3.12	3.83	4.42	4.94	5.41	6.25	6.99	7.65	8.26	8.84	9.37	9.88	10.4	10.8	11.7	12.5	14.0	15.
26.0	2.45	3.46	4.24	4.90	5.48	6.00	6.93	7.74	8.48	9.16	9.80	10.4	11.0	11.5	12.0	13.0	13.9	15.5	17.
28.0	2.69	3.81	4.66	5.38	6.02	6.59	7.61	8.51	9.32	10.1	10.8	11.4	12.0	12.6	13.2	14.2	15.2	17.0	18.
30.0	2.93	4.15	5.08	5.87	6.56	7.19	8.30	9.28	10.2	11.0	11.7	12.4	13.1	13.8	14.4	15.5	16.6	18.6	20.
32.0	3.18	4.49	5.50	6.35	7.10	7.78	8.99	10.0	11.0	11.9	12.7	13.5	14.2	14.9	15.6	16.8	18.0	20.1	22.
34.0	3.42	4.84	5.92	6.84	7.65	8.38	9.67	10.8	11.8	12.8	13.7	14.5	15.3	16.0	16.8	18.1	19.3	21.6	23.
36.0	3.66	5.18	6.34	7.32	8.18	8.97	10.4	11.6	12.7	13.7	14.6	15.5	16.4	17.2	17.9	19.4	20.7	23.2	25.
38.0	3.90	5.52	6.75	7.80	8.72	9.55	11.0	12.3	13.5	14.6	15.6	16.5	17.4	18.3	19.1	20.6	22.1	24.7	27.
40.0	4.14	5.85	7.16	8.27	9.25	10.1	11.7	13.1	14.3	15.5	16.5	17.5	18.5	19.4	20.3	21.9	23.4	26.2	28.
45.0	4.71	6.67	8.17	9.43	10.5	11.5	13.3	14.9	16.3	17.6	18.9	20.0	21.1	22.1	23.1	24.9	26.7	29.8	32.
50.0	5.27	7.45	9.12	10.5	11.8	12.9	14.9	16.7	18.2	19.7	21.1	22.3	23.6	24.7	25.8	27.9	29.8	33.3	36.
55.0	5.79	8.18	10.0	11.6	12.9	14.2	16.4	18.3	20.0	21.7	23.1	24.6	25.9	27.1	28.4	30.6	32.7	36.6	40.
60.0	6.27	8.87	10.9	12.5	14.0	15.4	17.7	19.8	21.7	23.5	25.1	26.6	28.1	29.4	30.7	33.2	35.5	39.7	43.

TABLE A. **ESTIMATED RELATIVE SOIL LOSSES FROM EQUAL LENGTH SEGMENTS OF A UNIFORM SLOPE**

Number of Segments	Segment Number 1/	Fraction of Soil Loss		
		Slope≥5%	Slope=4%	Slope≤1%
2	1	0.35	0.38	0.41
	2	.65	.62	.59
3	1	.19	.22	.24
	2	.35	.35	.35
	3	.46	.43	.41
4	1	.12	.14	.17
	2	.23	.24	.24
	3	.30	.29	.28
	4	.35	.33	.31
5	1	.09	.11	.12
	2	.16	.17	.18
	3	.21	.21	.21
	4	.25	.24	.23
	5	.28	.27	.25

1/ Segment number 1 is always at the top of the slope.

Procedure for Estimating Segmented Slope LS Values

(1) Divide the slope into three or four equal length segments.
(2) Number the segments beginning at the top of the slope.
(3) List each segment number and corresponding slope gradient beginning at the top of the slope.
(4) List the LS value for each gradient based on the total slope length. Use the appropriate LS TABLE for your area.
(5) List the corresponding soil loss fractions from TABLE A for the slope gradient of that segment. This may involve changing columns.
(6) Multiply each LS value by the corresponding fraction and add the products to obtain the LS value. Round to two decimals.

Example for a Convex slope

Segment	Slope	LS	Fraction	Product
1	5%	0.93	0.19	0.1767
2	10	2.35	.35	0.8225
3	16	4.47	.46	2.0562
300 ft			LS =	3.0554 Use 3.06

Example for a Complex Slope

Segment	Slope	LS	Fraction	Product
1	5%	0.93	.19	0.1767
2	16	4.47	.35	1.5645
3	5	.93	.46	0.4278
300 ft			LS =	2.1690 Use 2.17

LS Values for Irregular Slopes

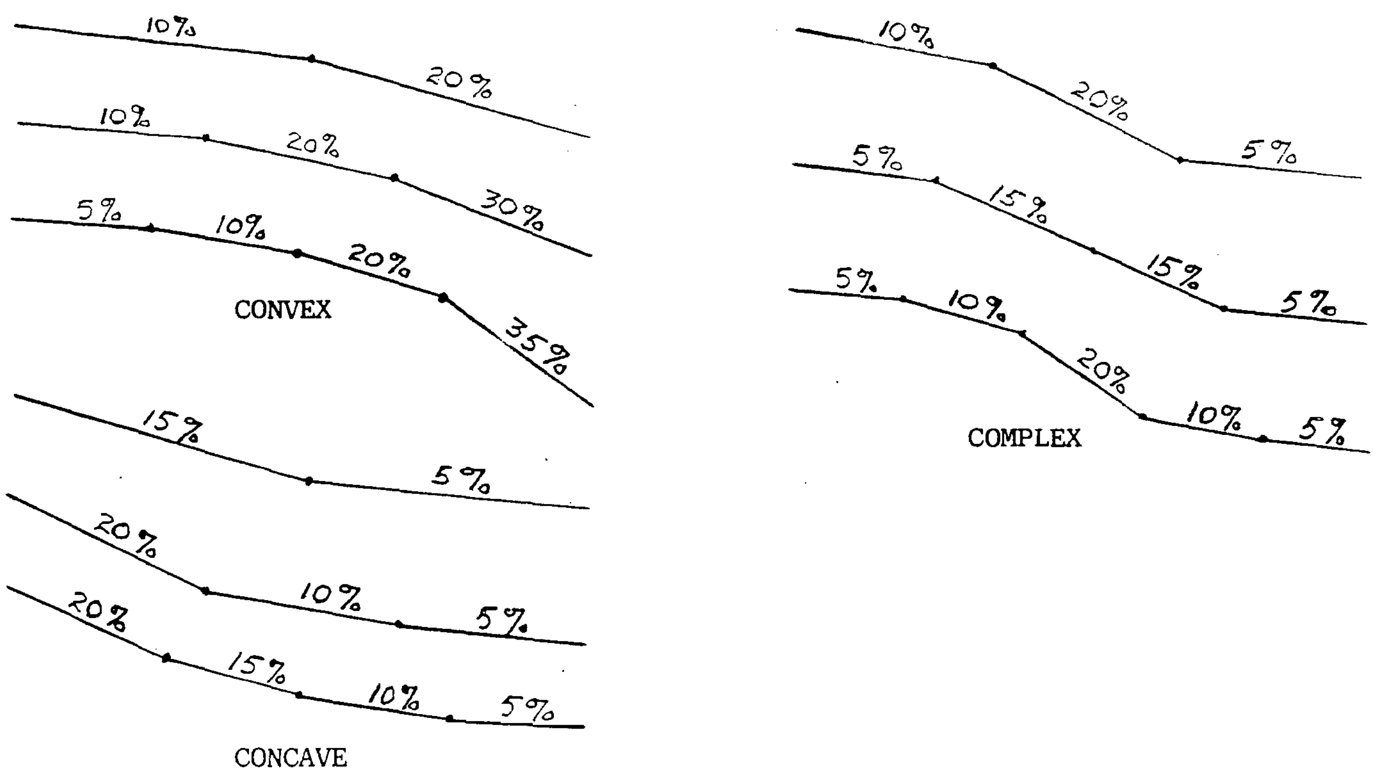
Most slopes used for USLE estimates will not be uniform.
Some will be convex slopes that steepen toward the bottom.
Some will be concave slopes that flatten toward the bottom.
Most will be complex slopes that flatten toward the top and bottom.
See FIGURE 1A.

Use of a single slope gradient to represent nonuniform slopes will:
(1) underestimate soil movement on a convex slope
(2) overestimate soil movement on a concave slope
(3) overestimate soil movement on a complex slope

Irregular slopes can usually be divided into three or four segments that have nearly uniform gradients. We need to be satisfied that:

(1) the slope can be divided into equal length segments where the gradient within each segment for practical purposes can be considered uniform, and
(2) the changes in slope gradient are not sufficient to cause deposition. When the slope gradient decreases by 65 percent or more, deposition is expected and a careful examination of the transition zone between the two slope segments is needed.

FIGURE 1A EXAMPLES OF NONUNIFORM SLOPES



September 1990

THE CROPPING-MANAGEMENT FACTOR (C), is defined as the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled, continuous fallow. In physical terms it describes the effect of protection against erosion provided by vegetation.

Analysis of a large number of field data produced the values of (C) for different types of agricultural land and percent of ground covers. Extention of the factor (C) to completely different situations is based upon three separate and distinct, but interrelated zones of influence: (reference 11) I, canopy cover: II, vegetative cover in direct contact with soil surface, and III, crop residues at and beneath the surface.

Type I, Canopy Cover

The canopy reduces rainfall erosivity by attenuating the impact of the drops on the soil surface. As such it may be considered as a modifier of the rainfall factor (R).

Type II, Close-Growing Vegetation

It is more effective than equivalent percent cover by canopy, because:

(a) It reduces the impact of the raindrop on the soil surface to zero. It may be thought of then as a modifier of (R).

(b) It reduces the erosive and transportive potential of runoff by slowing down flow velocity through increased resistance.

Type III, Crop Residues At and Near the Surface

In general they reduce runoff velocity and increase resistance of soil against erosion. They may be considered then as modifiers of the transport mechanism.

The effects of the three constituents can be determined separately, but for practical purposes they will be represented here by a single value of the factor (C).

THE EROSION-CONTROL PRACTICE FACTOR (P), is defined as the ratio of soil loss with the supporting practice to the soil loss with up-and-down-hill culture. In physical terms it is a factor describing reduction in runoff intensity caused by changing the geometric characteristics of the site. It may be considered then as a modifier of the transport mechanism.

DISCUSSION OF THE USLE

The main attraction of the equation is that the relationship between the factors influencing erosion is simple and straightforward. The evaluation of those factors follows procedures that reflect effects of the conditions that are fixed for the site as well as of those that can be modified by means of land management activities.

The main drawback, on the other hand, is that the equation predicts only the amount of soil that would be eroded from the problem land area by local rainfall and runoff. Erosion caused by runoff imported from adjacent lands is not included in the prediction. Soil loss estimates, therefore, obtained from the equation are meaningful only if adjusted to reflect the contribution of this other cause or preferably, if precautions were taken to prevent inflow of water from outside. Conservation practices that may be used for this purpose are: ponds, diversions, berms, grassed waterways, drains, outlets and storm sewers.

Recognition of the above limitation contradicts the previously stated ability of the equation to predict soil losses caused by snowmelt, which involves processes associated primarily with runoff. Yet, the procedure described in appendix A that estimates the contribution from snowmelt, though admittedly inconsistent, is not arbitrary. It is based on rational and systematic analysis of existing data so that it is expected to produce fairly accurate results. It is conceivable that the procedure will undergo improvements as more data becomes available which would increase confidence in its accuracy.

Because of its simplicity the equation may be solved easily for any of the variables and hence be used either as a prediction or as a management tool.

When used for predictions the dependent variable is "A" the anticipated soil loss. The equation is commonly applied in this form to obtain estimates of soil losses expected to occur under alternative erosion control programs including the alternative of no program.

As a management tool the equation helps to select the type and extent of the erosion control program that would reduce soil loss below a prescribed limit. This target erosion rate referred to as "Soil-Loss Tolerance" and denoted by "T" is discussed below. The most common form of application involves substitution of "T" for "A" in the equation and subsequent solution for "C".

SOIL-LOSS TOLERANCE (T)

Definition: Soil-loss tolerance (T), sometimes called permissible soil loss, is the maximum rate of soil erosion (whether from rainfall or wind) that will permit a high level of crop productivity to be sustained economically and indefinitely.

The T factor is used in the soil-loss prediction equations for rainfall and for wind erosion. The same T factors are used for each equation and are not additive if both rainfall erosion and wind erosion occur on the same soil.

Assigning T Factors: A single T factor is normally assigned to each soil series. A second T factor may be assigned to certain soils where erosion has significantly reduced the thickness of the root zone. In these instances the T factor should be assigned to the textural phase that reflects the severe erosion.For example, Sierra coarse sandy loam, sandy loam, T=4; Sierra clay loam T=3.

Classes: T factors of 1 through 5 are used. The numbers represent the permissible tons of soil loss per year.

Estimates of T Factors: Estimates of T factors are made using the following criteria:

1. Maintenance of an adequate rooting depth for crop production. For soils that are shallow over hard rock, it is important to maintain the remaining soil; therefore, not much soil loss is tolerated. The soil-loss tolerance should be less on such soils than for soils of similar depth overlaying soft substrata that can be renewed by management practices. The following kinds of horizons or layers will be considered as non-renewable in California: hard rock and soft rock with unfavorable nutrient or textural composition that cannot be renewed by economical means, duripans, natric, strong calcic, gypsic, petrocalcic, petrogypsic and salic horizons. In cases where losses expose sublayers that differ abruptly from surface layers such as gravelly, cobbly, stony, sandy lenses or clayey subsoils, the loss tolerances will have to be judged on the cost and difficulty of re-establishing vegetation when these sublayers are exposed.

   Substrata that may be economically renewed with tillage, fertilizer, organic matter and other management practices will be considered as renewable.

Guide for Assigning Soil Loss Tolerance Values (T) to Soils Having Different Rooting Depths

Rooting Depth	Soil Loss Tolerance Values (Annual Soil Loss—Tons/Acres)	
(Inches)	Renewable Soil	Non-Renewable Soil
0-10	1	1
10-20	2	1
20-40	3	2
40-60	4	3
60+	5	5

2. Crop yield reduction. Soils that have significant yield reductions when the surface layers are removed by erosion are given lower soil-loss tolerances.

3. Maintenance of water-control structures such as open ditches, ponds, and other structures affected by sediment.

4. Prevention of gullies.

5. Value of nutrients lost. The value of nitrogen and phosphorus in a ton of soil is about $2. Plant nutrient losses of more than $10. per acre per year may be excessive—suggesting a 5 ton loss as the maximum for any soil.

Conversion for tons per acre to inches:

1 ton/ac = .0063 inches/year or 6.3 inches in 1,000 years

2 tons/ac = .0125 inches/year or 12.5 inches in 1,000 years

3 tons/ac = .0188 inches/year or 18.8 inches in 1,000 years

4 tons/ac = .0250 inches/year or 25.0 inches in 1,000 years

5 tons/ac = .0313 inches/year or 31.3 inches in 1,000 years

APPLICATION OF THE USLE IN AGRICULTURAL LANDS

Agricultural lands may be divided into two major categories: (a) Cultivated lands such as cropland, hayland, pastures in rotation, orchards, and (b) Undisturbed lands such as pasture land, rangeland, woodland, idle land. The difference between the two as regards soil erosion is in the type of action that can be taken toward its control. The action involves application of one or several conservation practices with the objective of reducing erosion rates to tolerable levels.

The effect of the practices is reflected in the values of the factors in the USLE. It becomes then possible to compare effectiveness among alternatives by evaluating the relevant factors and using them in the equation to compute corresponding soil losses.

Not all factors in the equation, can be manipulated. For instance, the "R" factor in a given location is fixed. The same is true in general for the "K" factor. The exception would be the case where land management activities involve deep cuts and fills that bring to the surface soils from deeper horizons with possibly different erodibility characteristics than the undisturbed soil. In situations like the above the value of "K" should be modified to reflect the effect of variation in erodibility.

The factor "LS" can be modified according to the erosion control conservation practice chosen. There are two such practices commonly used; terraces and diversions. The former influences both "S" and "L" of the "LS" factor whereas the effect of the latter is only on "L". The benefit derived from the installation of either practice can be easily evaluated, at least in terms of soil loss, by applying the equation twice, first with the original and second with the modified value of the factor "LS"

The factors considered so far are evaluated the same way for cultivated and for undisturbed agricultural lands. The difference between the two groups is in the evaluation of the remaining two factors "C" and "P". In order to underline the difference, the two cases will be treated separately.

1. Cultivated Lands

"C" – Cropping management factor:

Unlike the previously mentioned basic factors affecting erosion, vegetative cover and tillage practices are readily manipulated to produce wide variations in rates of erosion. Cropping management systems have been the most difficult to evaluate because of the many ways land can be used, cropped and managed.

To derive a "C" value, many variables must be taken into account, such as crop sequences, kind of crop growing season, amounts of residue left or removed, crop yields, soil fertility, density of canopy, rate at which water is used by plants, quantity of root growth and tillage management. In addition, consideration must be given to the distribution of the eroding rains throughout the year and its relationship to the stage of crop growth.

See Appendix C for "C" factors used in California.

~~The procedure to determine the expected value of "C" for a particular cropping system at a given locality is described below.~~

1. The year is divided into a series of crop-stage periods within each of which, cover and management may be considered uniform. There are five such periods defined as follows:

   Period F—Rough fallow. Turn plowing for seeding.

   Period 1—Seeding. Seedbed preparation to 1 month after planting.

   Period 2—Establishment. From 1 to 2 months after spring or summer seeding. For fall seeded grain, period 2 includes the winter months ending about April 15th for the larger part of the state. In the mountainous and colder regions, the end of period 2 may be set at May 1.

   Period 3—Growing and maturing crop. End of period 2 to crop harvest.

   Period 4—Residue or stubble. Crop harvest to plowing or new seeding. (When meadow was established in small grain, period 4 is assumed to extend 2 months beyond the grain harvest date. After that time, the vegetation is classified as established meadow.)

   Some adjustment in length of periods 1 through 3 may be necessary for vegetable crops.

2. A table is prepared listing the soil-loss ratio in percent for each crop-stage period. Such a table that provides data for the prevalent types of cover and crop management in California is included in appendix C. The partial percent ratios of soil-loss by stage listed in table C-1 have been derived under the assumption that the total rainfall and snowmelt contributing to the annual rainfall index factor R(t) occured within the period.

3. The above values are adjusted to reflect the influence of the actual hydrologic occurrence during the period. The adjustment involves multiplication of soil-loss ratio values by the portion of R (t) in percent corresponding to the period. The R (t) ratio for each crop-stage period is computed as the difference between the two end values obtained from the R (t) distribution curve. As mentioned previously the method of developing such a curve in a given location is described in appendix A.

4. The partial products obtained above are added together to obtain the representative value of the "C" factor for the entire crop period. This period can be any length of time, shorter, equal, or longer than one year. Table C-2 in ~~appendix C contains sample computations that illustrate how the method is used to determine effective values of "C" for two crops in California.~~

"P" Erosion Control Practice Factor

Practices most commonly used for this purpose are contour tillage, cross-slope farming, and contour stripcropping. They are support practices that will slow the runoff water and thus reduce the amount of soil it can carry. Stripcropping is alternate strips of a sod crop and cultivated crop with all strips of equal width. An alternate sod strip narrower than the cultivated strip or alternate strips of small grain and summer fallow will not qualify as stripcropping. Such operations qualify only for contouring when performed on the contour.

Values of "P" for the above three erosion control practices appear in table 4 below:

Table 4 "P" Factors For Erosion Control Practices

Slope (%)	Up & Down Hill	Cross Slope Farming Without Strips	Contour Tillage	Cross Slope Farming With Strips	Contour Stripcropping
2.0- 7	1.0	.75	.50	.37	.25
7.1-12	1.0	.80	.60	.45	.30
12.1-18	1.0	.90	.80	.60	.40
18.1-24	1.0	.95	.90	.67	.45

The full benefits of contouring are obtained only on fields relatively free from gullies and depressions other than grassed waterways. The effectiveness of this practice is reduced if a field contains numerous small gullies and rills that are not obliterated by normal tillage operations. In such instances, land smoothing should be considered before contouring. Otherwise, a judgement value greater than shown in table 1 should be used when computing the benefits for contouring.

There are also certain limits on the lengths of slopes in contour tilling beyond which the values of "P" in table 1 are not valid. Although observations point to a dependence of length limits to slope steepness the data available is not sufficient to support a firm relationship. ~~Suggested values are shown in table 2 below, but due to their speculative nature they should be used with caution.~~ See Tables 13 and 14 in A.H. 537.

~~Table 2 Length Limits For Contouring~~

~~Slope (%)~~	~~Maximum Slope Length Feet~~
~~2~~	~~400~~
~~4 to 6~~	~~300~~
~~8~~	~~200~~
~~10~~	~~100~~
~~12~~	~~80~~
~~14 to 24~~	~~60~~

August 1983

CONSERVATION PLANNING TO CONTROL SHEET AND RILL EROSION

When a field contains more than one soil map unit, selection of a specific soil for conservation planning should be based on the most erosive soil of significant size. We refer to it as the "critical" map unit for planning. Applying a Resource Management System that reduces erosion to a tolerable level on this soil effectively protects the whole field. Use the following steps to identify this soil.

FITTING RESOURCE MANAGEMENT SYSTEMS TO A FIELD

1. Identify those map units that occupy at least 25 percent of the field. Also identify those map units that occupy less than 25 percent of the field but occupy 50 acres or more. If no map units meet this criteria, identify those map units with low T and high K values.

2. Check if any candidate map units contain more than one soil component and represent an association or a complex. See the HEL Soils List in Section II of the FOTG. <u>If a map unit is an association</u>, then each component can be delineated and measured on the ground. Recheck each component to see if it qualifies under Paragraph 1. Obtain the R, T, and K values for each candidate map unit and component of an association and complex.

3. Visit the field and locate one "representative slope" for each candidate map unit, or in the case of an association, for each candidate component. Observe the variations in slope percent and slope length within each map unit and component and select one slope area that typifies that map unit or component. Determine the LS value for each representative slope. Slope percent usually changes along the slope. Try to record these breaks and divide the slope into two, three, or four equal length segments. Two of the segments can have the same slope percent. This will allow you to calculate a more accurate, adjusted LS value. See page 4.9 for examples.

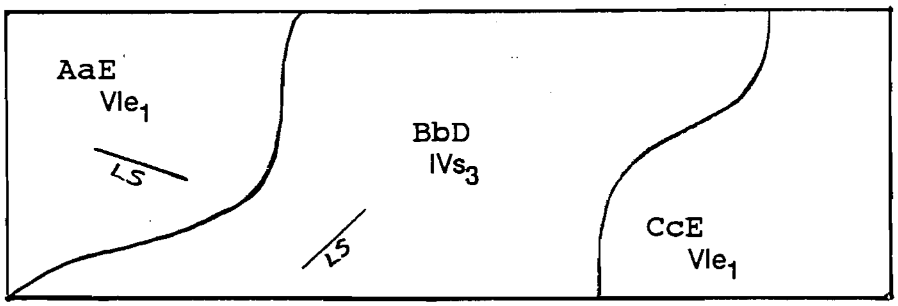
4. Calculate the EI value [EI=RK(LS)/T] for each candidate map unit. If a map unit is an association, calculate the EI value for each candidate component using the LS value for its representative slope. Assign the highest EI value to represent the association. If a map unit is a complex, calculate the EI value for each component that represents at least 25 percent of the map unit. In each case, use the LS value for the representative slope of that map unit. Assign the highest EI value to represent the complex.

5. Select the soil map unit with the highest EI value. This is the critical map unit for planning.

6. Calculate the USLE predicted sheet and rill erosion rate for the critical map unit. If the erosion rate for the current management system is greater than the acceptable level, then formulate alternatives with the help of the landuser and calculate their erosion rates. Continue until an acceptable combination of practices reduces the erosion rate to the acceptable level.

FITTING RESOURCE MANAGEMENT SYSTEMS TO A FIELD - AN EXAMPLE

SOILS MAP FOR EXAMPLE FIELD IN MLRA 15



CALCULATE EI VALUES:

	MU	Acres	R	K	L	S%	LS	T	EI
**	AaE	45	30	.32	250'	20	5.50	2	26.4
	BbD	70	30	.37	300	12	3.02	3	11.2
	CcE	35	1/						

Total = 150 Acres

1/ Less than 25% & Less than 50 acres

** Critical map unit for planning.

ESTIMATED SHEET AND RILL EROSION FOR CURRENT MANAGEMENT SYSTEM

	R		K		LS		C		P		
A =	30	*	.32	*	5.5	*	.25	*	.95	=	12.5 T/AC/YR

NEED TO REDUCE EROSION TO 2+1= 3 T/AC/YR OR LESS

ALTERNATIVE 1: REDUCE "C" to .04 by planting grain No-till or adding two more years of pasture to the cropping sequence.

	R		K		LS		C		P		
A =	30	*	.32	*	5.5	*	.04	*	.95	=	2.0 T/AC/YR

ALTERNATIVE 2: REDUCE "C" to .06 by planting grain No-till and adding one more year of pasture to the cropping sequence, and

REDUCE "P" to .65 by maintaining midslope buffer strips during grain years.

	R		K		LS		C		P		
A =	30	*	.32	*	5.5	*	.06	*	.65	=	2.0 T/AC/YR

APPLICATION OF THE USLE IN NONAGRICULTURAL LANDS

Erosion in nonagricultural lands is strongly influenced by man's activities. Examples are construction activities for residential, commercial, and industrial developments, highways and recreation facilities.

The processes of erosion caused by local rainfall and runoff are essentially the same as for agricultural lands so that prediction of soil losses from a construction site can be made by proper evaluation of the terms and application of the equation. This way several erosion control plans can be tested and rated in terms of efficiency. The effectiveness of each of those plans would be reflected on the values of the factors corresponding to the conservation practices considered.

The design and installation of conservation practices constitute the protective part of the overall erosion control effort. To be effective, it has to be preceded by a preventive part which involves decisions made during the planning stage. Considerations helpful in making decisions of this nature particularly, as regards urban planning, are contained in reference (3). The guidelines, however, are relevant to all activities involving large scale construction and it seems appropriate to introduce here basic concepts from the above publication.

1. Erosion Control Considerations During Planning

   Urban Planning involves studies to determine present and future land use for residential, recreational, educational and other related needs. More specifically it determines how available land should be distributed among the various needs such as homes, schools, utilities, and other public services.

   From the viewpoint of erosion control the rule governing land distribution is that the particular tract should be suitable for the proposed use. Major factors that determine this suitability are: geology, topography, hydrology, kinds of soils, and ground water conditions.

   Sources of information for the first three factors are geologic maps, geologic exploration records, topographic maps, land survey maps and records of rainfall and runoff. The most important factor in determining suitability is the type of soil encountered in each location. Information on this factor is furnished by the soil surveys which include the following: soil maps, soil descriptions, and soil interpretations.

   With the above information it is possible to analyze problems on proposed developments in terms of site potentials and limitations needed to obtain a good fit of the development on the site. The next step is to prepare a construction plan that minimizes erosion. The first and foremost rule is to limit duration of exposure of bare soils to erosive forces. This implies that each individual unit of work involving soil disturbance would be kept small to assure rapid completion of construction. A secondary consideration is scheduling work to minimize adverse weather effects.

2. Erosion Control Considerations During Design

Predictions of the mean annual rates of soil eroded by rainfall and removed by runoff from a construction site can be made by applying the soil loss equation with the factors evaluated so as to represent the following three conditions:

1. Prior to development; undisturbed land.

2. During development; disturbed land, temporary erosion control measures installed.

3. Post development; land restored, permanent measures installed.

The corresponding rates may be denoted by A(1), A(2), and A(3) respectively. It is evident that in general $A(2) > A(3) > A(1)$. The equation $A(3) = A(1)$ would imply that the permanent measures are effective enough to rehabilitate the site in full. This is a very desirable objective but in most instances difficult to attain because of the high cost involved.

The way to proceed is to establish first a tolerable level of erosion for the site, consistent with prevailing local conditions and availability of financial resources. A number of feasible erosion control practices are next examined and the one resulting in reducing the anticipated erosion rates to the desired tolerance level is selected. For a given site there are two such tolerance limits; one pertaining to conditions during construction and the other to permanent post development conditions. The two rates denoted Tc and Tp respectively, are different from each other and in general Tc is larger than Tp.

The acceptance of a certain amount of erosion as tolerable for the relatively stable post construction period is primarily governed by the desire to reduce as much as possible the damage to the site itself by erosion. The logical thing to do then, is to adopt as Tp the values recommended previously and shown in page 7. This, of course, is permissible only if there are no specific guidelines or requirements established by local regulatory agencies.

In dealing with construction sites, however, the concern is not limited to the damage caused by erosion to the site only. The allowable soil loss would consider also the damage from sedimentation to property and facilities downstream. The estimate of Tc would reflect, therefore, both the value and the distance of the endangered area from the site. Suggested values for Tc appear in reference 2 and are reproduced here in Table 6. The thing to remember in using those values is that they have no theoretical basis and are only given for guidance.

Table-6 A guide to values of T_c^* for Sediment Source Areas in Construction Sites (2)

Damage Area Condition (Reservoir, stream reach or other area that could be damaged by sediment)	Estimated T_c Value to Damage Area		Estimated Delivery Rates
	High	Low	
Damage area at or close to but less than 300 feet from the down slope boundary of the construction site	5	30	.90
Damage area more than 300 feet down slope from the construction site	20	40	.70
Damage area less than 1 mile downstream from construction site (stream flows through or close to but less than 300 feet from the slope boundary of site)	25	50	.60
Damage area less than 1 mile downstream from construction site (stream is more than 300 ft. down slope from construction site)	30	60	.50
Damage area more than 1 mile downstream	40	70	.40 or less

*T_c is the average annual soil loss considered to be reasonable from construction sites in tons per acre per year. These values are to be used as guides and should be adjusted by judgment evaluation of all hazard and damage conditions. The values may be converted to cubic yards by multiplying by 1.24 for saturated sediment and 0.93 for aerated sediment.

T_c values will need to be reduced for large sediment source areas.

A sediment specialist or geologist should be consulted when estimating T_c values for large areas where important high valued damage areas are involved.

Use of this table should be limited to exposed sediment source areas of 10 acres or less.

THE VALUES IN THIS TABLE ARE NOT BASED ON RESEARCH IN ANY WAY. THEY ARE BASED ON JUDGMENT ONLY. CAUTION SHOULD BE EXERCISED IN THEIR USE AND THEY SHOULD BE REVISED AS EXPERIENCE MAY INDICATE.

WE SHOULD ALWAYS STRIVE FOR 0 EROSION FROM ALL SOIL AREAS.

3. Erosion Control Measures During Construction

The objective of the erosion control program is to reduce the need for measures to the lowest possible level. A logical way to achieve this objective is to conduct all construction activities in a manner that would disturb site morphology and land cover as little as possible. In particular grading should be done carefully to avoid extensive and prolonged exposure of unprotected soil surfaces. Trees should not be removed unless all possible alternatives have been investigated and found less desirable. When application of measures is inevitable the soil loss equation may be used as a tool of rating and selection.

The soil loss equation for conditions during construction is:

$$T_c = (R)\ (K)\ (LS)\ (C)\ (P)$$

The two factors (R) and (K) are fixed for the site so that any management decisions aiming at reducing erosion losses can influence only the values of (LS), (C), and (P).

In most cases the slope factor (S) is rigidly established by the site topography so that effective changes in (LS) can be made only through change in the slope length (L). The two conservation practices that affect directly the value of (L) are diversions and terraces.

The term most readily influenced by management is the cover index factor (C). Conservation practices recommended for this purpose are seeding of small grain or grasses, sod, mulches, and asphalt emulsions. Standards and specifications of the practices are given in Appendix D. The measures are considered temporary which means they are expected to control erosion only during the period of construction. The effect of the practices on the factor (C) is shown in Table 7. The values are derived from limited data and should be treated as tentative.

In the general case the value of (P) could be assumed equal to unity on the presumption that this would lead to a conservative estimate. Yet field observations revealed that the value of (P) may be larger than one and in fact ranging between 0.8 and 1.3. The numerical evaluation of (P) is shown in Table 8. The values are based on limited data and should be considered tentative.

4. Post Development Conditions

The condition of expected erosion rate at the site being equal to the desired tolerable rate T_p is described by the equation

$$T_p = (R)\ (K)\ (LS)\ (C)\ (P)$$

The general concept of treating this case is similar to the one above. No management decisions can influence the values of the terms (R) (K) and (LS) so that any measures taken can affect only the value of (C) and to a lesser degree that of (P).

Table-7 COVER INDEX FACTOR C_c (2)

CONSTRUCTION SITES

TYPE OF COVER		FACTOR C_c	%*
None (fallow ground)		1.0	0.0
Temporary Seedings (90% Stand):			
Ryegrass (perennial type)		0.05	95
Ryegrass (annuals)		0.1	90
Small grain		0.05	95
Millet or sudan grass		0.05	95
Field bromegrass		0.03	97
Permanent Seedings (90% stand)		0.01	99
Sod (laid immediately)		0.01	99
Mulch:			
Hay rate of application tons per acre:			
	1/2	0.25	75
	1	0.13	87
	1-1/2	0.07	93
	2	0.02	98
Small grain straw	2	0.02	98
Wood chips	6	0.06	94
Wood cellulose	1-3/4	0.1	90
Fiberglass	1/2	0.05	95
Asphalt emulsion (1250 gals/acre)		0.02	98

Fiber matting, excelsior, gravel and stone may also be used as protective cover.

*Percent soil loss reduction as compared with fallow ground.

Table-8 (2)

PRACTICE FACTOR P_c OR SURFACE CONDITION FOR CONSTRUCTION SITES

SURFACE CONDITION WITH NO COVER	FACTOR P_c*
Compact and smooth, scraped with bulldozer or scraper up and down hill	1.3
Same condition except raked with bulldozer root rake up and down hill	1.2
Compact and smooth, scraped with bulldozer or scraper across the slope	1.2
Same condition except raked with bulldozer root rake across the slope	0.9
Loose as a disced plow layer	1.0
Rough irregular surface equipment tracks in all directions	0.9
Loose with rough surface greater than 12" depth	0.8
Loose with smooth surface greater than 12" depth	0.9

*Values based on estimates

2. Erosion Caused By Runoff

The soil loss quantities predicted by the soil loss equation pertain only to erosion caused by rainfall within a problem area. The equation does not predict erosion induced by runoff originating in the basin upstream. The problem in this case is complicated by the fact that rates of erosion are not governed only by factors characteristic of the site and rate of runoff, but also by the amount of sediment already carried by the flow before it enters the site.

It has been mentioned previously that the most effective way to deal with the problem is to intercept the flow before it enters the site and route it through an open channel or closed conduit to a point of disposal outside the site.

An alternative less effective than the above, is to admit the runoff from upstream into the site either as sheet flow, or concentrated in a stream.

To control erosion caused by spread, overland flow it is recommended to use vegetative measures such as mulches, legumes, vines, shrubs, and grasses. The way these measures influence erosion is through increase in friction near the soil surface which reduces flow velocities and hence their erosive potential.

Earth channels carrying concentrated flows will erode when the conditions of stability are exceeded. Fairly accurate methods exist that determine the limits of stability beyond which erosion is expected to occur. There is no way, however, to predict rates of erosion after limiting conditions are exceeded. It is therefore prudent to design such channels with confidence that they will not erode under anticipated flow conditions. Methods commonly used in stable channel design are described in Technical Release No. 25. Mechanical measures associated with these designs are chutes, drop structures, grade stabilizers, pipe and wire fences and revetments (solid or permeable). Additional protection, if local conditions warrant it, may be provided by a suitable combination of vegetative measures like the ones mentioned above.

3. Gully Erosion

If left unprotected earth channels carrying concentrated runoff are susceptible to rapid degradation and enlargement commonly referred to as "gully erosion". Particularly vulnerable are sparsely vegetated lands on steep terrain. The development of gullies depreciates the value of the land on one hand and contributes to the production of sediment on the other. Both aspects are undesirable and sound conservation management dictates the installation of measures that either prevent development of gullies or arrest the advance of head cutting. The Soil Conservation Service treats the stabilization of active gullies by vegetative or structural measures described in reference (5). In general terms the development and advance of gullies is controlled by vegetative means, by filling and shaping, by water diversion or retention and by grade stabilization structures.

The Soil Conservation Service developed also a procedure that estimates future rates of growth of gullies on the basis of measurable conditions above existing and advancing head cuts (7). A brief description of the procedure and the computational tools used in its application are included in Appendix E. It should be pointed out, however, that the method is only approximate and has not been tested sufficiently for use in California. It should not be used in particular to estimate sediment yield in economic studies related to sedimentation. Its purpose and hence the most useful application is for estimating extent of land deterioration from uncontrolled gullying. The estimates may be used to assess benefits from installation of control measures.

II Sediment Control

The detrimental effects of erosion are not confined withing the generation area where they are manifested as a depletion of a valuable resource. Very often they are felt, perhaps with diminishing intensity, along the entire course of the resulting sediment, from its source to the ocean. It follows then that the sound program, aiming at reducing the damage from sediment at a given site would consist of a system of preventive and protective measures the combined performance of which is optimum. The purpose of the preventive measures is to control erosion in the area above the site and of the protecting measures to regulate the movement of the sediment produced through the site so that it would cause the least possible damage. The two aspects of the overall strategy are discussed below:

1. Erosion Control Measures

Methods and types of measures recommended for erosion control purposes appeared previously when discussing the applications of the soil loss equation in agricultural and nonagricultural lands. A high point of the discussion was that success of the effort towards controlling erosion depends to a large degree upon a reliable prediction of the total amount of soil expected to be eroded during a prescribed period. Erosion in a certain area may be induced by water, wind, gravity, geologic processes or other minor causes.

The total amount of erosion by water is the summation of sheet erosion, gully erosion, channel erosion and of land slides. So far the only component that can be treated quantitatively through application of the soil loss equation is sheet erosion. Procedures for the other three have been proposed and are still being studied, but cannot be used yet with confidence.

It is evident from the above that the soil loss equation estimates only a part of the total water induced erosion which in turn is only a part of the total erosion, commonly referred to as "Gross Erosion". This calls for caution in using the equation in sedimentation studies. For the anticipated volumes of sediment would be grossly underestimated in cases where processes other than sheet erosion produce significant amounts of sediment.

The problem becomes more complicated because of the difference between the volume of soil eroded from a given area during the prescribed time interval and the amount that actually crossed the boundary of the site on which a sedimentation study is made. This second amount is called "Sediment Yield" and related to the "Gross Erosion" through the "Delivery Ratio", defined as:

$$\text{Delivery Ratio} = \frac{\text{Sediment Yield}}{\text{Gross Erosion}}$$

This demonstrates that even an accurate estimate of Gross Erosion is not sufficient for a complete treatment of the sedimentation problem in which the relevant quantity is the Sediment Yield. One has to know also the Delivery Ratio. Several methods have been developed that relate the Delivery Ratio to various physiograghic characteristics of the basin. The simplest ones among them, and hence the most practical, relate delivery ratio to distance from the source of sediment. Further discussion of the delivery ratio is beyond the scope of this paper and the only reason of mentioning it here is to warn about possible missuse of the soil loss equation.

It is recommended, as a practical rule, to use a delivery ratio equal to one in cases where it seems reasonable to estimate the gross erosion by means of the soil loss equation. A possible alternative is to incorporate the delivery ratio in the value of Tolerance as is done in Table 6.

2. Sedimentation Control Measures

The purpose of the erosion control measures is to reduce the rate of sediment production at the source. If absolutely successful, the damage caused by the reduced sediment to the lands below will be negligible and there would be no need for installation of protection measures. Only if the remaining yield is high enough to be considered as a hazard to property and facilities below the question of selecting suitable sedimentation control measures would arise.

A simple and fairly effective way to handle the problem is to intercept and remove the sediment from the watercourse at a point as close as possible to the source. The recommended measure for this, is a debris basin which in essence is a small reservoir, but with sufficient capacity to trap a large percentage of the coarser particles. The finer sediment particles remain in suspension and are carried by the flow downstream. The method currently used by the Soil Conservation Service to determine capacity of debris basins is described in Appendix F.

A weak point of the method is that it does not lead to a unique solution. It only establishes a relationship between capacity and "trap efficiency" which is defined as the percentage of the sediment trapped. This relationship is a management tool that helps to determine the storage capacity most desirable in a given situation.

When a debris basin is not feasible or adequate the sediment laden flow has to be carried in a channel or a closed conduit. The capacity of these systems has to be large enough to insure that both sediment and water will move through smoothly, without development of severe flow disturbances caused by sediment deposits. Another consideration which is an important factor in the design and construction of channels in earth is stability. The problems of capacity and stability of such channels are complicated and constitute the subject of research by numerous investigators. Considerable progress has been made lately and certain aspects have been fully resolved. A practical method, however, that could treat the problem completely has not been developed yet and the current policy in California is to handle the problem in a case by case manner. In order to keep the effort coordinated it is recommended that engineering activities regarding work of improvement of channels in earth be handled by the State Office.

SUMMARY

The problems of erosion and sedimentation should be recognized at the earliest possible stage of land conversion and the local factors governing the processes clearly identified and assessed.

Land distribution to the various uses should be done carefully to provide assurance that soils and other site characteristics are suitable for the purpose intended.

Construction schedules should provide for minimum exposure of bare soils to adverse climatological conditions as regards both time and space.

Whenever it becomes apparent that the above precautions are not sufficient and a certain amount of erosion is inevitable, a concentrated effort should be made to keep this amount below tolerable limits. These limits vary from site to site and have to be established individually according to local conditions.

Control of the erosion and sedimentation processes is achieved through judicious application of conservation practices. Estimates of erosion rates at a given site corresponding to conditions before and after application may be obtained from the Universal Soil Loss Equation. These estimates limit themselves to the part of erosion that is induced by local rainfall. The part that is caused by runoff imported from the area outside the site cannot be predicted. Despite this limitation the equation is very useful in comparing alternatives.

These alternatives involve application of conservation measures the effectiveness of which to control erosion, and to a certain degree sedimentation, is predictable. Recommended practices are listed according to type and purpose in Table 9.

Table 9 Conservation Measures for Control of Erosion and Sedimentation

STRUCTURAL	RAINFALL EROSION R	K	LS	C	P	RUNOFF EROSION	SEDIMENTATION
Debris Basin							X
Dike			X			X	
Diversion			X			X	X
Drain System			X			X	X
Grade Stabiliz. Structure						X	X
Grassed Waterway						X	X
Heavy Use Area Protect.		X		X	X	X	
Hillside Ditch						X	
Lined Waterway or Outlet						X	X
Open Channel						X	X
Recreation Land Grading and Shaping			X		X		
Regulating Water and Drainage Systems						X	X
Rock Barrier						X	
Spoilbank Spreading						X	
Streambank Protection						X	X
Streamchannel Stabilization						X	X
Sub Surface Drain						X	
Terrace			X		X	X	
VEGETATIVE							
Critical Area Planting				X		X	
Grassed Waterway						X	X
Heavy Use Area Prot.				X			
Low Growing Vegetative Cover				X		X	
Mulching				X		X	

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APPENDIX A

DETERMINING "R" VALUES

AND

TIME DISTRIBUTION CURVES FOR "R"

DETERMINING "R" VALUES

California is divided into three zones for determining "R" values. Figure A-1 shows their general boundaries and they are defined by Major Land Resource Area (MLRA) as follows:

Frozen Soil Area	includes MLRAs 21 and 23
R Zone 1	includes MLRAs 14, 15, 16, 17, 18, 19, 20, and 22
R Zone 2	includes MLRAs 4, 5, 26, 29, 30, and 31

R values in the Frozen Soil Area are based on the equation

$$R = -58.282 + 8.735P - 0.149P^2$$

where P = average annual precipitation in inches

R values in R Zone 1 are based on the equation

$$R = 16.55P^{2.17}$$

where P = the 2 year 6 hour precipitation value for the desired location as shown in NOAA Atlas 2 "Precipitation Frequency Atlas of the Western United States, Volume XI California."

R values in R Zone 2 are based on the equation

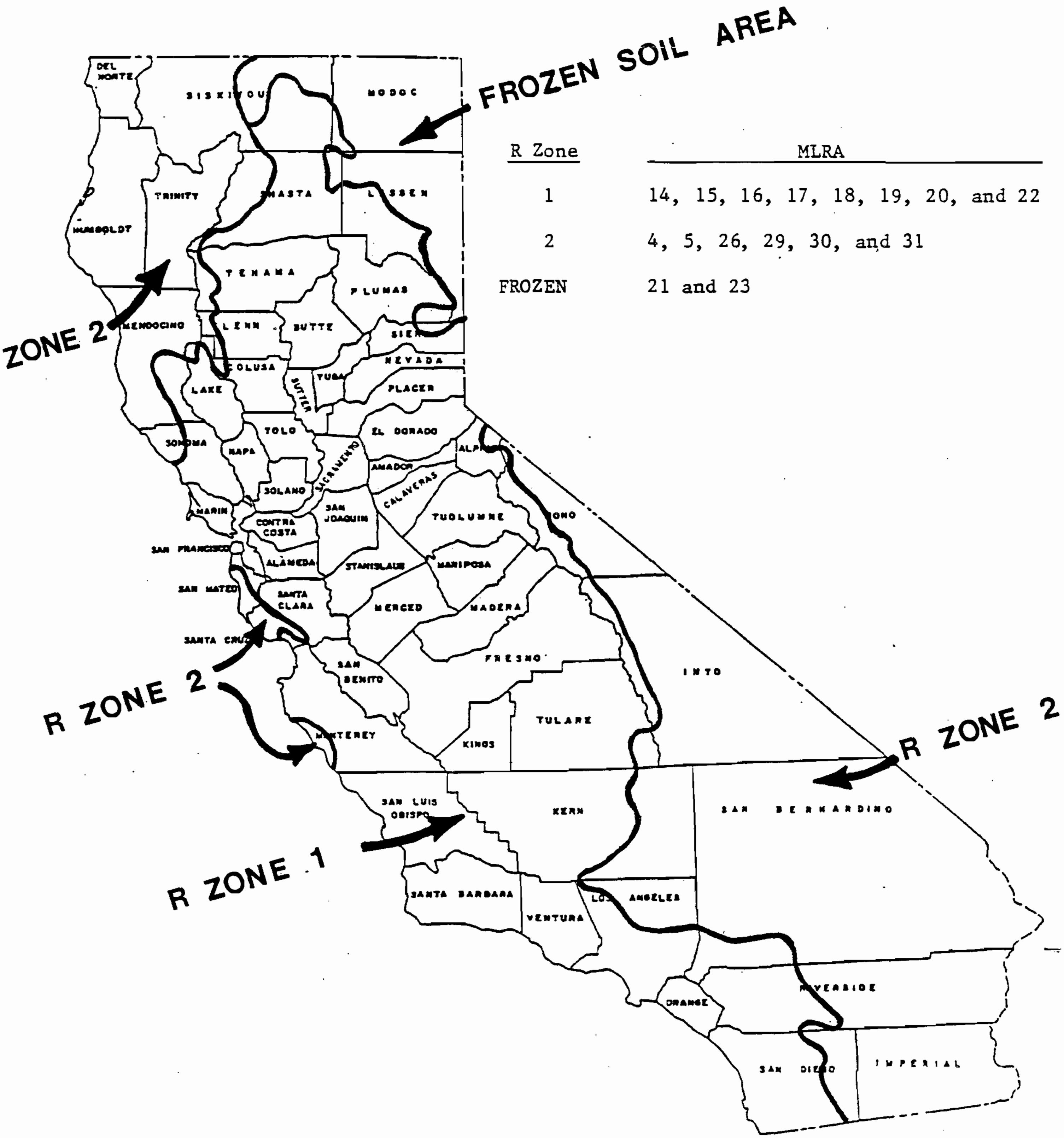
$$R = 27P^{2.17}$$

where P = the 2 year 6 hour precipitation value

R values in California will be obtained using the appropriate part of Table A-1 or an R factor map based on Table A-1.

R values will be rounded to the nearest 5 units and lowest R value will be 10.

Figure A-1. R Factor Zones in California



R Zone	MLRA
1	14, 15, 16, 17, 18, 19, 20, and 22
2	4, 5, 26, 29, 30, and 31
FROZEN	21 and 23

Table A-1. Rounded Annual "R" Values for California R Zones.

R Zone 1	2 Year 6 Hour Ppt (Inches)	R Zone 2
10	<0.7	10
10	0.7	10
10	0.8	15
15	0.9	20
15	1.0	25
20	1.1	35
25	1.2	40
30	1.3	50
35	1.4	55
40	1.5	65
45	1.6	75
50	1.7	85
60	1.8	95
65	1.9	110
75	2.0	120
85	2.1	135
90	2.2	150
100	2.3	165
110	2.4	180
120	2.5	195
130	2.6	215
145	2.7	235
155	2.8	250
165	2.9	270
180	3.0	295
195	3.1	315
205	3.2	335
220	3.3	360
235	3.4	385
250	3.5	410
265	3.6	435
285	3.7	460
300	3.8	490
315	3.9	520
335	4.0	545

Avg. Annual Ppt (Inches)	Frozen Soil Area
<9	10
9	10
10	15
11	20
12	25
13	30
14	35
15	40
16	45
17	50
18	50
19	55
20	55
21	60
22	60
23	65
24	65
25	65
26	70
27	70
28	70
29	70
30	70
>30	70

R Zone 1: $R = 16.55\ P^{2.17}$ where P = 2 year 6 Hour Ppt.

R Zone 2: $R = 27\ P^{2.17}$ where P = 2 year 6 Hour Ppt.

Frozen Soil Area: $R = -58.282 + 8.735\ P - 0.149\ P2$ where P = Avg. Annual Ppt.

TIME DISTRIBUTION CURVES FOR "R"

It is often desirable to have estimates of potential soil losses for periods shorter or longer than one year. The values then of "R" can be determined from a distribution curve. Distribution curves are needed for calculating "C" factors.

Example: Let Cloverdale, California, be the hypothetical location. The 2-year, 6-hour rainfall is 2.5 inches. The location is in R ZONE 1. R = 120 from Table A-1.

Procedure

1. List the monthly preciptation normals of the station closest to the site.
2. List the cumulative precipitation amounts.
3. List the cumulative percentages of the total amount.
4. Use the values of step 3 to plot a distribution curve.

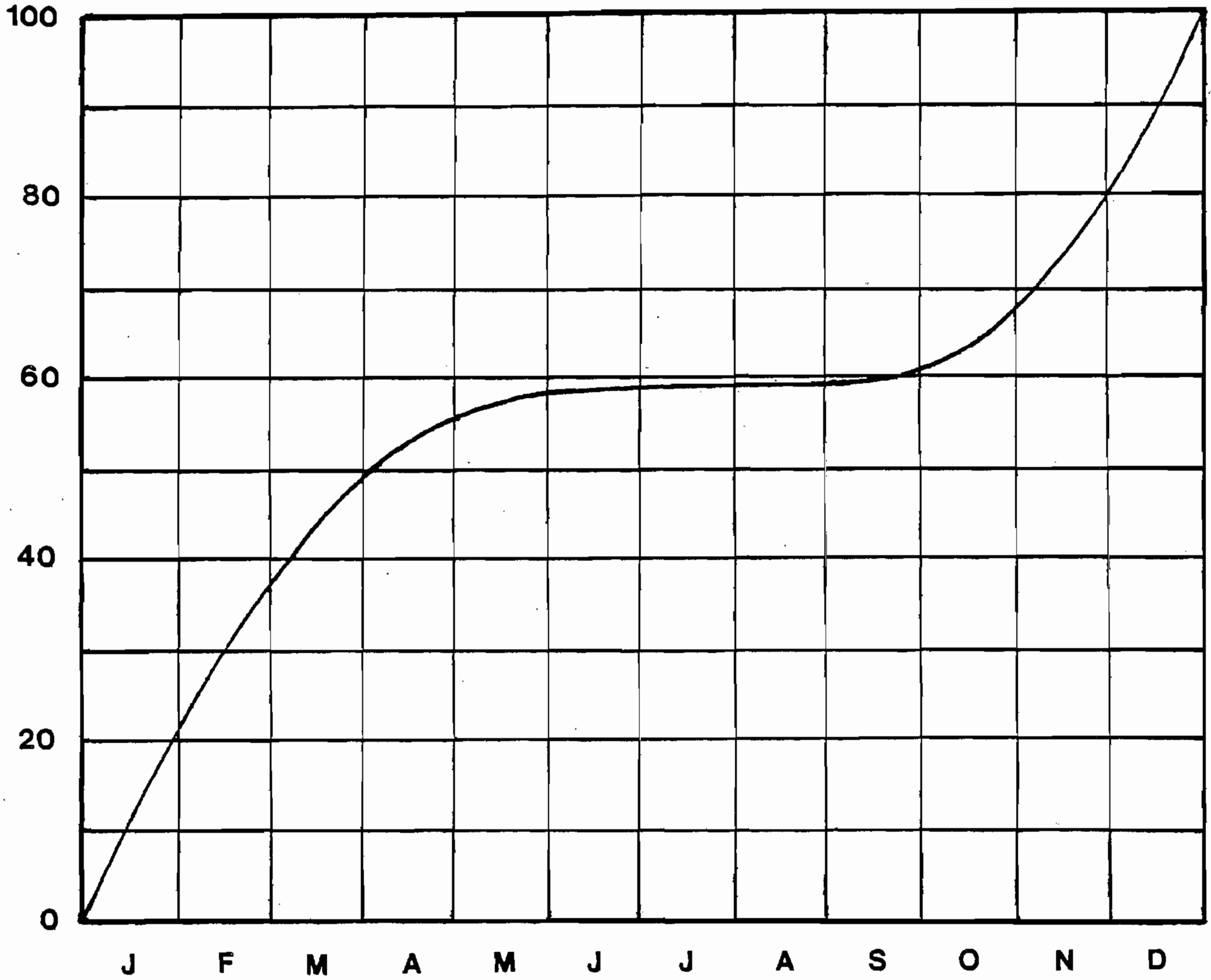
Table A-2: "R" Distribution Curve - Cloverdale

		CUMULATIVE	
Month (1)	Ppt (inches) (2)	Ppt (3)	% Col. (3) (4)
Jan	9.64	9.64	22
Feb	6.77	16.41	37
Mar	4.92	21.33	49
Apr	3.30	24.63	56
May	0.89	25.52	58
Jun	0.39	25.91	59
Jul	0.03	25.94	59
Aug	0.15	26.09	59
Sep	0.32	26.41	60
Oct	2.82	29.23	67
Nov	5.61	34.84	80
Dec	8.67	43.51	100
Total	43.51 Inches		

The data in column (4) is used to plot the distribution curve. See Figure A-2. If the period of interest were from February 1 to March 31 the values of "R" from the curve at the two end points would be 22 and 49. Their difference is 27 so that the value of "R" for the period would be 30 (.27 x 120 rounded to 30).

In situations where the period transcends the calendar year, the value of the period's end is increased by 100. For instance if the period is from Sept. 1 to January 31 of the following year, the two end values would be 59 and 122. The mean annual value of "R" should be multiplied by the factor (122-59)/100 = .63. The period factor "R" will be 75 (.63 x 120 rounded to 75).

Figure A-2. "R" Distribution Curve for Cloverdale, California



APPENDIX B

AIDS FOR ESTIMATING "K" FACTOR

APPENDIX – B

ESTIMATION OF SOIL ERODIBILITY FACTOR "K"

A. Use Wischmeier's nomograph shown in figure 4 of the text to determine "K" from:

1. percent silt and very fine sand (0.002 - 0.10mm)

2. percent of other sand (0.10 - 2.0mm)

3. percent of organic matter

4. structure

5. permeability .

Use laboratory data, if available, to obtain percentages and permeability and soil descriptions to classify structure.

All percentages refer to the soil sample fragment of size smaller than 2 mm.

The percent of organic matter is the product of percent carbon in the soil sample multiplied by a factor 1.8.

The relationship between measured rates of permeability and permeability class is as follows:

Permeability Class	Permeability Rate (inch/hour)
1. rapid	higher than 6.0
2. moderate to rapid	2.0 – 6.0
3. moderate	0.6 – 2.0
4. slow to moderate	0.2 – 0.6
5. slow	0.06 – 0.2
6. very slow	lower than 0.06

Stratified soils should be represented by the least permeable layer.

A general comment is that values of "K" derived from the nomograph must be adjusted to reflect effect of coarse fragments. For soil high in such material (gravelly, chanery, shaly, slaty, cherty, cobbley, or flaggy) "K" values should be reduced by one or two classes. If the content is very high a reduction by two or three classes is recommended (reference B-1).

Where no laboratory data is available the following empirical procedure may be used to estimate silt plus very fine sand, other sands and permeability (reference B-2).

1. Make depth interval selections based on magnitude of variations in characteristic and properties of major soil horizons. Do not make separate depth intervals unless the "K" value exceeds 2 classes.

2. Give the dominant USDA textural classes and percent rock fragments for each selected depth segment.

3. Estimate percent silt plus very fine sand (.002 to 0.10 mm) through the following two steps:

   a. Estimate percent clay (.002 mm; normal range) from texture class or obtain from soil descriptions if field estimations have been made.

   b. Estimate percent of material < 2 mm. passing #200 sieve (< 0.74 mm.), normal range for texture class without rock fragments either through Chart B-1 from percent clay estimated above and texture class or directly from the engineering classification if soils are not gravelly, cobbly or stony.

   c. Subtract percent clay from percent passing #200 to obtain the .002 to 0.74 mm. fraction. (Subtract low clay from low percent passing #200 sieve and higher clay from higher percent passing #200 sieve.)

   d. Use Chart B-2 to estimate silt and very fine sand from percent passing #200 sieve — (minus) percent clay, obtained in "c" above and from texture class.

4. Estimate percent other sands. (0.10 to 2 mm.)

   a. Add percent clay (from 3a above) and percent silt and very fine sand (from Chart B-2), and subtract from 100.

5. Organic matter content — use data from similar soils in the same survey.

6. Structure – obtain from soil descriptions for the respective soil phase or layer in the profile. Rate structure as follows:

    1. very fine granular

    2. fine granular

    3. medium or coarse granular

    4. blocky, platy or massive

7. Permeability – use Chart B-3 to estimate permeability class from texture class, structure and rock fragment content for each depth segment. (See insturctions for use of Chart B-3.)

    Correct for compact soils, pH or pores as outlined on the nomograph and in the instructions for Chart B-3.

B. Method of estimating "K" from textural triangle nomograph (reference B-2).

The attached Chart B-4 – Textural triangle nomograph for soil erodibility can be used for a quick estimate of "K".

The "K" Class curves imposed over the textured triangle were drawn by using Wischmeier's "Soil-Erodibility Nomograph" and average normal particle size distribution curve for the various texture classes. The "K" Class lines refer to soils with 2 percent organic matter, structure other than granular and with permeability that is normal for the texture class (from Chart B-3).

Use appropriate percent sand, silt and clay data or estimates, rounded to the closest 5 percent to find a point in the triangle. Follow parallel to the solid dark curve lines to the right hand side to determine the "K" value class. Make adjustments as needed.

1. The "K" class lines on Chart B-4 refer to soils that include a normal range of 5 to 15 percent very fine sand. Soils that contain more than 15 percent very fine sand need adjustment in silt and sand content as follows:

    a. For soils that are coarser texture than loam, subtract 5 percent from the very fine sand content, add the difference to the silt content and subtract it from the sand content. (Example–a loamy fine sand has 5 percent clay, 15 percent silt and 80 percent sand, 50 percent is very fine sand.

Subtract 5 from 50 = 45; add 45 to 15 = 60% silt and subtract 45 from 80 = 35% sand. Use the new figures in the nomograph.)

b. For soils that are loam or finer textured, subtract 10 percent from the very fine sand content. (Example—a clay loam has 35% clay, 30% silt and 35% sand. 20% is very fine sand. Subtract 10 from 20 = 10; add 10 to 30 = 40% silt; subtract 10 from 35 = 25% sand. Use these figures in the nomograph.)

2. Corrections are needed for (a) granular structure, (b) organic matter content other than 2 percent, (c) coarse fragment and (d) permeability that is other than normal for the texture because of pH, compaction or porosity. The recommended adjustments are outlined briefly on the nomograph and described in more detail below.

a. Structure—If the structure is granular the following corrections are needed; for soils that have—

(1) very fine granular structure, subtract .09 from the "K" value.

(2) fine granular structure subtract .06.

(3) moderate or coarse granular structure subtract .03.

b. Organic Matter—If the organic matter content is other than 2 percent make corrections as follows:

	Organic Matter Percent				
K Value	0	1	2	3	4 (or more)
>.40	+.14	+.07	0	−.07	−.14
.20 to .40	+.10	+.05	0	−.05	−.10
<.20	+.06	+.03	0	−.03	−.06

c. Permeability—If the permeability requires adjustment for compaction pH or porosity, make the following adjustments.

(1) Compaction—Loam or finer texture soils with density > 1.5, add 0.03 to the "K" value; if more sandy than loam with density > 1.7 add 0.03 to the "K" value.

(2) pH—If pH is more than 9.0 add 0.03 to the "K" value.

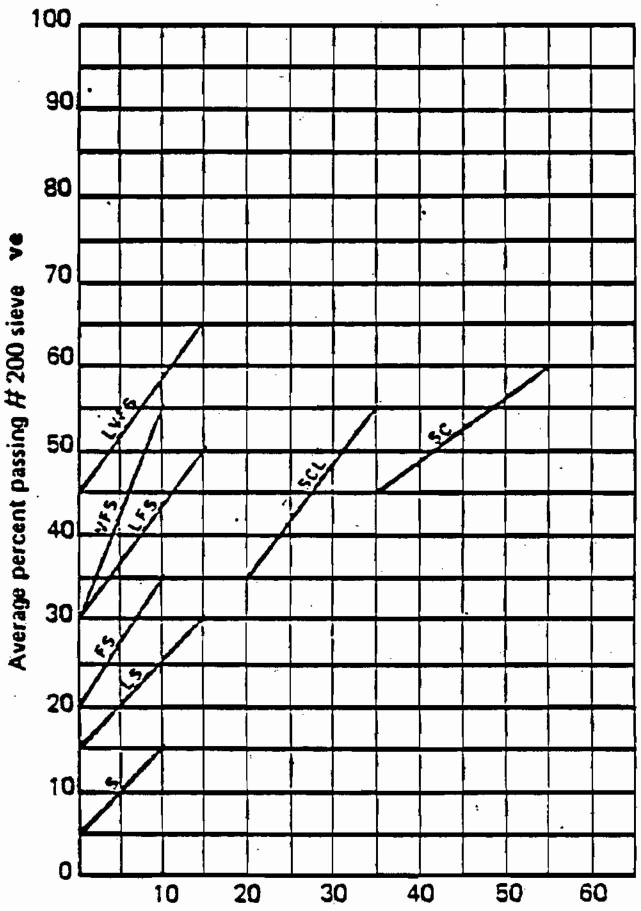
(3) Porosity—If there are many medium or large pores subtract 0.03 from "K" value.

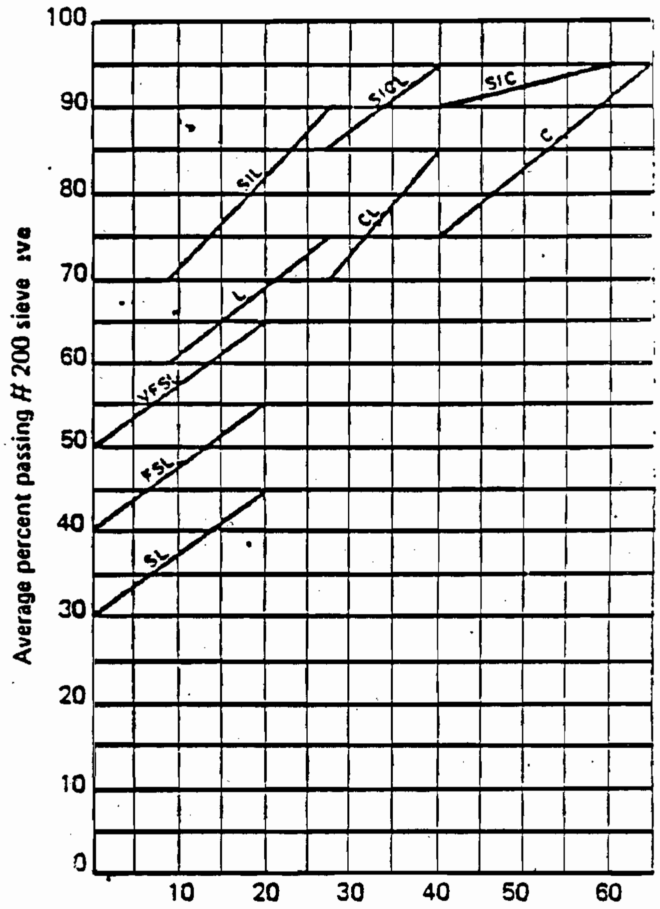
REFERENCES

B-1: Guide for Developing the Soil Erodibility Factor "K" in the Universal Soil Loss Equation. Attachment to Advisory SOILS—6, February 6, 1973 - USDA-SCS.

B-2: Aids for Estimating Soil Erodibility — "K" Value Class and Soil Loss Tolerance — Austin J. Erickson - USDA-SCS - Utah, 1973.

Chart B–1: Estimate Percent of Material < 2 mm. Passing # 200 Sieve from Percent Clay and Texture Class (Average)





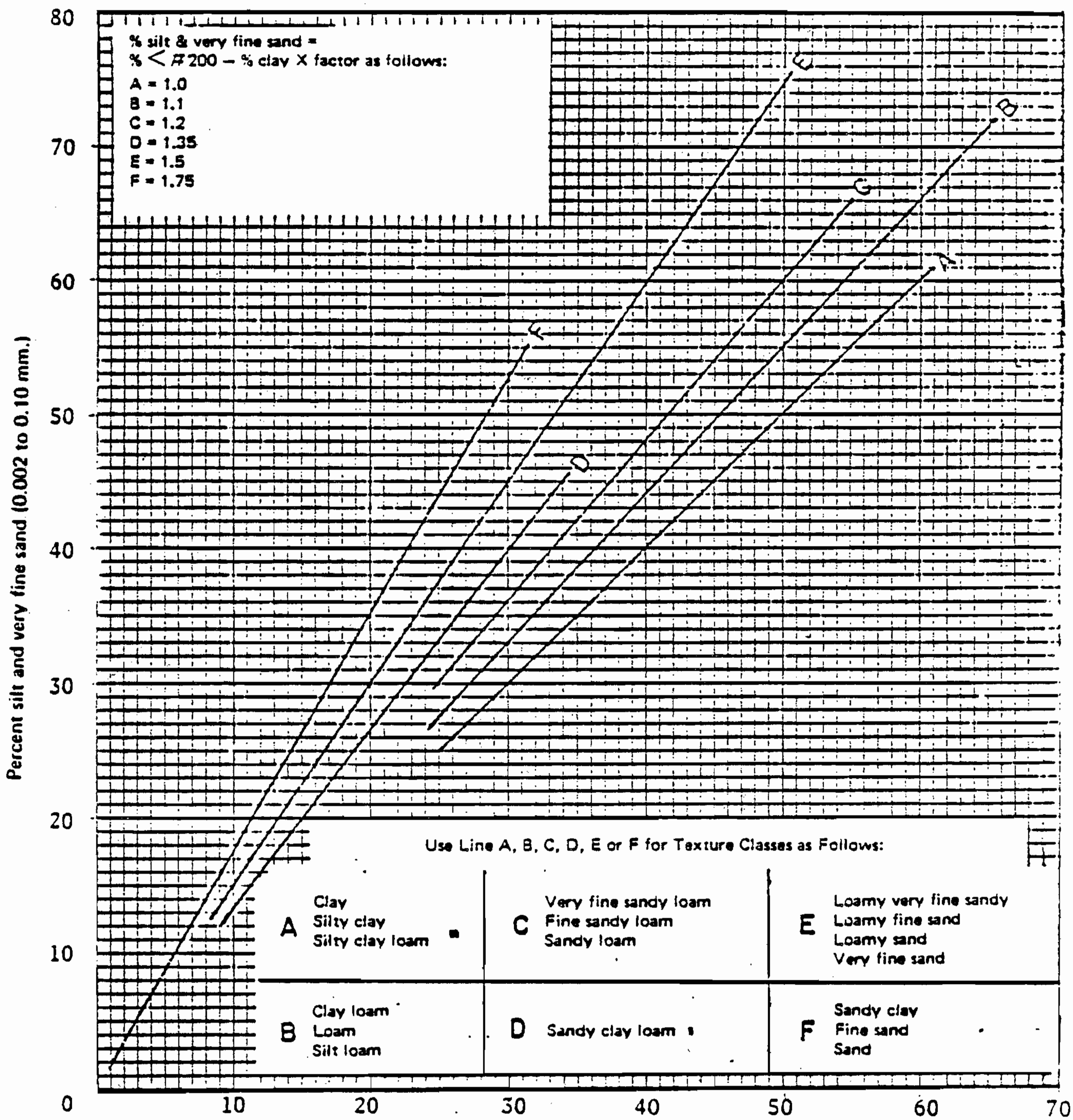
S — Sand
LS — Loamy sand
FS — Fine sand
LFS — Loamy fine sand
VFS — Very fine sand
LVFS — Loamy very fine sand

SCL — Sandy clay loam
SC — Sandy clay

SL — Sandy loam
FSL — Fine sandy loam
VFSL — Very fine sandy loam

L — Loam
SL — Silt loam
CL — Clay loam
SiCL — Silty, clay loam
SiC — Silty clay
C — Clay

Chart B–2: Estimate Percent Silt & Very Fine Sand (.002 to 0.10 mm.) from Percent of Material 2 mm. Passing # 200 Sieve, Percent Clay & Texture Class. *

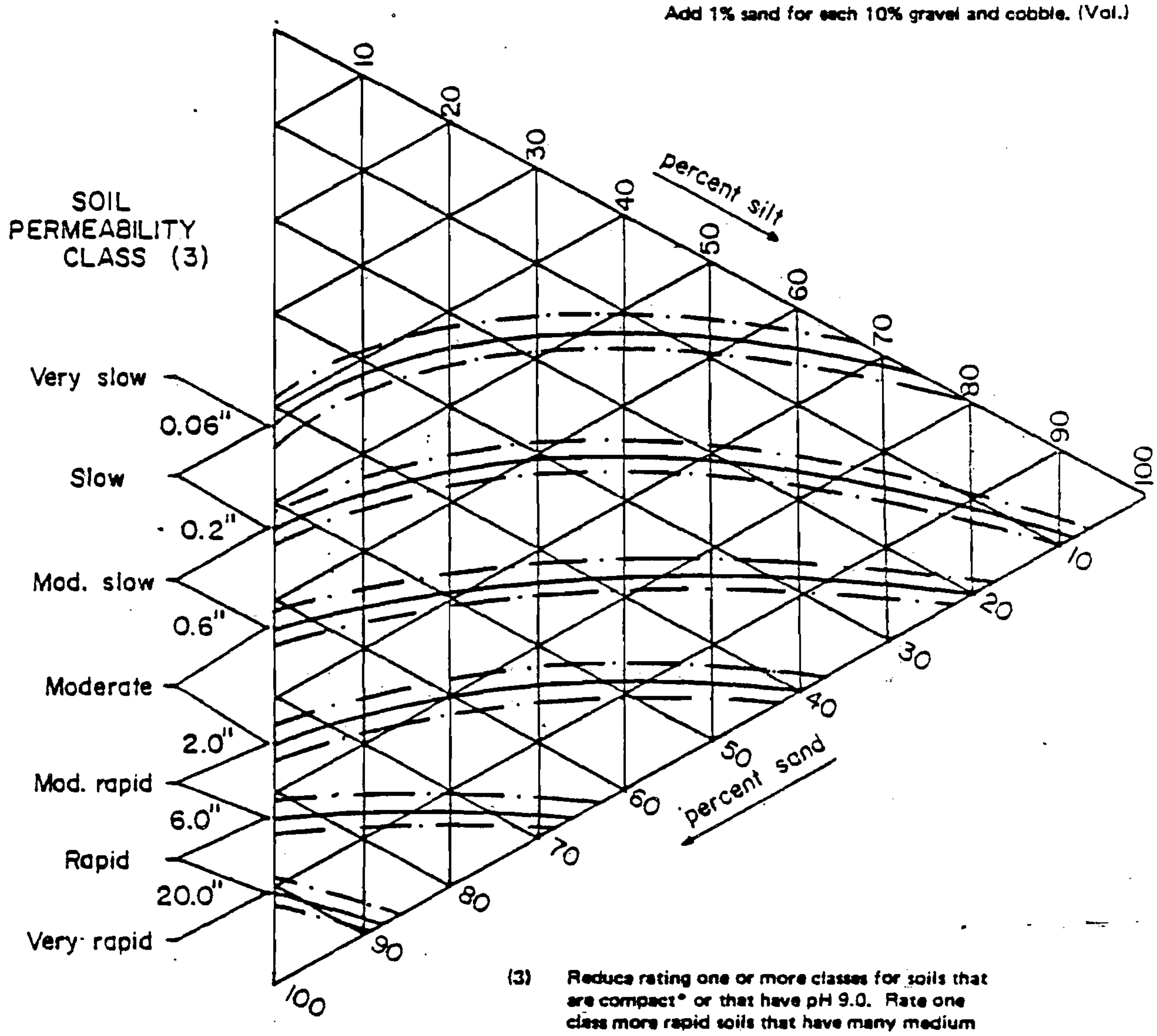


* Reproduced from Reference B–2

Chart B–3: Soil Permeability Class Related to Texture (Reproduced from Reference B–2)

Estimate Soil Permeability from Percent Sand and Silt
Correct for (1) Rock Fragments and (2) Structure.

(1) Correction for Gravel & Cobble
Add 1% sand for each 10% gravel and cobble. (Vol.)



(3) Reduce rating one or more classes for soils that are compact* or that have pH 9.0. Rate one class more rapid soils that have many medium or coarse pores.

* – Rate as compact loam of finer textured soils that have bulk density of 1.5 and soils more sandy then loam that has bulk density of 1.7 or higher.

(2) The solid center line separating the permeability classes is for soils that have moderate medium structure, or fine granular, or medium or coarse granular or single grained. The dotted line below the solid line is the extension of the permeability class for soils that have weak or fine structure or very fine granular. The dotted line above the solid line is the extension of the permeability class for soils that have strong structure or prismatic, blocky, thick platy or massive.

Instructions for Use of Chart B-3—"Estimating Soil Permeability Class" from percent silt, sand and rock fragments, and structure (porosity, density and pH).

1. Estimate from texture class or obtain from laboratory data the percent silt and percent sand. For soils that are gravelly or cobbly increase the percent sand 1 percent for each 10 percent rock fragments by volume.

2. Enter the triangle for the appropriate silt percent and follow down to the appropriate sand percent, then follow to the left side for the permeability class.

   a. The solid center line separating the permeability classes is average for soils that have moderate medium structure, or fine, medium of coarse granular, or are single grained.

   b. The dashed line below the solid line is the extension of the slower permeability class line for soils that have weak or fine structure, or have very fine granular structure.

      The dotted line above the solid line is the extension of the more rapid permeability class line for soils that have strong structure—prismatic, blocky, thick platy or are massive.

3. Soils that (1) are compact, or (2) have pH 9.0 or higher or have more than 25 percent exchangeable sodium, should be rated one permeability class or more, slower than the chart rates. Rate as compact loams or finer textured soils that have a bulk density of more than 1.5, and soils more sandy than loam that have bulk density of 1.7 or higher.

4. Soils that have many medium or coarse pores should be rated one permeability class more rapid than the chart states.

Soils that have abrupt textural changes—layered or highly stratified soils—will require measurements or close field examination to evaluate permeability rates.

Chart B–4: Textural Triangular Nomograph for Soil Erodibility (Reproduced from Reference B–2)

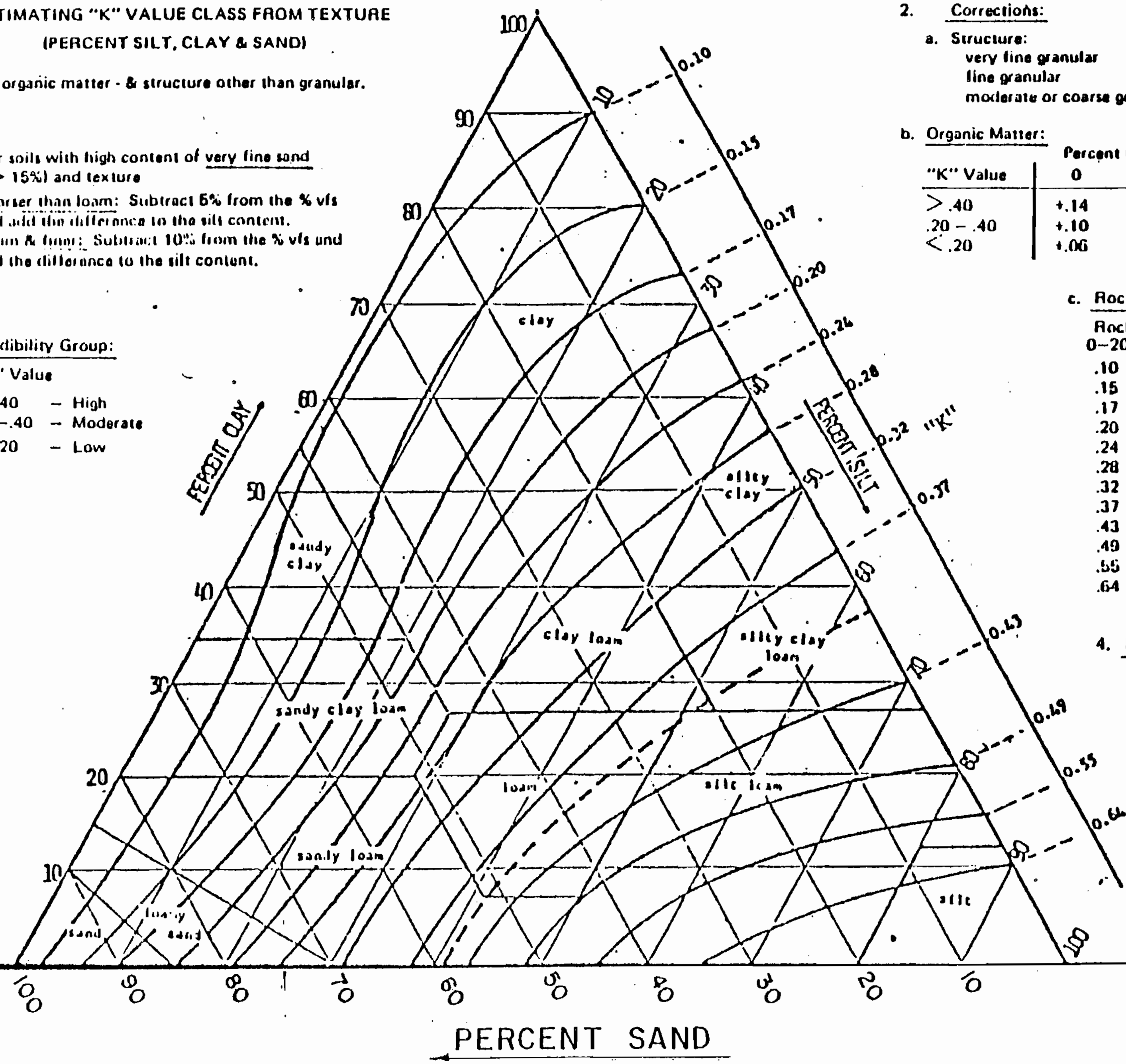
ESTIMATING "K" VALUE CLASS FROM TEXTURE
(PERCENT SILT, CLAY & SAND)

2% organic matter - & structure other than granular.

1. For soils with high content of very fine sand (> 15%) and texture
   - a. Coarser than loam: Subtract 5% from the % vfs and add the difference to the silt content.
   - b. Loam & finer: Subtract 10% from the % vfs and add the difference to the silt content.

Erodibility Group:

"K" Value	
> .40	– High
.20–.40	– Moderate
< .20	– Low



2. **Corrections:**

a. Structure:

very fine granular	– .09
fine granular	– .06
moderate or coarse granular	– .03

b. Organic Matter:

"K" Value	Percent O.M. 0	1	2	3	4
> .40	+.14	+.07	0	–.07	–.14
.20 – .40	+.10	+.05	0	–.05	–.10
< .20	+.06	+.03	0	–.03	–.06

c. Rock Fragments (by Volume)

Rock Fragment Content – (Percent) 0–20	20–35	35–50	50–70
.10	.10	.10	.10
.15	.15	.10	.10
.17	.15	.10	.10
.20	.17	.15	.10
.24	.20	.17	.15
.28	.24	.20	.17
.32	.28	.24	.20
.37	.32	.28	.24
.43	.37	.32	.28
.49	.43	.37	.32
.55	.49	.43	.37
.64	.55	.49	.43

4. **Permeability**

Compact soil or pH > 9.0	+.03
Many medium or coarse pores	–.03

APPENDIX C

EVALUATION OF "C" FACTOR FOR CROPPING PERIODS

Soil Loss Equation "C" Factors for California Cropping Systems

It is not intended that the tables following include all cropping systems in California. The cropping systems and "C" factors listed are to provide examples for helping conservationists make accurate estimates of "C" values for cropping systems within their work areas.

Table 1, below, provides criteria that should enable most conservationists to make "Average Annual C" estimates for a cropping system with fair accuracy once they know the tillage and crop residue practices for the system and relate these to the periods of precipitation causing erosion.

TABLE 1

Soil Management Practice	Estimated "C"
* 1. Continuous clean tilled fallow (Research plots)	1.00
2. Continuous tilled fallow, 1000 lb. straw per acre maintained on soil surface	0.50
3. Continuous bare soil surface - untilled	0.50
4. Orchard Cover Crop - spring disked	0.25
5. Orchard strip Cover Crop, untilled, mowed	0.10
6. Continuous annual grass or legume pasture or hay (100% cover)	0.01
7. Continuous perennial grass (100% cover)	0.003

* Item 1 represents a condition induced by continuous loose fallow over a period of several years. Thus, for practical purposes, Average Annual "C" on agricultural land would always be less than 1.00.

In general, erosion from rainfall in California occurs during the 6 month period between November 1 and April 30. Thus "C" values in the state relate almost entirely to condition of the soil surface during these winter months. Bare tilled soil surface will give "C" values approaching 1.0. Non-tillage of bare surface, or light surface mulches on a tilled surface will reduce erosion and "C" values to about half (0.5). A complete cover of annual grasses and weeds during the winter months will reduce soil losses to about one-tenth on tilled cropland as compared to clean tilled fallow, giving a "C" value of 0.1.

Excepting non-tilled orchards with cover crop, California cropping systems will usually have average annual "C" values between 0.1 and 0.5 with high crop yield stubble mulch systems producing low values and clean-tilled low crop yield systems the higher values.

TABLE 2

Soil Loss Equation "C" Factors for Nonirrigated Cropland in Coastal Areas, Central Valley and Central Valley Foothills

Fallow started in ~~Spring~~ Fall

Cropping System	"C" Factors — Crop Residues Removed	"C" Factors — Crop Residues Left 1/
Stubble Mulch Residue Tillage with cropping sequences of high yield:		
1. Grain, 4 year pasture, summer fallow	0.16	* 0.15
2. Grain, 3 year pasture, summer fallow	0.19	* 0.18
3. Grain, 2 year pasture, summer fallow	0.21	* 0.20
4. Grain, 1 year pasture, summer fallow	0.25	* 0.24
5. Continuous grain	0.24	0.16
6. Grain - summer fallow	0.42	0.33
Conventional tillage with cropping sequences of high yield:		
1. Grain, 4 year pasture, summer fallow	0.18	* 0.17
2. Grain, 3 year pasture, summer fallow	0.20	* 0.19
3. Grain, 2 year pasture, summer fallow	0.22	* 0.21
4. Grain, 1 year pasture, summer fallow	0.28	* 0.25
5. Continuous grain	0.35	0.36 ← ?
6. Grain - summer fallow	0.50	0.42

* Field not grazed until volunteer growth reaches grazing readiness following grain harvest.

1/ "Residues Left" values are based on 1500 to 1750 pounds of straw on the soil surface immediately following harvest. Adjustment should be made for significantly greater or lesser amounts.

TABLE 3

Soil Loss Equation "C" Factors for Nonirrigated Cropland in Northern California Mountain Valleys

Fallow started in Spring

Cropping System	"C" Factors	
	Crop Residues	
	Removed	Left 1/
Stubble Mulch Residue Tillage with cropping sequences of high yield:		
1. Grain, 4 year pasture, summer fallow	0.12	* 0.11
2. Grain, 3 year pasture, summer fallow	0.12	* 0.11
3. Grain, 2 year pasture, summer fallow	0.13	* 0.12
4. Grain, 1 year pasture, summer fallow	0.14	* 0.13
5. Grain, summer fallow	0.16	0.15
Conventional tillage with cropping sequences of high yield:		
1. Grain, 4 year pasture, summer fallow	0.16	* 0.14
2. Grain, 3 year pasture, summer fallow	0.17	* 0.15
3. Grain, 2 year pasture, summer fallow	0.19	* 0.17
4. Grain, 1 year pasture, summer fallow	0.21	* 0.19
5. Grain, summer fallow	0.23	0.20
Conventional tillage medium yield, grain, summer fallow	0.24	0.21

* Field not grazed until the spring following grain harvest.

1/ Use Table 2 statement.

Computer Print-outs for Determining Maximum Permissible "C"

To use the print-outs for obtaining maximum permissible "C" values on individual soils, the conservationist will follow instructions on the "Sheet and Rill Erosion Computation" sheet (Form CF-13 following).

In rare instances, actual lengths of slope in a field may exceed the limits provided for on the print-outs. In such instances the technician can use the Soil Loss Equation to solve for maximum permissible "C" using criteria from the current "Guides for Erosion and Sediment Control", U.S.D.A. Soil Conservation Service, Davis, California.

Well managed non tilled orchards, vineyards, and Christmas tree plantings should yield "C" values of 0.1 or less. Pasture and hayland, properly used should achieve values not exceeding 0.01.

In California irrigation water is not ordinarily applied to cropland during seasons with sufficient rainfall to produce runoff. Thus, fair evaluations of sheet and rill erosion potential from rainfall only can be made on most irrigated cropland using the soil loss equation. Erosion potential of the irrigation water must be determined separately.

Assumptions Made to Develop the Cropping System "C" Factor Tables

Several assumptions were necessary to develop Tables 2 and 3 of Cropping System "C" values that would be applicable over the large areas intended. Where actual cropping systems take exception to one or more assumptions, the technician should make judgment corrections of the table values as needed.

Assumption

1. In the Coastal Areas, Central Valley, and Central Valley Foothills small grain fields will be tilled in the fall preceding summer fallow. In the Northern California Mountain Valleys small grain fields will not be tilled until the spring preceding summer fallow.

2. Conventional tillage in California covers most of the crop residues with the first tillage (usually plowed or deep disked). Stubble mulch tillage maintains most of the crop residues on the soil surface (tillage implements are sweep, duckfoot, rod-weeder or skew treader).

3. All cropping systems maintain sufficient soil fertility and tilth to produce high crop and crop residue yields.

Example adjustments of the table values:

1. A conservationist servicing a Central Valley Foothill small grain area knows his cooperators do not till until the spring preceding summer fallow. To adjust for the erroneous assumption the field office could use the table for Northern California Mountain Valleys (substitute Table 3 for 2).

2. Examination reveals that a cooperator is using tillage that maintains about half his residues on the soil surface. The table value may be adjusted as follows:

$$\text{Correct "C"} = \frac{\text{Stubble Mulch "C"} + \text{Conventional Tillage "C"}}{2}$$

3. Crop color and stand indicates that field soil fertility is low; or, sparse straw cover may indicate low fertility. It is suggested that the conservationist increase the table "C" value by 10% to compensate for increased erosion potential resulting from apparent low fertility.

TABLE 4

Universal Soil Loss Equation "C" Factors For Row and Field Crop Sequences

Cropping Sequence 1/	Years With Winter Cover 2/	"C" Value 3/
6 Year Row and Field Crop Sequence	0	.68
	1	.60
	2	.52
	3	.44
	4	.36
	5	.29
	6	.21
5 Year Row and Field Crop Sequence	0	.68
	1	.58
	2	.49
	3	.39
	4	.30
	5	.21
4 Year Row and Field Crop Sequence	0	.68
	1	.56
	2	.44
	3	.32
	4	.21
3 Year Row and Field Crop Sequence	0	.68
	1	.52
	2	.36
	3	.21

1/ All row and field crops including vegetables.

2/ Based on 1,000-1,500 pounds of small grain residue on the surface from November 1 - May 1. Convert row crop residues to small grain straw equivalent.

3/ Soil loss from irrigation is not included.

TABLE 5

USLE "C" Factors for Nondeciduous, Nontilled

Avocado and Citrus Groves 1/

Stage of Development	% Raised Canopy Cover 2/	% Ground Cover 3/ 0	20	40	60	80	95+
Clearing to 2 Year Old	0 A 1/	.45	.20	.10	.042	.013	.003
	B 1/	1.00	.44	.22	.092	.029	.007
2 - 5 Years Old	25	—	.17	.090	.038	.012	.003
5 - 10 Years Old	50	—	—	—	.035	.012	.003
10+ Years Old	75	—	—	—	—	.011	.003

1/ Tillage for clearing may occur in grove development. Therefore, clearing to 2 years old under stage of development is divided between A and B.

A = Hand clearing or light mechanical clearing which leaves at least the root network of the previous plants.

B = Clearing or land forming is done by a bulldozer or other equipment, removing all surface residues including removal of the previous plant root network.

No tillage operations are done after the establishment year.

2/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection - "a bird's-eye view".

3/ Categories of percent ground cover might be accomplished through the use of a mulch or cover crop, especially important over winter months.

TABLE 6

USLE "C" Factors for Deciduous, Nontilled

Orchard - Almond, Peach, Walnut, etc. 1/

Stage of Development	% Raised Canopy Cover 2/	% Ground Cover 3/					
		0	20	40	60	80	95+
Clearing to 2 Years Old	0 A 1/	.45	.20	.10	.042	.013	.003
	B 1/	1.00	.44	.22	.092	.029	.007
2 - 5 Years Old	25	.40	.18	.093	.040	.013	.003
5 - 10 Years Old	50	.34	.16	.085	.038	.012	.003
10+ Years Old	75	.28	.14	.080	.036	.012	.003

1/ Tillage for clearing may occur in orchard development. Therefore, clearing to 2 years old under stage of development is divided between A and B.

A = Hand clearing or light mechanical clearing which leaves at least the root network of the previous plants.

B = Clearing or land forming is done by a bulldozer or other equipment, removing all surface residues including removal of the previous plant root network.

No tillage operations are done after the establishment year.

2/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection - "a bird's-eye view".

3/ Categories of percent ground cover might be accomplished through the use of a mulch or cover crop, especially important over winter months.

TABLE 7

USLE "C" Factors for Deciduous, Tilled

Orchard - Almond, Peach, Walnut, etc. 1/

Tree Row Tilled:

Stage of Development	% Raised Canopy Cover 2/	% Ground Cover 3/ 0	20	40	60	80	95+
Clearing to 2 Years Old	0	1.00	.44	.22	.092	.029	.007
2 - 5 Years Old	25	.88	.40	.20	.089	.028	.007
5 - 10 Years Old	50	.75	.35	.19	.085	.027	.007
10+ Years Old	75	.62	.31	.18	.081	.027	.007

Tree Row Nontilled:

Stage of Development	% Raised Canopy Cover 2/	% Ground Cover 3/ 0	20	40	60	80	95+
Clearing to 2 Years Old	0	.80	.35	.18	.074	.023	.006
2 - 5 Years Old	25	.70	.32	.16	.071	.022	.006
5 - 10 Years Old	50	.60	.28	.15	.068	.022	.006
10+ Years Old	75	.50	.25	.14	.065	.022	.006

1/ Continuous weed free tillage except as noted when tree row is nontilled.

2/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection - "a bird's-eye view".

3/ Percent ground cover over winter months.

TABLE 8

USLE "C" Factors for Vineyards - Tilled 1/

Vine Row Tilled:

Stage of Development	% Raised Canopy 2/	% Ground Cover 3/					
		0	20	40	60	80	95+
Clearing to 1 Year Old	0	1.00	.44	.22	.092	.029	.007
1 - 3 Years Old	15	.92	.41	.21	.090	.028	.007
3+ Years Old	30	.85	.39	.20	.088	.028	.007

Vine Row Nontilled:

Stage of Development	% Raised Canopy 2/	% Ground Cover 3/					
		0	20	40	60	80	95+
Clearing to 1 Year Old	0	.80	.35	.18	.074	.023	.006
1 - 3 Years Old	15	.74	.33	.17	.072	.022	.006
3+ Years Old	30	.68	.31	.16	.070	.022	.006

1/ Continuous weed free tillage except as noted when vine row is nontilled.

2/ Portion of total-area surface that would be hidden from view by canopy in a vertical projection - "a bird's-eye view".

3/ Percent ground cover over winter months.

APPENDIX D

CHEMICAL SOIL STABILIZERS, MULCHES AND MULCH TACKS

APPENDIX – D

All material in this appendix has appeared originally in the report entitled "Guidelines for Erosion and Sediment Control Planning and Implementation" prepared by the Environmental Protection Agency, Serial Number EPA-R2-72-015 August 1972.

The listing of products does not constitute endorsement by either the Environmental Protection Agency or the Soil Conservation Service. The products are available on the commercial market and being used according to manufacturer's recommendations. Requests for specific information regarding use, handling limitations, toxicity, etc., should be directed to the manufacturer.

The listing is not meant to be all inclusive. Other similar products may be available for use and their exclusion is in no manner a reflection on their utility or quality.

AEROSPRAY® 52 BINDER

Technical Information

DESCRIPTION

AEROSPRAY® 52 BINDER is a milk-white colored, viscous, water dispersible alkyd emulsion. It is nontoxic and nonphytotoxic and the pH is 8-9.

OBJECTIVE:

Temporary Soil Stabilization—On denuded areas it penetrates the soil and binds soil particles into a coherent mass that reduces erosion by water.

Chemical Mulch—On seeded areas it penetrates the soil and binds soil particles into a coherent mass. Water and air movement into the soil is maintained.

WHERE USED:

AEROSPRAY® 52 BINDER is used as a temporary soil stabilizer and mulch on all types of soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

Various dilution ratios and application rates have been developed by the manufacturer and this chemical should be applied in accordance with the manufacturer's recommendations if optimum results are to be achieved. Some general guidelines are listed below. On steeply inclined, exposed slopes AEROSPRAY® 52 BINDER should be applied in concentrated form at the rate of one gallon per 100 square feet. When used on a seedbed, it is applied at a rate of 30-45 gallons of concentrate per acre in dilution ratios that vary up to 10 parts of water to one of chemical.

MEANS OF APPLICATION:

In general, it can be applied with any nonair entraining equipment employed for applying liquid fertilizer, asphalt emulsions, and water. It can also be applied on small plots with garden type hand sprayers. Hydroseeder agitation devices should be disengaged after initial mixing of the chemical and water to minimize foaming.

CURING TIME:

AEROSPRAY® 52 BINDER dries in four hours at 90°F, and in eight hours at 60°F and 50 percent relative humidity.

HANDLING LIMITATIONS:

Will freeze, but freezing will not damage the product.

MANUFACTURER:

American Cyanamid Company
Industrial Chemicals and Plastics Division
Wayne, New Jersey 07970

NOTES

AQUATAIN

Technical Information

DESCRIPTION:

AQUATAIN is a water dispersible liquid concentrate containing sodium polypectate, glycerin, and ammonia. It is nontoxic and nonflammable.

OBJECTIVE:

Chemical Mulch– Partially binds surface soil in order to reduce erosion and evaporation losses and thereby favorably affect the development of a permanent vegetative cover. May be used in hydroseeder slurries as well as on preseeded areas.

WHERE USED:

AQUATAIN is used as a chemical mulch on all types of soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

AQUATAIN is generally mixed with water at a ratio of one part AQUATAIN to 5.5 parts water. An application rate of approximately 3 gallons AQUATAIN, plus the required water, per 1000 square feet of surface area is normally required for most soil surfaces.

MEANS OF APPLICATION:

AQUATAIN can be applied with a hydroseeder along with seed and fertilizer. Equipment used for applying asphalt emulsions and water can also be used to apply AQUATAIN with little or no modification. For small areas, the chemical is generally applied with small hand operated sprayers.

CURING TIME:

No information available.

HANDLING LIMITATIONS:

None listed, but the chemicals are carried in water so the product must be stored in above freezing temperatures.

MANUFACTURER:

The Larutan Corporation
1424 South Allec Avenue
Anaheim, California 92805

NOTES

®CURASOL AE

Technical Information

DESCRIPTION:

®CURASOL AE is a milky-white, polyvinyl acetate copolymer emulsion. It is physiologically harmless and has no phytotoxic properties. The pH value is 4-5 and it is water dispersible.

OBJECTIVE:

Temporary Soil Stabilization—Temporarily binds surface soil in denuded areas in order to reduce water erosion.

Chemical Mulch—Partially binds surface soil in order to reduce erosion and evaporation losses and thereby favorably affect the development of a permanent vegetative cover. May be used in hydroseeder slurries as well as on preseeded areas.

Mulch Tack—Binds natural fiber mulches to reduce losses caused by wind and rain.

WHERE USED

®CURASON AE is used as a temporary soil stabilizer, mulch, and mulch tack on all types of soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

For use as a chemical mulch and/or soil stabilizer, the amounts of ®CURASOL AE and water generally required per acre of area are as follows:

Flat Areas—30 gallons ®CURASOL AE to 1000 gallons of water for moist soil. For dry soil use 2000 gallons of water.

3:1 to 2:1 Slopes—40 to 55 gallons ®CURASOL AE to 1000 gallons of water for moist soil. For dry soil use 2000 gallons of water.

1-1/2:1 Slopes—55 to 65 gallons ®CURASOL AE to 1000 gallons of water for moist soil. For dry soil use 2000 gallons of water.

Swales and Ditches—90 to 100 gallons ®CURASOL AE to 1000 gallons of water for moist soil. For dry soil use 2000 gallons of water.

MEANS OF APPLICATION

®CURASOL AE can be applied with a hydroseeder along with the seed and fertilizer. Spraying equipment normally used for applying asphalt emulsions or water can also be used, with little or no modification, to apply the binder.

CURING TIME

Curing time is dependent upon weather conditions, but is generally 2-6 hours after application.

HANDLING LIMITATIONS:

Will freeze at 23°F. Can be applied at temperatures above 34°F. Treated surfaces should be traffic free except when very high concentrations of material are used. May be sprayed on wet or dry soil. May be stored at least 6 months, but should not be stored in extreme heat, sunlight, or subfreezing conditions.

MANUFACTURER:

American Hoechst Corporation
1041 Route 202-206 North
Bridgewater, New Jersey 08876

NOTES

®CURASOL AH

T chnical Information

DESCRIPTION;

®CURASOL AH is a milky-white, high-polymer synthetic resin dispersion. It is physiologically harmless and has no phytotoxic properties. The pH value is 4-5 and it is water dispersible.

OBJECTIVES:

Temporary Soil Stabilizer—Temporarily binds surface soil in denuded areas in order to reduce water erosion. Chemical specially designed for use under freeze-thaw conditions or when stabilized area is subject to some traffic.

Mulch Tack— Binds natural fiber mulches to reduce losses caused by wind and rain.

WHERE USED:

®CURASOL AH is used as a temporary soil stabilizer and mulch tack on all types of soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

Straw Mulch Tack—Under normal conditions, using a mulch blower, a mixture of 30 to 45 gallons of ®CURASOL AH and 150 to 300 gallons of water is generally required to tack one acre of mulch. A greater quantity of water, generally 300 to 500 gallons, is required when the tack is applied with a hydroseeder.

Hay Mulch Tack—a mixture of 20 to 30 gallons of ®CURASOL AH and 150 to 300 gallons of water is generally required for one acre of area when the tack is applied with a mulch blower. Using a hydroseeder, a greater quantity of water, generally 300 to 500 gallons, is required in the mixtur

MEANS OF APPLICATION:

®CURASOL AH can be applied with a mulch blower or sydroseeder and with sprayers normally used for applying asphalt emulsions or water.

CURING TIME:

Curing time is dependent upon weather conditions, but is generally 1-6 hours after application.

HANDLING LIMITATIONS:

Will freeze at 23°F. Can be applied at temperatures above 41°F. May be stored under normal conditions for at least six months. Should not be exposed to strong sunlight or heat. Must be protected from frost.

MANUFACTURER:

American Hoechst Corporation
1041 Route 202-206 North
Bridgewater, New Jersey 08876

NOTES

DCA-70

Technical Information

DESCRIPTION:

DCA-70 is a milky-white, viscous, water dispersible polyvinyl acetate emulsion. It is nonflammable, nontoxic, and nonphytotoxic. The pH ranges from 4 to 6.

OBJECTIVE:

Temporary Soil Stabilizer— On denuded areas it penetrates the soil and binds soil particles into a coherent mass that reduces erosion by water.

Chemical Mulch—Partially binds surface soil in order to reduce erosion and evaporation losses and thereby favorably affect the development of a permanent vegetative cover. May be used in hydroseeder slurries as well as on preseeded areas.

Mulch Tack—Binds natural fiber mulches to reduce losses caused by wind and rain.

WHERE USED:

DCA-70 is used as a temporary soil stabilizer, mulch, and mulch tack on all types of soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

Various dilution and application rates will depend on soil, slope, etc., conditions and the material should be applied in accordance with manufacturer's recommendations. However, general requirements are as follows:

Soil Stabilizer—Mix one part DCA-70 to one part clean water and apply 0.5 or more gallons per square yard.

Chemical Mulch—Mix one part DCA-70 to 20 or more parts of clean water and apply 0.5 gallon per square yard on permeable soils.

Mulch Tack—Mix one part DCA-70 to 10-20 parts water. Apply this solution at a rate sufficient to disperse 30-45 gallons of DCA-70 concentrate per acre.

MEANS OF APPLICATION:

Equipment used for applying asphalt emulsions and water can be used to apply DCA-70. Hydroseeders can also be used to apply the chemical with little or no modification.

CURING TIME:

DCA-70 cures in one hour at 90°F and two hours at 60°F and 50 percent relative humidity.

HANDLING LIMITATIONS:

Solids separation occurs in temperatures below 40°F.

MANUFACTURER:

Union Carbide Corporation
Chemicals and Plastics
270 Park Avenue
New York, New York 10017

NOTES

LIQUID ASPHALT

Technical Information

DESCRIPTION:

The basic component is asphalt cement. It is dispersed or suspended in water or various solvents.

OBJECTIVE:

Mulch Tack—Binds natural fiber mulches to reduce losses caused by wind and rain.

Chemical Mulch—Partially binds surface soil in order to reduce erosion and evaporation losses and thereby favorably affect the development of a permanent vegetative cover.

WHERE USED:

Liquid Asphalt is used as a mulch tack and chemical mulch on all types of soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

Chemical Mulch—Apply Liquid Asphalt or emulsified asphalt as a spray at the rate of 0.15-0.30 gallons per square yard, depending upon soil and slope conditions.

Mulch Tack—Apply Liquid Asphalt at a rate of 0.1 gallon per square yard and emulsified asphalt at a rate of 0.04 gallon per square yard.

MEANS OF APPLICATION:

Asphalt may be applied by hand-spray nozzle or with an offset distributor bar attached to an asphalt distributor truck.

CURING TIME:

Varies widely for various types of asphalt and water conditions, but is generally 24 hours.

HANDLING LIMITATIONS:

Will adhere to shoes, etc., unless completely cured. Special care must be used when applying so that material will not drift beyond the area mulched.

PRODUCT INFORMATION SERVICE:

The Asphalt Institute
Asphalt Institute Building
College Park, Maryland 20740

NOTES

PETROSET® SB

Technical Information

DESCRIPTION:

PETROSET® SB is a light tan colored oil in water emulsion of high strength rubber. It is free flowing and is water dispersible. The material is not flammable and is not toxic to humans or animals.

OBJECTIVE:

Temporary Soil Stabilization—On denuded areas it penetrates the soil and binds soil particles into a coherent mass that reduces erosion by water.

Chemical Mulch—On seeded areas it penetrates the soil and binds soil particles into a coherent mass. Water and air movement into the soil is maintained.

Mulch Tack—Binds natural and synthetic fiber mulches together and thereby reduces loss of mulch due to removal by wind and rain.

WHERE USED:

Used as a temporary soil stabilizer, mulch, and mulch tack on all types of soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

Numerous dilution ratios (i.e., parts of PETROSET® SB to parts of water) and application rates (also spreading rates) have been developed by the manufacturer for different soil textures, desired penetrations, and intended usages. In general, the greater the dilution ratio (i.e., the greater the percentage of water) the deeper the penetration of the binder and the weaker the binding strength for a given soil condition. In addition, the finer the soil texture the greater the dilution ratio and application rate required to achieve a desired penetration. For example, in order to protect against normal rainwater and wind erosion and obtain a penetration of approximately ½ inch, a fine textured (fine grained) soil generally requires an application rate of one gallon dilute PETROSET®SB, having a dilution ratio of 1:14, per square yard. In order to achieve the same objective, a coarse textured soil generally requires an application rate of 0.4 gallon of dilute PETROSET®SB, having a dilution ratio of 1:5, per square yard. Specific application and cost formulas and nomographs are furnished by the manufacturer.

MEANS OF APPLICATION:

Practically any spraying equipment capable of delivering the desired quantity of dilute PETROSET®SB can be used. Distributor trucks with calibrated spreader bars, as well as hydroseeding equipment, are suitable for applying the chemical.

CURING TIME:

Thirty minutes after application this product has cured enough to perform satisfactorily and will not adhere to shoes.

HANDLING LIMITATIONS:

Will freeze, but freezing will not damage the product. Clean equipment should be used for application. Product contains some solvents and should therefore be kept away from children. Storage should be at temperatures of less than 150°F.

MANUFACTURER:

Phillips Petroleum Company
Chemical Department
Commercial Development Division
Bartlesville, Oklahoma 74003

NOTES

TERRA TACK

Technical Information

DESCRIPTION:

TERRA TACK is a highly concentrated, water dispersible chemical marketed in powdered form which forms a thick green liquid when mixed with water.

OBJECTIVE:

Chemical Mulch— Partially binds surface soil in order to reduce erosion and evaporation losses and thereby favorably affect the development of a permanent vegetative cover. May be used in hydroseeder slurries as well as on preseeded areas.

Mulch Tack—Binds natural fiber mulches to reduce losses caused by wind and rain.

WHERE USED:

TERRA TACK is used as a chemical mulch and mulch tack on dry or porous soil surfaces.

GENERAL APPLICATION REQUIREMENTS:

For wet application in combination with seeding, an application rate of 50 pounds of TERRA TACK in 2000 gallons of water is recommended per acre. For dry application in combination with seeding, use 86 pounds per acre. When used as a mulch tack for long fiber mulches such as straw or hay, a mixture ratio of 1:20 parts water is recommended. This slurry should be applied at a rate of 1000 gallons per acre. For use with short fiber mulches like wood fiber mulch, a ratio of 1:40 is applied at a rate of 2000 gallons of slurry per acre.

MEANS OF APPLICATION:

Standard hydroseeding equipment used for applying seed, fertilizer, and certain mulches can be employed with little or no modification. For dry application, standard hopper spreaders used for applying fertilizers or lime can be utilized.

CURING TIME:

No specific curing information is available, but the manufacturer recommends application on dry soil at least two hours before sunset or rainfall.

HANDLING LIMITATIONS:

Avoid contact with skin and eyes. Avoid breathing dust or solution spray. Wash body thoroughly after using TERRA TACK. Tank life is limited to several hours, so use immediately after mixing.

MANUFACTURER:

Grass Growers, Inc.
P.O. Box 584
Plainfield, New Jersey 07061

NOTES

EXCELSIOR BLANKET

Technical Information

PRIMARY USAGE:

The Excelsior Blanket is a protective blanket used in the establishment of vegetation in critical areas. As a mulching product it conserves soil moisture, serves as an insulator against intense solar insolation, dissipates energy from falling raindrops, and reduces erosion caused by overland flow. The use of a reinforcing weave, the intertwined nature of the excelsior, and the fact that the blanket is secured to the soil by metal staples make this product resistant to erosion by concentrated storm runoff. It can, therefore, be used in critical areas such as swales, ditches, steep slopes, highly erodible soil, etc.

DESCRIPTION:

The Erosion Control Excelsior Blanket consists of a machine produced mat of curled wood excelsior of 80 percent eight inch or longer fiber length. It is of consistent thickness and the fiber is evenly distributed over the entire area of the Blanket. The top side of each Blanket is covered with a 3" x 1" weave of twisted Kraft paper or biodegradable plastic mesh that has a high wet strength. Blankets are smolder resistant and contain no chemical additives. The Blankets are available in 3' x 150' rolls and in 4' x 180' rolls. They are secured to the soil by the use of heavy duty wire staples.

INSTALLATION INSTRUCTIONS:

Each specific site may require some modification or variation from the general criteria listed below. Manufacturer technical representatives or conservation specialists experienced in the use of this product should be consulted for guidance. In general the Blanket is rolled out on the seeded area to be protected and is stapled into place. Suggested staple application rate, under normal conditions, is five staples per six linear feet of Blanket, placed two along each side and one in the middle. Where more than one Blanket is required they are butt-joined and securely stapled. Care should be exercised to ensure that the Blanket is placed with the weave side up. When used in areas of concentrated flow they must be extended laterally to an elevation that is several inches above the elevation of the design high flow. This precaution will discourage gully and rill formation along the margins of the installation.

PRODUCT INFORMATION SOURCE:

American Excelsior Company
P.O. Box 5067, 850 Avenue H. East
Arlington, Texas 76011
(Erosion Control Excelsior Blanket)

FIBER GLASS MATTING

Technical Information

PRIMARY USAGE:

Erosion check construction is one of the most common applications of Fiber Glass Matting. In its various forms, it is also used in landscaping as a filter-separator between topsoil and gravel drainage beds, and as a mulch for seedbeds and for other applications. In this document it is only considered in its application for use in the construction of erosion checks and as a mulch for seedbeds.

DESCRIPTION:

Fiber Glass Matting is composed of flexible fiber glass that is made of inorganic materials that will not rot, corrode, or burn. It is supplied in rolls of material ½-inch thick. Roll width can be variable from two to six feet. Roll length varies from 100 to 150 feet.

INSTALLATION INSTRUCTIONS:

At locations where erosion checks are planned a trench is dug across the ditch, swale, slope etc. Place fiber glass matting in an "L" shape with the long dimension up; staple matting against the vertical side of the trench and along the bottom sufficiently to hold it in place. Backfill, tamp, and trim matting flush with the surface.

Where long-term resistance to erosive forces is desired in conjunction with vegetation, Fiber Glass Matting can be used as a mulch blanket. It is applied in a similar manner to the Excelsior Blanket.

PRODUCT INFORMATION SOURCE:

Certain-Teed Products Corporation
Gustin-Bacon Division
3050 Fairfield Road
P.O. Box 15079
Kansas City, Kansas 66115
(Ultracheck®)

PPG Industries, Inc.
Fiber Glass Division
One Gateway Center
Pittsburgh, Pennsylvania 15222
(Topsoil Separator)

GLASSROOT®

Technical Information

PRIMARY USAGE:

GLASSROOT® is a mulch product for use on newly seeded areas. As a mulching product it conserves soil moisture during dry periods, serves as an insulator against intense solar energy, dissipates energy from falling raindrops, and reduces erosion caused by overland sheet slow.

DESCRIPTION:

GLASSROOT® is a fiber glass product. Its appearance is somewhat similar in appearance to the "angel hair" used in Christmas decorations. It consists of a bundle of continuous fiber glass rovings that are packaged in 35 pound units. It is dispensed by means of a simple application kit that consists of a light metal container complete with shoulder strap for easy carrying, a valve and nozzle, and a 50-foot hose. The hose is connected to an air compressor unit operating at 50 to 60 pounds pressure. As GLASSROOT® is fed into the nozzle, compressed air propels and separates the strands of glass fibers, spreading them evenly over the area. GLASSROOT® is inorganic and will not react or decompose when exposed to water, sunlight, or chemicals found in the soil.

INSTALLATION INSTRUCTIONS:

Conduct normal seeding operations. Apply GLASSROOT® at the rate of about 35 pounds per 150-200 square yards. This rate can be varied depending upon individual site conditions and as experience with the product is acquired. Tacking is generally not required because the fiber glass strands tend to "attach" to every tiny surface irregularity and thereby anchor the mulch. Since this product is nonbiodegradable, it provides reinforcement to turf. Foot traffic by animals and humans on mulched areas should be discouraged until such time as the mulch has become an integral part of the turf.

PRODUCT INFORMATION SOURCES:

PPG Industries, Inc.
Fiber Glass Division
One Gateway Center
Pittsburgh, Pennsylvania 15222

JUTE NETTING

Technical Information

PRIMARY USAGE:

Jute Netting is used in the establishment of vegetation in critical areas. As a mulching product, it conserves soil moisture, serves as an insulator against intense solar insolation, dissipates energy from falling raindrops, and reduces erosion caused by overland flow. The thick strands and heavy weave enable this product to withstand the higher flow velocities associated with critical swales, ditches, median strips, etc.

DESCRIPTION:

Jute Netting is a heavy woven jute mesh of rugged construction. It is constructed of undyed and unbleached twisted jute fibers. It can be treated to be smolder resistant. It is commonly available in individual rolls, 225 feet long and 4 feet wide. Each roll contains 100 square yards and weighs approximately 90 pounds.

INSTALLATION INSTRUCTIONS:

Prepare seedbed according to local specifications. Seeding may be split so that one-half of seed is sown after the jute has been applied. Each specific site may require some modification or variation from the general criteria listed below. Manufacturer technical representatives on conservationists experienced in the use of this material should be consulted for specific guidance.

In general, start laying the thatching from the top of the channel and unroll downgrade so that one edge of the strip coincides with the channel center. Lay a second strip parallel to the first on the other side of the channel and allow a two-inch overlap. If one roll of thatching does not extend the length of the channel, continue downhill with additional rolls.

Bury the top end of the jute strip in a trench four inches or more deep. Tamp the trench full of soil. Reinforce with a row of staples driven through the jute about four inches downhill from the trench. These staples should be 4 to 10 feet apart. The outside edges may be stapled similarly at any time after the center has been stapled. Closer stapling along the sides is required where concentrated water may flow into the channel.

Succeeding strips of thatching, farther down the channel, are secured in a similar manner.

Where one roll of thatching ends and another roll begins, the end of the top strip overlaps the trench where the upper end of the lower strip is buried. Make the overlap at least four inches and staple securely. If the ends and edges of the strips of thatching are securely stapled, stapling in the strip middles may be 10 feet apart or ommitted entirely.

At any point the thatching may be folded for burying in slit trenches and secured as were the upper ends. This checks water flow and erosion that may begin under the matting. It also gives improved tie-down.

Insure contact between thatching and soil by rolling after laying, stapling and seeding is complete. Perfect contact is vital to keep water flow over, not under, the jute.

After job completion, make sure the thatching is in contact with the soil at all places and that critical areas are securely stapled down.

Hairpin-shaped wire staples, No. 8 gauge; 6, 8, and 10 inches long have been used. The longer staples are used in loose or wet soil. Wire staples are better than wooden pegs because the staples can be driven flush with the matting. Wooden pegs extend above the thatching and may catch trash that diverts water flow out of the thatch-protected channel. Wooden pegs may also set up a damaging turbulence.

PRODUCT INFORMATION SOURCE:

Belton Bagging Company
P.O. Box 127
Belton, South Carolina 29627

Bemis Company, Inc.
P.O. Box 12224 Soulard Station
2400 South Second Street
St. Louis, Missouri 63104

Ludlow Corporation
Textile Division
Needham Heights, Massachusetts 02194

MULCH BLANKETS

Technical Information

PRIMARY USAGE

Mulch Blankets are used in the establishment of vegetation in critical areas. As a mulching product they conserve soil moisture, serve as insulators against intense solar insolation, dissipate energy from falling rain, and reduce erosion caused by overland flow.

DESCRIPTION:

Conwed Turf Establishment Blanket is a composite of all new cellulose fibers that are bonded with a water soluble binder that is noninjurious to seed germination or growth. The bound material forms a homogeneous mat. An extruded, oriented plastic net with approximate ¼-inch by ¼-inch mesh openings is bonded to the top surface of the mat. The material weighs approximately 25 pounds per 1000 square feet. After application and saturation by rain, the fibrous blanket loosens to form a thick mulch cover. This cover and the underlying seed and soil is then held in place by the mesh plastic net. The fiber mulch blanket conforms to the surface to prevent erosion by wind and water.

Swif-Gro is a lightweight, all cotton woven (leno weave), open mesh fabric laminated to cellulose tissue. Tensile minimum is 45 pounds in the warp direction and 35 pounds in the filling direction. Roll length is approximately 500 yards. Roll width is 75 inches, plus two inches, minus one inch. One roll weighs 170 pounds ± 10 percent.

INSTALLATION INSTRUCTIONS:

Specific sites may require some modification or variation from the general criteria listed below. Manufacturer technical representatives or conservation specialists experienced in the use of this product should be consulted for guidance. Both materials are designed to be unrolled and stapled over prepared, seeded soil surfaces. Where more than one roll of material is required, sufficient overlap should be provided to ensure against separation at these seams. Neither material should be stretched tight. They should be applied so as to conform to surface irregularities and must be in continuous contact with the soil surface. Material should be secured in depressions with additional staples.

Care must be exercised to ensure that the Conwed Turf Establishment Blanket is installed with the plastic net on top. When used in areas that experience concentrated overland, flow, fabric blankets must be extended laterally to an elevation that is several inches above the elevation of the design high flow.

PRODUCT INFORMATION SOURCE:

Conwed Corporation
332 Minnesota Street
St. Paul, Minnesota 55101
(Conwed Turf Establishment Blanket)

Southern Phenix Textiles, Inc.
Box 1108
Phenix City, Alabama 36867
(Swif-Gro)

NETTING

Technical Information

PRIMARY USAGE:

Netting is used as a means by which natural or synthetic fiber mulch can be securely anchored on seeded areas or areas temporarily stabilized with mulch on which conventional mulch tacking products (asphalt, chemicals, etc.) are judged to be insufficient. This approach to tacking mulch is often used on very steep areas and on odd shaped areas, especially around structures. Nettings are also used to reinforce newly placed turf that may be subjected to severe runoff velocities before the root zone has matured to the point where turf structure alone can withstand the anticipated stress.

DESCRIPTION:

Several products are on the market and compositions range from tightly twisted Kraft paper yarns to polypropylene oriented plastic to fiber glass scrim. All are lightweight. The Kraft paper yarns are biodegradable. The polypropylene is ultraviolet sensitive and gradually disintegrates in the presence of sunlight. The polypropylene net and fiber glass scrim will not support combustion. All products are marketed in rolls. Roll widths range from 3.75 to 15 feet. Lengths range to 2500 feet.

INSTALLATION INSTRUCTIONS:

Generally these products are unrolled and stapled on areas that have been mulched with natural and synthetic fiber mulch. Staple placement is not as critical in securing netting on mulch as it is with some of the other products discussed in this Appendix. Guidance can be secured from manufacturer's technical representatives or conservation specialists familiar with the use of these products.

When used to anchor newly placed sod, stapling becomes more critical and staple placement on 36-inch centers is often used. Netting with small openings is susceptible to heaving as the turf matures.

PRODUCT INFORMATION SOURCES:

Bemis Company, Inc.
P.O. Box 12224 Soulard Station
St. Louis, Missouri 63157
(Mulch net – Kraft paper)

Conwed Corporation
332 Minnesota Street
St. Paul, Minnesota 55101
(Conwed Erosion Control Netting)

PPG Inductries, Inc.
Fiber Glass Division
One Gateway Center
Pittsburgh, Pennsylvania 15222
(Fiber glass scrim)

PLASTIC FILTER SHEET

Technical Information

PRIMARY USAGE:

Plastic Filter Sheets are used as a replacement for graded filter systems and filter blankets in conjunction with many hydraulic structures.

DESCRIPTION:

Plastic Filter Sheet is a cloth woven of polypropylene monofilament yarns. The cloth is 18 mils thick, weighs 7.35 ounces per square yard, and is not affected by salt water. Porosity is 146 cfm and the cloth is strong and abrasion resistant. It loses no strength when wet and stretches 25 percent before breaking. It is available on rolls of 50 to 200 foot lengths and 6 to 84 foot widths, it can be fabricated with grommeted edges. The material is secured to the soil surface with metal securing pins and staples and with fiber glass rods.

INSTALLATION INSTRUCTIONS:

Each specific site may require some modification or variation of the general criteria listed below. Manufacturer technical representatives or specialists experienced in the use of this product should be consulted for guidance. In general, the material is rolled out onto the prepared surface and secured with specially designed pins, staples, or rods. Where more than one sheet is required, they should be lap jointed to ensure continuous coverage of the area to be protected. When in place, the succeeding layer of materials, i.e., gravel, rock, can be placed on the filter sheet. Heavy and/or sharp material should be placed with care in order that the integrity of the sheet can be maintained.

PRODUCT INFORMATION SOURCE:

Carthage Mills Incorporated
Erosion Control Division
124 West 66th Street
Cleveland, Ohio 44102

STRAW OR HAY

Technical Information

PRIMARY USAGE:

Straw or hay is a mulch product for use on newly seeded areas. In this capacity, it conserves soil moisture during dry periods, dissipates energy from falling raindrops, serves as an insulator against intense solar energy, and reduces erosion caused by overland sheet flow. It is also used as a temporary measure to protect bare soil areas that have not been seeded. The latter practice is applicable only for relatively short periods of time or until the next seeding season has been reached.

DESCRIPTION:

Generally, unweathered, unchopped small grain straw is used. Wheat straw is preferred. Hay can also be used.

INSTALLATION INSTRUCTIONS:

Straw or hay mulch can be applied by hand spreading (shaking) on small plots and by mulch blowing equipment on larger areas. It is applied at rates of one to two tons per acre. Straw and hay mulch should be tacked to insure against excessive losses by wind and water. Liquid and emulsified asphalt is the most commonly used mulch tack. However, other chemicals and mulch netting products are available for use as mulch tacks. Mulch anchoring tools can also be used to anchor straw and hay. This equipment consists of a series of notched discs which punch and anchor the mulch material into the soil. Soil must be moist, free of stones, and loose enough to permit disc penetration to a depth of two to three inches if this mulch anchoring technique is to perform in a satisfactory manner.

WOODCHIPS

Technical Information

PRIMARY USAGE:

Woodchips are used as a temporary or interim erosion control technique to protect bare soil areas that have not been seeded. They are also used as a mulch product on newly seeded areas. In this capacity, they conserve soil moisture during dry periods, dissipate energy from falling raindrops, serve as insulators against intense solar insolation, and reduce erosion caused by overland sheet flow. Woodchips may also be used on pathways and to reinforce leaf mold, duff, etc., in wooded areas that are to be preserved.

DESCRIPTION:

Chips of wood are produced by processing tree trunks, limbs, branches, etc., in woodchipping machines. The chips are placed by blower back on the site from which they originate or are placed in trucks for transport to other sites where they are spread for use.

INSTALLATION INSTRUCTIONS:

As a temporary technique on unseeded areas, the chips are placed by machine or spread by hand tools. Application rates range from 4 to 6 cubic feet of woodchips per 100 square feet of area. This application rate is ample to protect bare soil under normal conditions. If intensive foot or vehicle traffic is anticipated, this rate may be increased to the point where woodchip depths of several inches are attained. This very heavy application rate is particularly applicable to yard areas adjacent to homes under construction if autos and light trucks drive and park in the yard areas.

As a mulching product on newly seeded areas, woodchips may be placed by machine blower or by hand from stockpiles. Application rates of 60-100 cubic yards per acre are commonly recommended. Mulching with woodchips has proven successful and when used with late fall seeding operations that require protection over winter. Experimental work is needed to perfect seed mixtures for this type of operation. However the woodchip mulch has proven to be satisfactory under these conditions.

As more interest in preserving "natural" woodland conditions on construction sites is expressed, the use of woodchips to supplement existing leaf mold, duff, etc., is accelerating. Chips that cannot be utilized in mulching operations can safely be returned to the forest floor to supplement existing organic cover. This technique is beneficial in that it upgrades the woodland surface area and provides a means to recycle rather than dispose of a natural by-product.

WOOD FIBER MULCH

Technical Information

PRIMARY USAGE:

Wood fiber mulch is specifically designed for use as a hydraulically applied mulch that aids in the establishment of turf or other seeded or sprigged ground covers. As a mulching product, it conserves soil moisture, serves as an insulator against intense solar insolation, and dissipates energy from falling raindrops.

DESCRIPTION:

Wood fiber mulch is a natural, short fiber product, produced from clean, whole wood chips. A nontoxic dye is used to color the mulch green in an effort to aid visual metering in its application. It is evenly dispersed and suspended when agitated in water, and when applied uniformly on the surface of the soil, the fibers form an absorbent cover, allowing percolation of water to the underlying soil. Wood fiber mulch has the following physical properties:

Property	Nominal Value
Moisture Content	9.0-12.0% ± 3.0%
Organic Matter (Oven-Dried Basis)	99.2-99.6% ± 0.2%
Ash Content	0.4-0.8% ± 0.2%
Water Holding Capacity (grams of water/100 grams of fiber)	at least 1080-1150 grams

Wood fiber mulch contains no growth or germination inhibiting factors. In hydroseeder slurries, it is compatible withh seed, lime, fertilizer, etc. It is packaged in Kraft paper bags containing 50 pounds each.

INSTALLATION INSTRUCTIONS:

Wood fiber should be applied by hydroseeder at rates of 1000-1500 pounds per acre. It is introduced into the slurry tank after the proportionate quantities of seed, fertilizer, etc., have been introduced. The components are agitated into a well mixed slurry and are sprayed onto the sites or plots to be seeded.

APPENDIX E

ESTIMATION OF LAND DAMAGE FROM GULLY EROSION

APPENDIX – E

This appendix describes (a) procedures for estimating land damage and sediment volume produced by gully erosion and (b) methods currently used by the Soil Conservation Service to stabilize active gullies.

(a) Gully erosion and resulting sedimentation.

1. **Estimating Rates of Gully Advance:** The subject is treated at some length in Technical Release No. 32 (reference E-1). The most useful tool in the release is the equation shown below that predicts future rates of gully growth on the basis of past experience and of measurable parameters above the advancing headcut.

$$Rf = Rp\,(A)^{.46}\,(P)^{.20} \qquad \text{(E-1)}$$

where

Rf = predicted annual rate of gully head advance for a given reach, in feet per year.

Rp = past average annual rate of gully head advance, in feet per year.

A = ratio of the average drainage area of a given upstream reach (Wf) to the average drainage area of the reach through which the gully has moved (Wp).

P = ratio of the expected long term average annual total of 24-hour rainfalls of 0.5 inches or greater (Pf) to the average annual total of 24-hour rainfalls of 0.5 inches or greater for the period (if less than 10 years) in which the gully head has moved (Pp).

The equation has been developed from actual measurement in areas east of the Rocky Mountains, but can be used with confidence along the coast and in the mountainous regions of California. For other areas in the state it would be advisable to seek assistance on gully erosion problems from the state geologist.

Evaluation of Factors

A helpful tool in the evaluation is a map of the entire drainage area upstream from the lower end of the existing gully (figure E-1).

Rp (present rate) is computed from the equation

$$Rp = \frac{\text{Gully length (feet)}}{\text{Age of gully (yrs.)}} = \frac{A-B}{\text{Yrs.}} = \text{ft./yr.}$$

$$A = \frac{Wf}{Wp} = \frac{\text{Drainage Area above B}}{\text{Drainage Ares of Reach A}-\text{B}}$$

The value of $A^{0.46}$ may be read directly from Figure (E-2a).

The value of Pf (future precipitation) can be read directly from the isopluvial map in Figure (E-3).

The value of Pp (present precipitation) may be computed from published data by the U.S. National Weater Service (reference E-2).

P = Pf/Pp and values of $P^{0.20}$ may be read directly from Figure (E-2b).

The values of advance rate computed above may have to be adjusted to reflect effect of differences in material. As a rule if the soils upstream contain a smaller fraction of clay than the material through the advance in the past, the adjustment would involve multiplication by a factor larger than one. The opposite, naturally, is true when the material upstream becomes progressively more cohesive. In either case the assignment of a value to the factor is governed only by judgement.

Another condition influencing rate of gully advance is the relative position of the water table upstream in respect with the floor of the gully. Again there is no way of assigning numerical values to the adjustment factor, but in general an accelerated rate should be anticipated when the water table intercepts the gully profile.

The method is fairly simple, but if there is a need for further clarification, the reader is referred to the illustrative example in reference (E-1).

2. **Estimating Gully Widening:** The results by any method treating this problem can be as accurate at the most as the estimated rate of headcut advance. The best way to proceed after the latter has been determined, is to apply existing criteria related to earth channel stability to compute stable cross-section dimensions and grade consistent with soil properties and anticipated rates of runoff. Such an approach would furnish a complete and reliable solution to the problem in the form of unique relations between rate of headcut advance and rate of gully lateral growth.

   Although accurate the above method is not easy to handle mainly because of the type and quantity of data required. As an alternative the simpler and more practical empirical procedure developed by the Soil Conservation Service is described briefly below.

   The procedure is based on the following two relationships established from comparison of the top widths and depths of a large number of gullies.

   1. On the average, where the gully advances through cohesive materials the gully width is about three times the depth.

2. In non-cohesive materials the gully width is about 1.75 the depth.

The two relationships are represented by the graphs in figures E-5 and E-6 respectively.

It is obvious from the preestablished rigid relationship between depth and width of a gully that in many instances the procedure will not be applicable. A possible way to avoid obtaining unrealistic estimates is to test the relationship using present or past data of the problem gully. Only if the relationship passes this test use of the procedure is justified.

3. Estimating Damage from Gullying

The damage from gully development can be direct or indirect.

a. Direct damage can be expressed physically in terms of the area voided by the gully system. Projecting into the future the expansion of the system by means of the method described previously provides the basis for an economic evaluation of the anticipated land damage and hence of its rate of depreciation. Establishing this rate is the joint responsibility of the geologist and the economist.

b. Indirect damages that can be attributed to gully erosion are depressed yields in cropland or forced replacement of grass cover in pasture land caused by lowering of the ground water table. Gullies also may create problems of free movement for machinery and impede access to severed parcels of land. Finally if left uncontrolled their advance may endanger the safety of culverts, bridges and other facilities located along its path.

4. Sedimentation Problems Related to Gullying

The procedure described above is not recommended for use when the intent is to use the results for treating only the sedimentation aspect of the problem. In most instances the contribution of gullies in the overall sediment volume is negligible and can be easily ignored. When, however, circumstances warrant the application of the procedure to estimate sediment yield and consequently damages from sediment downstream, the point to remember is that computed quantities have to be adjusted by multiplication with the delivery ratio defined in page 23 of the text.

(b) Gully Treatment (Reference E-3)

1. Planning

Gully control can best be attained through a plan that takes into account the treatment of the watershed draining into the gully, as well as treatment of the gully itself. A conservation plan for, or the conservation treatment of, any piece of land should consider all needed and feasible gully stabilization work. The plan may include such practices as critical area plantings, grassed waterways or outlets, grade stabilization structures, diversions, and debris basins. These may be used singularly or in combination with other practices to accomplish the following:

1. Interception of runoff water above the gullied area with a diversion or terraces.

2. Retention of runoff water on the drainage area by tillage practices, vegetation and structures.

3. Elimination of the gully by filling and shaping the drainage way with earth-moving equipment for critical area planting or grassed waterway development.

4. Revegetation, either by natural processes or by critical area planting and grassed waterway development.

5. Construction of grade stabilization structures to control the grade of the gully and detain or impound water.

6. Complete exclusion of livestock.

7. Control of sediment from active gullies with debris basins.

8. Drainage of seep areas where gully banks are unstable.

2. Gully Treatment by Vegetative Means

The objective of most gully control work is to stabilize the gully surfaces by vegetative means. All other measures should lead to that objective, except in areas where rainfall is too low to support a good grass cover.

Any gully, regardless of its size or condition, usually will regain a cover of natural vegetation if it is properly protected and is in an area where vegetation will grow readily. Diversion or retention of the water which causes the gully, protection from grazing or trampling by livestock, protection from fire, and the removal of other causes of disturbance usually result in growth of natural vegetation which will, in time, cover the gully and heal the erosion scars.

Nearly all structural measures used, particularly in grassland areas, depend upon vegetation to support them and to stabilize the soil exposed to excessive runoff. Of first importance in revegetation is the exclusion of livestock or mechanical disturbance from gullied area.

Most gullied areas or gully banks are not in good condition for vegetative growth since the fertile topsoil has been washed away, slopes are steep, and the battering of raindrops on the unprotected soil has produced conditions adverse to plant survival. Bank sloping may be necessary before vegetation can be expected to do an adequate job of gully stabilization.

Adapted grasses, trees, shrubs, or vines provide good protection to gullied areas planned for critical area planting. The possible uses of the area after stabilization will determine the type of vegetation to be established.

A stabilized gully may be used as a grassed waterway for terrace outlets, a wildlife habitat, a woodland area or pasture. It should not be cultivated, burned, or used in a way that will weaken or destroy the reestablished vegetation. The best possible use should be selected after considering the size of the gully, its location with respect to other land uses on the farm, the control measures needed, and the type of maintenance required.

If it is to be used for a grassed waterway, the gully should be shaped to proper size and proportion. Erosion-resistant grasses should be well established before any terraces are constructed to empty into the channel. Trees, vines and shrubs ordinarily are not used in waterways unless the amounts of water flowing through the channel are relatively small and of infrequent occurrence.

Critical area planting of a gullied area in pastureland will be affected by the intensity of grazing on the area. Limited grazing of a grass vegetation during the establishment stage is often beneficial in controlling competitive weeds and shrubs. Overgrazing will seriously hinder establishment. Gullied areas in pastures might be better protected permanently from all grazing and retained for wildlife use after planting with grasses, shrubs, vines or trees suitable for wild life habitat. In wooded or gullied area adjacent to woods, it is desirable to plant trees of an adapted species and use the area as protected woodland.

In gullied areas where erosion is less critical, the slowest but cheapest method of gully control is protection from disturbance. Good results may be obtained and heavy expense avoided by the simple process of fencing the area to exclude grazing or cultivation.

3. **Gully Treatment by Filling and Shaping**

Elimination of the gully or critically gullied area by filling and shaping may be the most practical or feasible means of treatment in preparation for critical area planting or grassed waterway development. When this method of treatment is used, the gully or gullied area is shaped and smoothed so that the area can be established to vegetation and maintained with regular farm equipment.

During the filling process, the soil worked into the gully should be compacted since uncompacted material offers little resistance to erosion. It is best to fill field gullies during the time of the year that a close-growing crop may be seeded immediately on the distrubed area to protect it from washing. Piecemeal filling or shaping should be discouraged since the partial blocking of the waterway often causes overfalls and increased gully erosion, and more land and soil may be lost than if the gully were untreated.

4. Gully Treatment by Water Diversion or Retention

Reduction of the runoff which flows through a gully is one of the most effective control measures. This may be accomplished by diverting all or most of the runoff to a protected outlet or by holding excess rainfall on the land in the drainage area. Where these methods are feasible, they should be installed before other needed control measures are attempted within the gully.

Water Diversion

Care should be given to the disposal of the diverted water. Where it is not possible to empty a diversion onto a smooth, well-vegetated area or into a protected outlet, the water should not be diverted; otherwise, the diverted runoff may cause gullying in the disposal area. It may be possible to divert water from a number of gully heads to a common location and install a single, more economical stabilizing structure.

Diversions usually are constructed from the upper side in order to provide a wide channel section and easier construction. Diversions constructed adjacent of a gully or at the head of a gully overfall should be located away from the edge of the gully a distance equal to at least three times the depth of the gully. This will provide space for the gully banks to slough and stabilize, or to be shaped, without endangering the diversion.

Where a small gully has started on an area of thin vegetation in pastureland, it is often possible to stop head cutting by constructing a eyebrow-shaped ridge above the gully head with the ends of the ridge leading slightly downslope onto good grass cover. This is a temporary measure and requires considerable skill and care in the selection of outlet areas. Prompt application of revegetative measures in the gully should follow this practice.

Water Retention

Proper land use and conservation cropping and tillage practices are the first steps in holding water on the drainage area of a gully. These can be supplemented, as necessary and feasible, by other water-holding measures to further reduce the runoff into the gully. Some of these measures are discussed in the following paragraphs.

Level impounding terraces provide storage and can be farmed where cropland is involved in the drainage area of the gully. The ends may be left partially open, if necessary to drain part of the water from the terrace channel to prevent drowning out of crops or pasture vegetation. If level terraces are to retain all of the runoff, they should be constructed only on permeable soils and mild slopes.

Runoff water often can be prevented from entering or flowing through relatively large gullies by the use of carefully located earthen dams.

Selection of the damsite and elevation of the spillway are very important. The dam should be located near enough below the gully head that the channel gradient will be lowered to a slope that will stop the headward extension of the gully. The site should provide enough natural storage so that the emergency spillway will not flow often. Generally, a principal spillway or trickly tube is needed to reduce frequency and duration of emergency spillway flow.

In many areas where gullies are formed by runoff from small drainage areas, small earth dams are used to stop headward cutting and to furnish temporary stock water after periods of rainfall. Such structures, however, give better protection if equipped with a drop inlet that will slowly release the impounded runoff water and provide storage space for runoff from succeeding rains. Since there will be only occasional spillway discharge, vegetative practices and natural reproduction of native vegetation below the fill will have an opportunity to control the gully at little cost.

The two types of earth dam structures described above usually are designed as grade stabilization structures which are discussed below.

5. **Gully Treatment by Grade Stabilization Structures**

It is not always possible to keep runoff water out of gullies by retaining or diverting it, and the runoff must flow through the gully channel. To do this safely may require that both vegetation and structures be planned and established in the gully at critical points.

Planning gully treatment under these conditions may require that the gradient of the channel be reduced so that water will travel at a non-erosive velocity. Some type of structure may be required at overfalls abrupt changes in gradient, entrances of branch gullies or at other critical points to supplement vegetation in stabilizing the channel gradient.

Structural Measures

Structural measures should be used for gully control only when other measures are not applicable or adequate. The following types of structural measures are used in gully control work.

1. Straight drop spillway

   This type of structure is generally used in the lower reaches of water disposal systems, such as terraces, diversions, outlets, and waterways; for large overfalls adjacent to streams; or for drainage.

2. Box inlet drop spillway

   This type of structure has the same general usage as the straight drop spillway but is better adapted to larger flows and sites where the channel width is limited.

3. Hood inlet spillway

   This structure uses a straight-pipe spillway, usually on a steep slope, in an earth embankment to control head cutting or to safely drop water to a lower level.

4. Drop inlet spillway

   This type of structure has the same general usage as the hood inlet and has the added advantages of permitting drainage of the pond or fluctuating the water level for management purposes.

5. Chute spillways

   This structure is sometimes used where the head or drop to be controlled and spillway capacities are relatively small. Formless chutes are limited to areas where temperature variations are moderate and conditions are favorable for building the shape of the structure in the soil.

Earthfill Structures with Vegetated Spillway Only

These may be used as grade stabilization structures and to impound sediment or water for gully treatment. They may also provide temporary livestock water or be used as debris basins. This type has limited use since a vegetated spillway stable enough to withstand frequent flows through it can seldom be found in the right location in gullied areas. Vegetated spillways occasionally can be developed prior to construction of the earthfill. Requirements for design and installation are the same as those for ponds and reservoirs.

Sediment Control With Debris Basins

Debris basins are used where physical conditions or landownership prevent the treatment of the sediment source by the installation of gully control measures.

This type of structure is a dam, usually equipped with a pipe principal spillway, constructed across a waterway or at some other suitable location to form a sediment storage basin. A debris basin is used to preserve the capacity of reservoirs, ditches, canals, diversions, waterways or streams and to prevent undesirable deposition on bottom lands. This is done by storing a high percentage of the sediment and other debris moving from the drainage area.

The capacity of a debris basin is governed by the volume of sediment expected to be trapped at the site during the planned useful life of the sturcture or the improvements it is designed to protect. Where it is assured that periodic removal of debris will take place, the design capacity may be reduced accordingly.

A procedure leading to the establishment of a relationship between Storage Capacity of a Debris Basin and Trapping Efficiency is described in Appendix F.

References

E-1 Procedure for Determining Rates of Land Damage, Land Depreciation and Volume of Sediment Produced by Gully Erosion. USDA-SCS-Technical Release No. 32.

E-2 Climatologic Data-California-Daily Precipitation Data. USDC-NOAA-Environmental Data Service.

E-3 Gully Treatment-USDA-SCS-Engineering Field Manual Chapter 10.

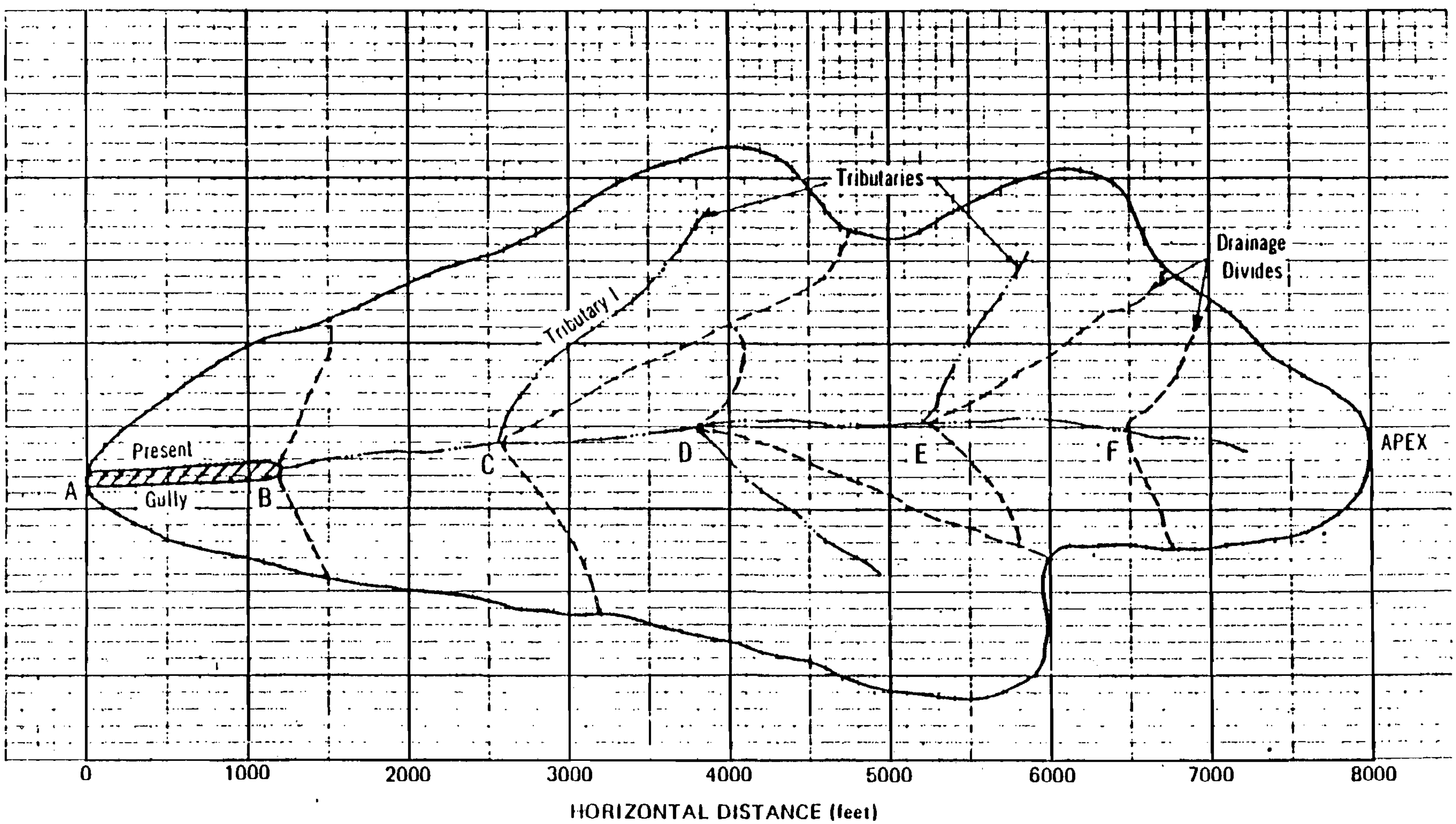


Figure E–1: Drainage Area of the Gully Showing the Reaches Selected, Horizontal Distance, Tributaries and Subwatersheds.

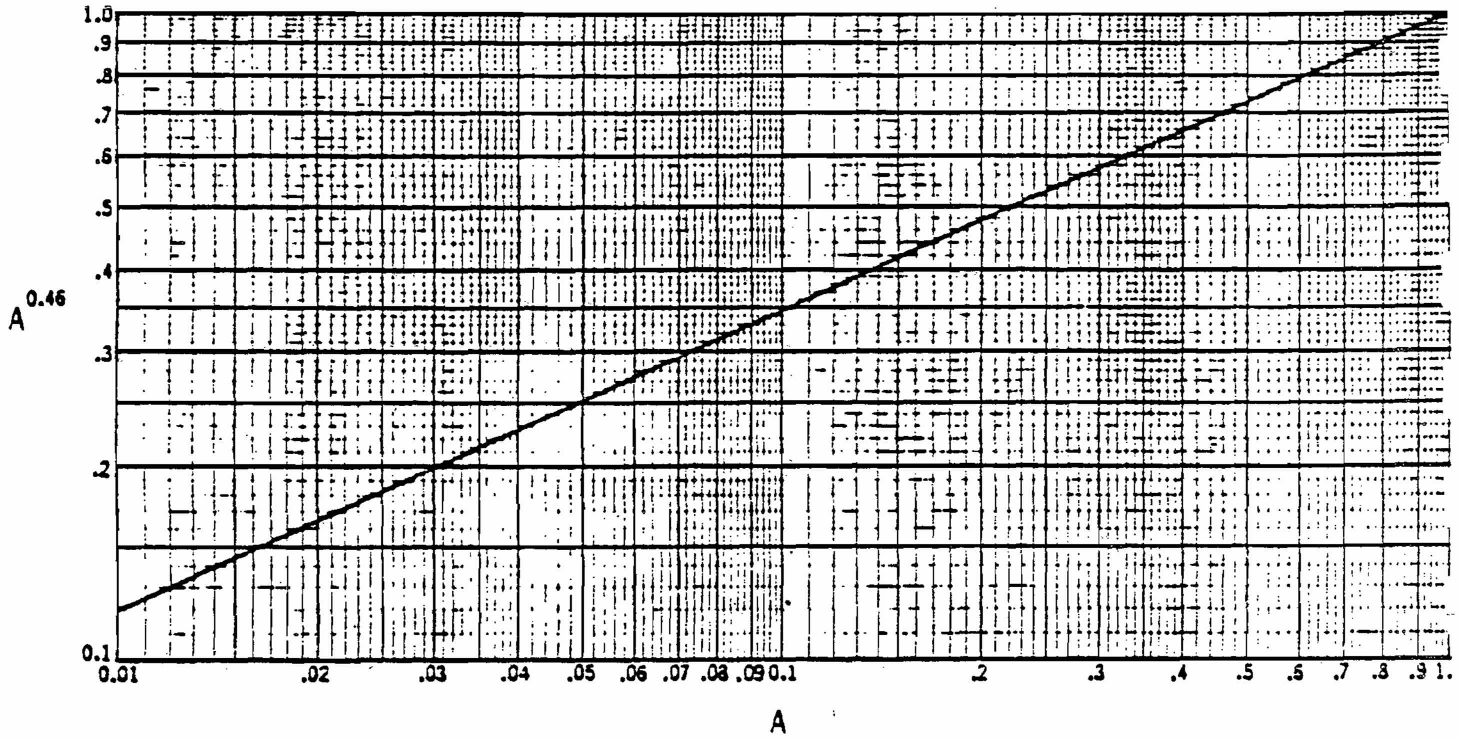


Figure E–2 a. Graph for Obtaining the 0.46 Power of Ratio A

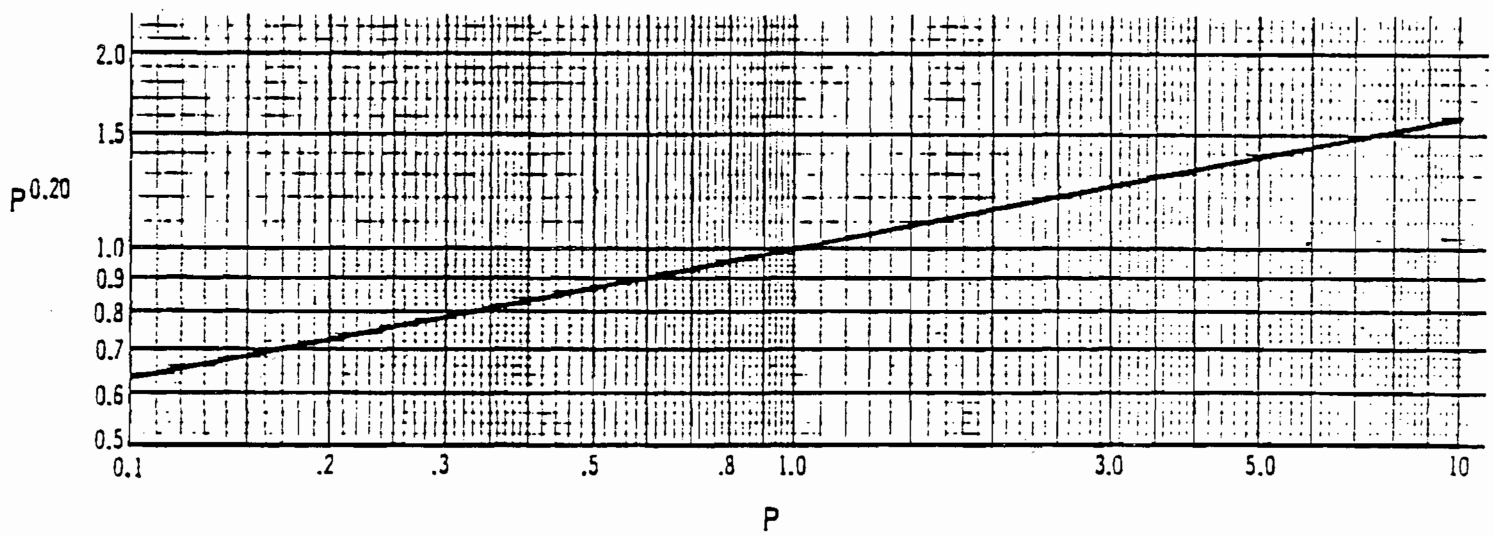
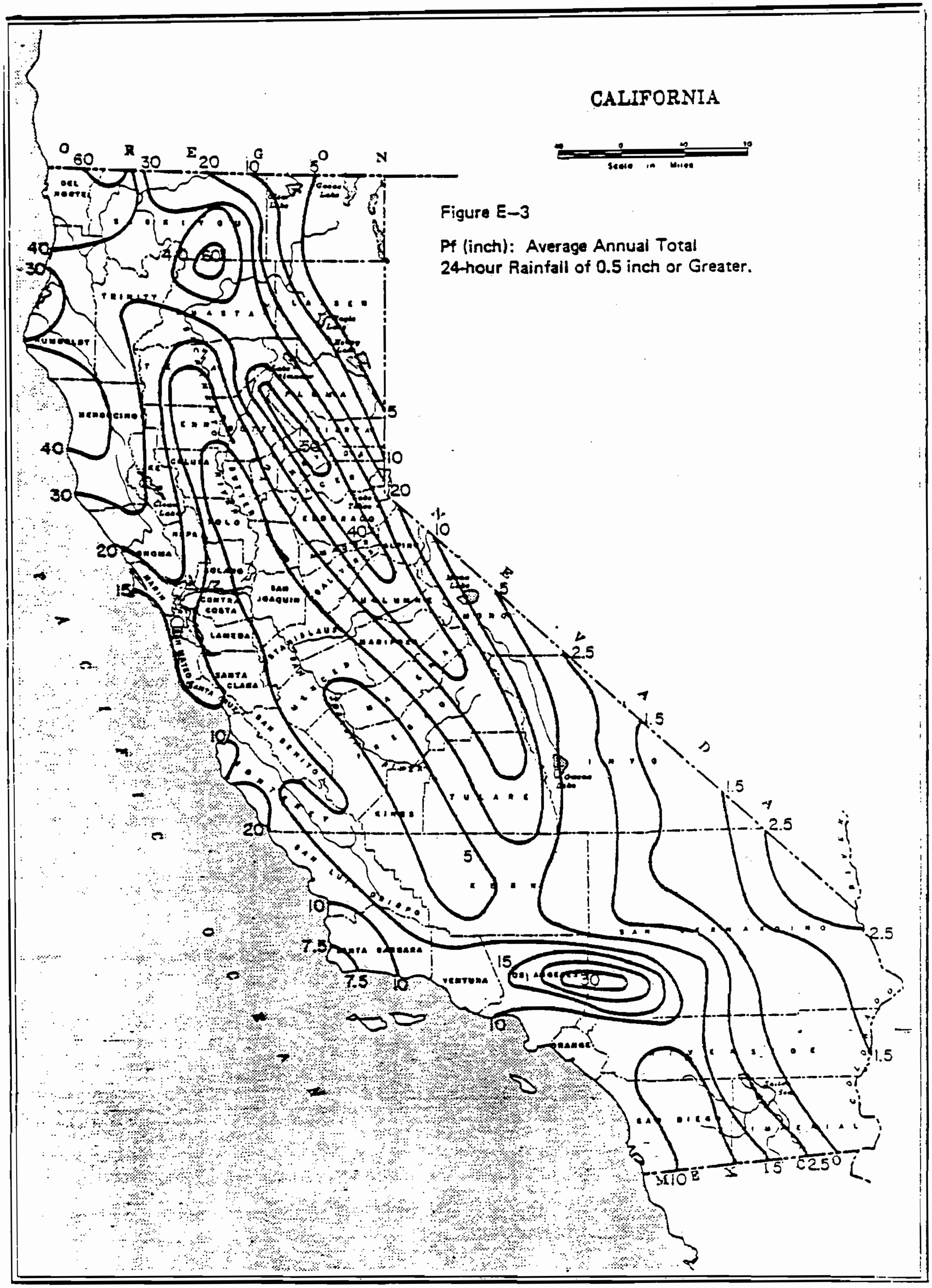


Figure E–2 b. Graph for Obtaining the 0.20 Power of Ratio P


CALIFORNIA
Scale in Miles
O R E G O N
Figure E–3
Pf (inch): Average Annual Total
24-hour Rainfall of 0.5 inch or Greater.
60
30
20
10
5
40
15
7.5
2.5
1.5
TRINITY
HUMBOLDT
MENDOCINO
SONOMA
MARIN
CONTRA COSTA
SAN JOAQUIN
SANTA CLARA
SAN BENITO
TULARE
KINGS
KERN
SANTA BARBARA
VENTURA
ORANGE

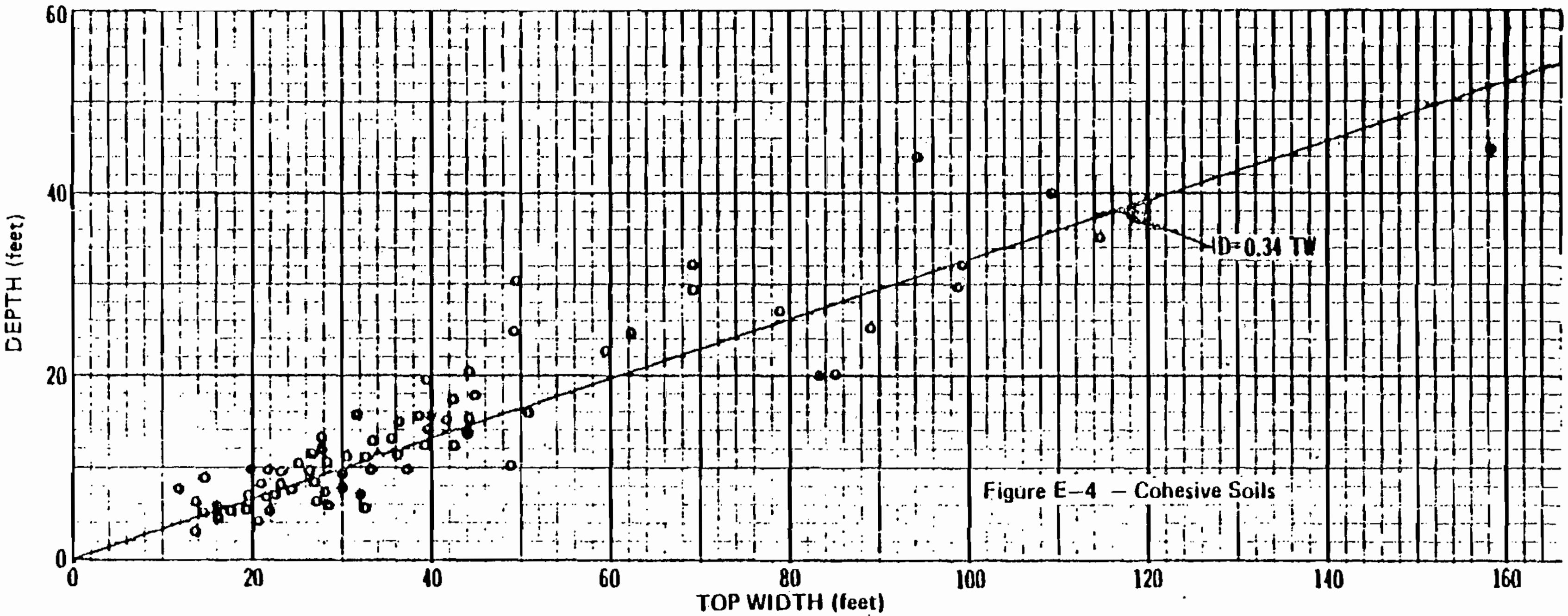


Figure E-4 — Cohesive Soils

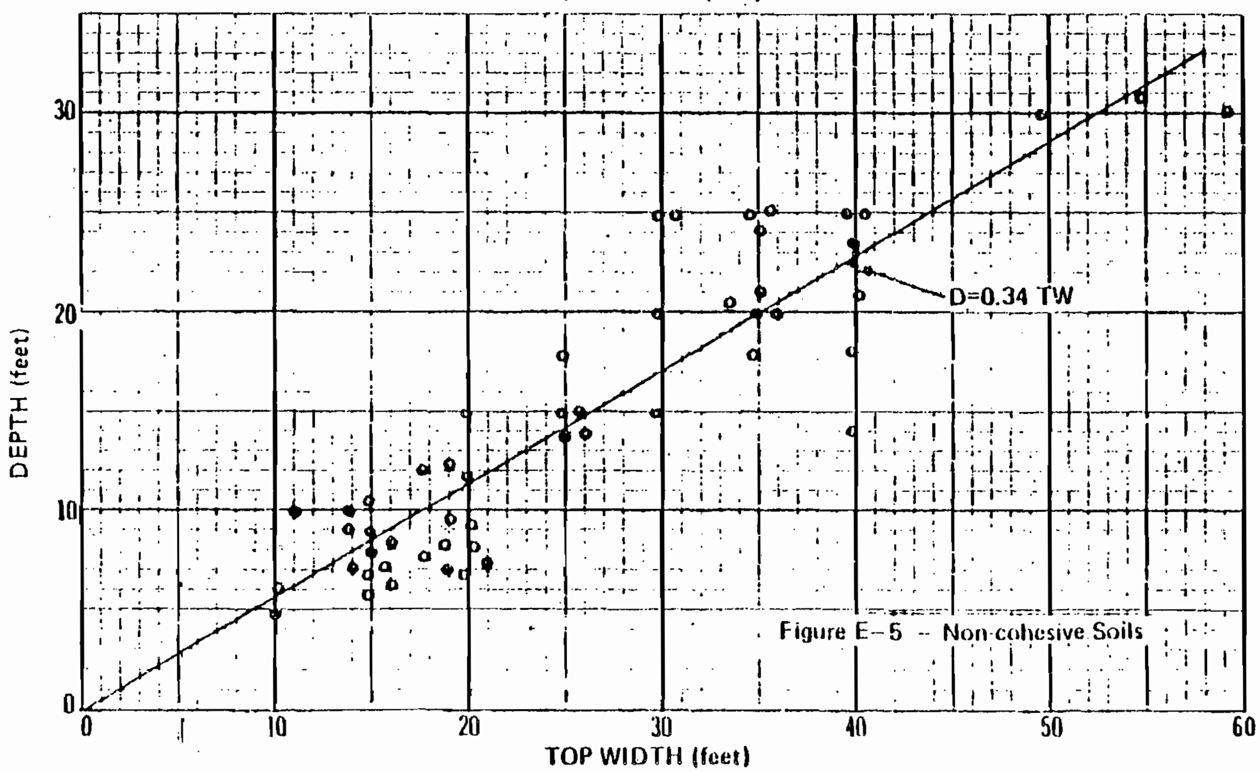


Figure E-5 — Non-cohesive Soils

APPENDIX F

DEBRIS BASINS

APPENDIX – F

DEBRIS BASIN DESIGN (reference F-1)

Objective: Develop Storage Capacity—Trap Efficiency Relationship of a Debris Basin. Storage Capacity is measured to the crest of emergency spillway level. Trap Efficiency is the percent of the total incoming sediment trapped by the basin.

PROCEDURE

1. Assume a value for the storage capacity of the basin in cu. ft. or in Acre-ft.

2. Convert this value into depth in inches over the watershed area serviced by the basin.

3. Obtain the average annual runoff for the site, in inches, from the map in figure F-1.

4. Divide the value in step 2 by that in step 3 and enter the graph in figure F-2 with the ratio to obtain the corresponding value of Trap Efficiency.

   Note: The upper curve in figure F-2 is used where incoming sediment is coarse-grained or highly flocculated. The median curve is used when the sediment is well graded.

   The lower curve is used when the sediment contains high percentages of colloids, dispersed clays and fine silts.

5. Reduce value in step 4 by 10% if the incoming sediment is predominantly sand, and by 20% if it is chiefly fine textured.

Through the procedure a realtionship between storage capacity and trap efficiency is established.

The curve describing this relationship may be used to determine the optimum size of the basin. The determination would be based on the following considerations:

1. Installation cost of structure

2. Maintenance cost

3. Economic and environmental damage caused by untrapped sediment.

References:

F-1 USDA-SCS-"Procedure-Sediment Storage Requirements for Reservoirs." Technical Release No. 12 (Rev.).

F-2 USDI-GS-"Annual Runoff in the Conterminous United States". Atlas HA-212 (1966)

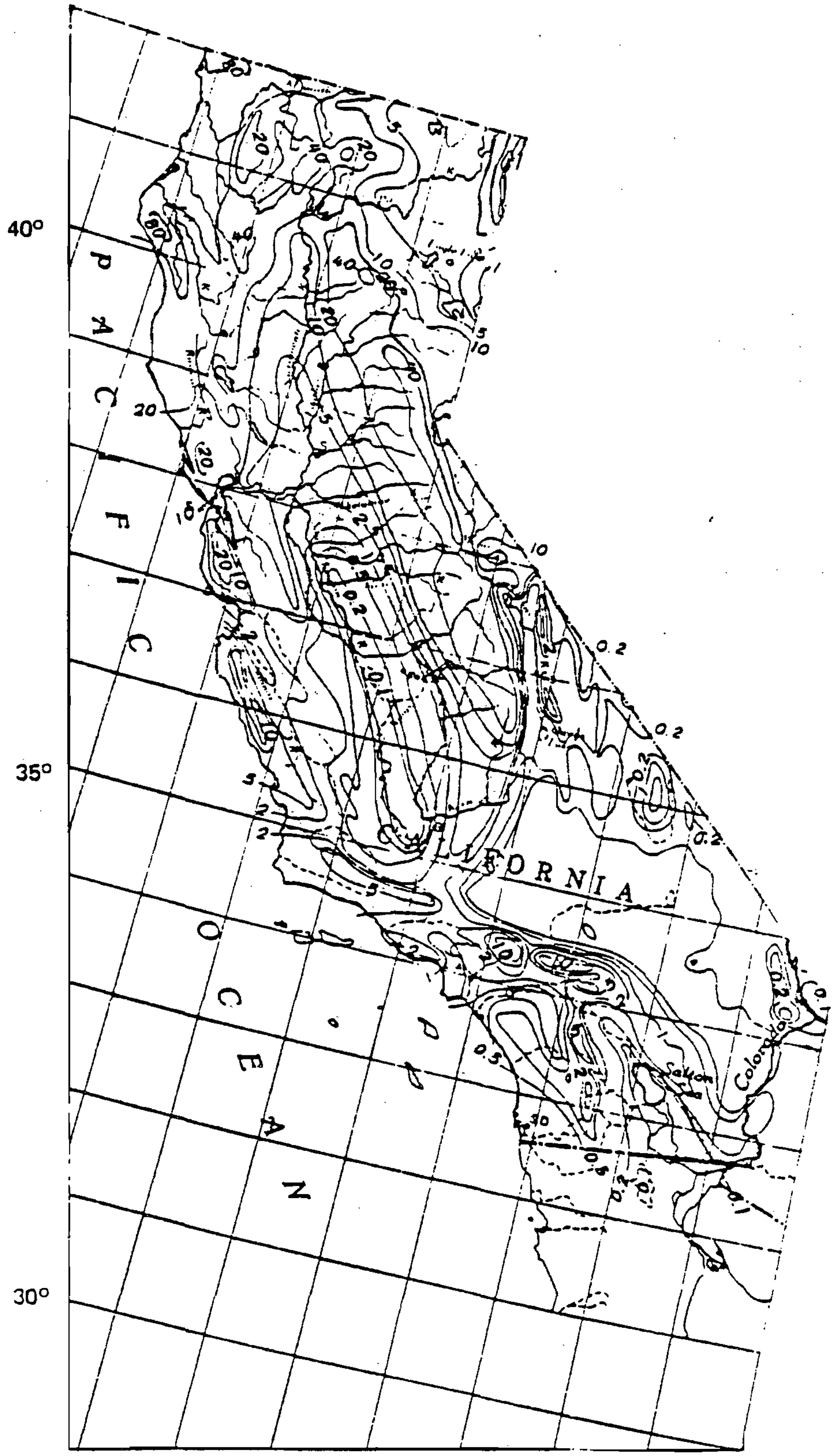


Figure F-1: Average Annual Runoff in Inches — California (Reference F-2)

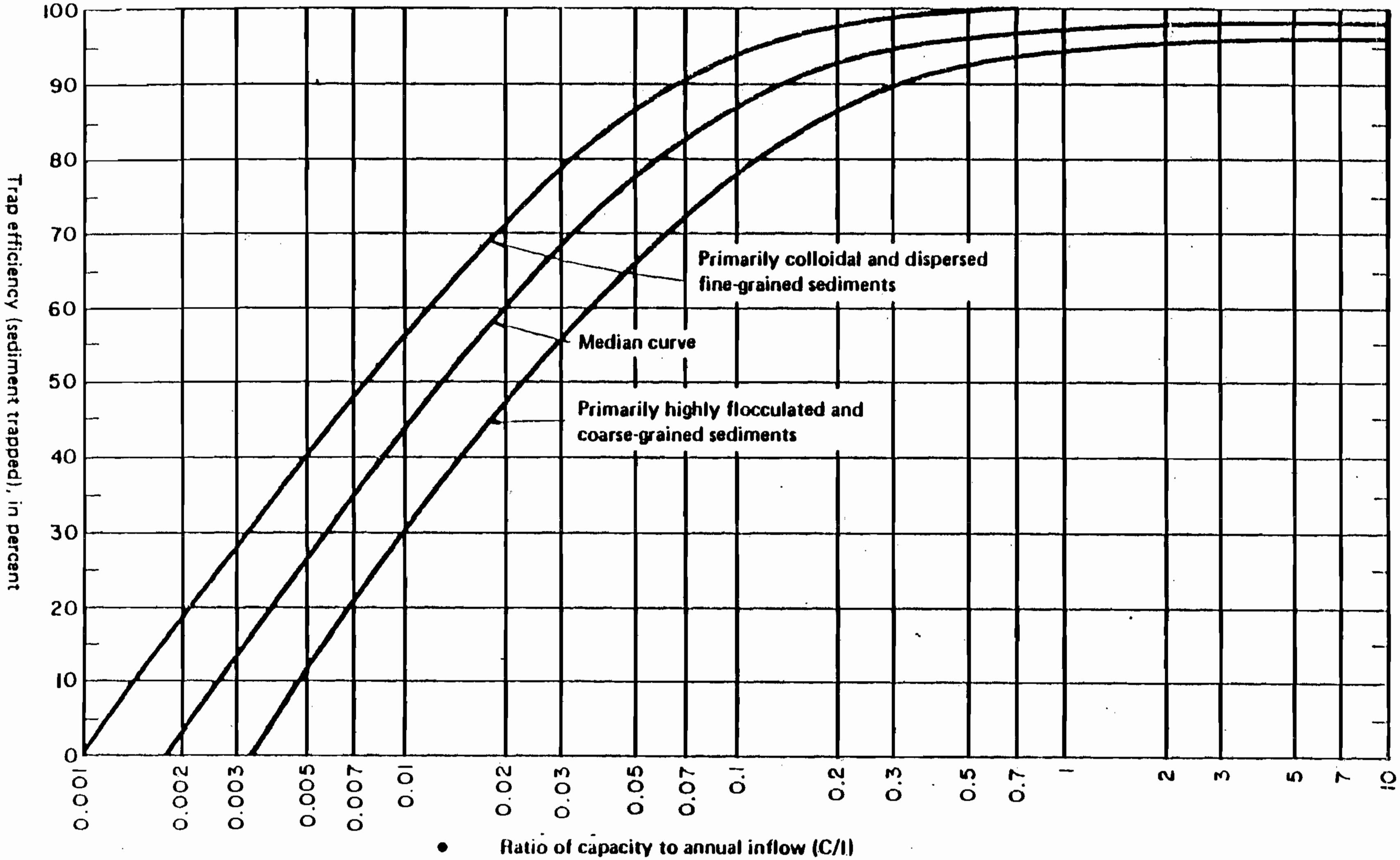


Figure F—2: Trap efficiency of reservoirs

APPENDIX G

EPHEMERAL GULLY EROSION

APPENDIX - G

EPHEMERAL GULLY EROSION

DEFINITION

Ephemeral gully erosion is erosion that occurs on arable lands where overland flow waters come together and form concentrated flows. Since the erosion mechanics of channel flows are different from sheet and rill, the Universal Soil Loss Equation, USLE, does not predict this erosion. These ephemeral channels are removed by tillage operations so they only last for one year or until the next tillage. This erosion has long been recognized but until recently no efforts have been made to quantify or predict amounts.

OTHER STUDIES

The erosion mechanics of concentrated flows on cultivated ground are very complex. This makes quantification and prediction very difficult. Ephemeral gully development depends upon rain storm events, their sequence, magnitude, and duration, as well as soils characteristics, soil moisture content, tillage, cover and cropping. The drainage area size and shape affects runoff volumes and consequently channel erosion.

Several states have conducted studies and attempted to develop some simple field technique to predict this erosion. Most of these techniques have been developed from limited studies and have very limited technical support.

SCS has contracted with the USDA - Agricultural Research Service (ARS) for the development of a technique to quantify and predict ephemeral gully erosion. Research has been started but it will be several years before any information will be available to the field. At this time, one report has been published but it does not provide adequate guidance for the prediction of ephemeral erosion 1/. ARS, at this time, has nothing to offer that can be applied in the field without intensive study.

CALIFORNIA COMMITTEE

The Ephemeral Erosion Control Committee was formed to review available information and generate some guidelines for field use to predict ephemeral gully erosion to some degree. The present technique of actual void measurements is time consuming and lacks the ability to make credible future erosion values.

At this time, the best estimates will have to be based on your professional judgement and experience. You will need to look at the site, make some measurements or observations by field reconnaissance and/or aerial photography, and past erosion history.

The following procedure was presented at the SCS Area Specialists Workshop held in Sacramento on December 4-7, 1984, and adopted for interim use in California until an improved method or a national procedure is available.

1/ Prediction of Soil Loss due to Ephemeral Gullies in Arable Fields, Colin R. Thorne, Dept. of Civil Engineering, Colorado University, Fort Collins, Colorado, 80523, May 1984.

PREDICTING EPHEMERAL GULLY EROSION IN CALIFORNIA

To establish some uniformity within the state, the guidelines for applying professional judgement are to be used. These guidelines allow freedom to use the best available information and still provide a uniform approach in all areas. These guidelines are:

1. Ephemeral gully erosion will be considered only on tilled Conservation Treatment Units (CTU's) where this type of erosion is occurring or is expected to occur.

2. Through field reconnaissance, aerial photographic interpretations, grower input, and personnel judgement, estimate the percentage of the field that is affected by ephemeral gully erosion. A reasonable range would be from 1 to 5 percent. If unable to determine the area affected, use one (1) percent. The affected area would be the channel void area measured or anticipated to occur over some crop cycle period. Caution is advised on using single year or single storm event erosion as being representative.

3. Estimate the channel soil loss rate. This is determined by the depth of the channel void. Average channel depth can be determined from measurements, observations, grower input, or judgement. The tonnage will be based on soil weight of 90 pounds per cubic foot. The following guide can be used. (See examples.)

    a. Where the average channel depth is 6 inches the erosion rate will be 1000 tons per acre.

    b. Where the average channel depth is 9 inches the erosion rate will be 1500 tons per acre.

    c. Where the average channel depth is 12 inches, the erosion rate will be 2000 tons per acre.

    d. In the absence of visual observations, grower input, or past history, use 1000 tons/acre or an amount adjusted to the average tillage implement depth.

ESTIMATING IMPACTS OF PRACTICES

It is necessary to estimate the "after treatment" erosion rates, which should be reduced between 50 to 90 percent of the before treatment.

<u>Reduced tillage</u> should be near the 50 percent reduction range.

<u>No-till</u> should be near the 90 percent reduction range.

Documentation should be on the presently used CRES SOIL EROSION COMPUTATIONS WORKSHEET. See Exhibit G-1.

COMPUTATION EXAMPLES

CTU Field = 100 Acres
Predicted ephemeral gully lengths and widths
(Summation of all identified on the CTU)

30,000 feet of ephemeral gullies
1.5 feet width
$30,000 \times 1.5 = 45,000 \text{ feet}^2$

$\frac{45000 \text{ ft}^2}{43560 \text{ ft}^2/\text{Ac}} = 1.03$ AC total area

$\frac{1.03 \text{ Ac}}{100 \text{ Ac}} = 1\%$

Estimated average depth of ephemeral gully = 6" or 0.5 feet

$45000 \text{ ft}^2 \times 0.5 \text{ ft} = 22,500$ cubic feet of soil loss

$22500 \text{ ft}^3 \times 90 \text{ lbs/ft}^3 = \frac{2025000}{2000} = 1012$ tons

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Serving on the Ephemeral Erosion Control Committee were Assistant State Conservation Engineer Harold Honeyfield - Chairman; State Agronomist Walt Bunter; State Geologist Jerry Curry; District Conservationist Boyd Desonia; Area Agronomist Nick Pappas; Soil Mechanics Engineer Tom Smith; and Assistant State Soil Scientist Alan Terrell.

(Reserved)

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

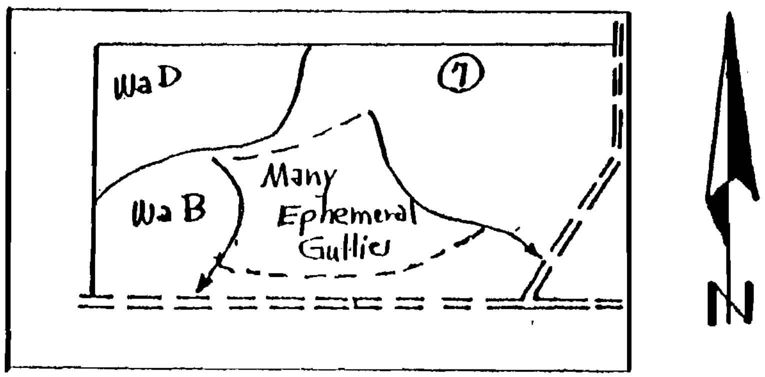
CRES SOIL EROSION COMPUTATIONS

NAME ABC Farms CASE FILE NO. U-300 BY W. Bunte
ASCS FARM NO. B 331 COUNTY Solano DATE 11-28-84

SHEET AND RILL EROSION

FIELD NO/NAME SOILS	FIELD AREA (ACRES)	"T" VALUE	T/K VALUE	SLOPE LENGTH (FT)	PERCENT SLOPE (%)	USLE FACTORS 1/ "LS"	"K"	"R"	"C"	"P"	"A" (TONS/AC/YR)	TOTAL SOIL LOSS (TONS/YR)
(7) BEFORE CONDITION/CROPPING SYSTEM: Continous Barley - Conventional Till												
WaB	80	4		250	6	1.06	.37	45	.35	1	~~6.2~~ 6	~~480~~
WaD	20	3		200	10	1.92	.37	45	.35	1	~~11.2~~ 11	220
TOTALS:	100											700
										Average Weighted "A" =	7	
AFTER CONDITION/CROPPING SYSTEM: Continous Barley - No Till w/ 2,000 lbs residue after planting												
WaB	80								.09		~~1.6~~ 2	160
WaD	20								.09		~~2.9~~ 3	60
												220
										Average Weighted "A" =	~~2.2~~ 2	

LOCATION MAP



1/ "C" FACTOR DETERMINATION:
TABLE NO. 2 ; COLUMN NO. 1 : LINE NO. 11
June 27, 83 Memo 1 8

WIND EROSION

If problem, obtain data from Wind Erosion Worksheet.

OTHER EROSION

PROB. TYPE		BEFORE QUANTITY	BEFORE TOTAL EROSION (Tons/Yr.)	AFTER QUANTITY	AFTER TOTAL EROSION (Tons/Yr.)
1	Streambank Erosion	L.F.		L.F.	
1	Shoreline Erosion	L.F.		L.F.	
2	Gully Erosion	Acres		Acres	
2	Concentrated Flow Erosion	1 Acres	1,000	1 Acres	150
3	Irrigation Erosion	Acres		Acres	
4	Other Erosion	Acres		Acres	

Before:

Ephemeral Gullies not visible today but grower says they happen almost every year

Portion of Field Affected = Use 1%

Area Affected = 0.01 × 100 Ac = 1 acre

Age of Gullies = 1 yr (reworked each summer)

Ave. Channel Depth = 6" based on grower input

∴ Use 1,000 Tons/acre rate

THEN: 1,000 Tons/acre × 1 acre ÷ 1 yr = 1,000 Tons/yr

After:

No-Till w/2,000 lbs. residue after planting will give 85% reduction

Then: 0.15 × 1,000 Tons/yr = 150 Tons/yr

U.S. DEPARTMENT OF AGRICULTURE

REFERENCE SLIP

DATE 3 Sept 2009

TO RITA BICKEL
STATE CONSERVATION
AGRONIST, DAVIS

- [ ] ACTION
- [ ] APPROVAL
- [x] AS REQUESTED
- [ ] FOR COMMENT
- [ ] FOR INFORMATION
- [ ] INITIALS
- [ ] NOTE AND FILE
- [ ] NOTE AND RETURN
- [ ] PER PHONE CALL
- [ ] RECOMMENDATION
- [ ] REPLY FOR SIGNATURE OF
- [ ] RETURNED
- [ ] SEE ME
- [ ] YOUR SIGNATURE

REMARKS Here is enough C factor information for the lady who needed it to evaluate a project in the Sacramento Valley

Attachments

FROM Walt Bunter

Subject: [Fwd: RUSLE Implementation]
Date: Wed, 28 Jul 1999 10:24:26 -0700
From: Walt Bunter <Walt.Bunter@ca.usda.gov>
To: Dave.Schertz@usda.gov
CC: Diane.Holcomb@ca.usda.gov

--
WALT BUNTER
STATE AGRONOMIST
DAVIS, CALIFORNIA
(530)792-5652

Subject: RUSLE Implementation
Date: Wed, 28 Jul 1999 10:15:44 -0700
From: Walt Bunter <Walt.Bunter@ca.usda.gov>
To: Dave.Schertz@usda.gov
CC: Diane.Holcomb@ca.usda.gov

Subject: ECS - RUSLE Implementation   Date: July 28, 1999
To: David L. Schertz,   File code: 190-11
National Agronomist, NRCS, NHQ

1. FOCS RUSLE has been implemented all field offices. The Capitola FO is experiencing a problem in accessing its climate files. We are not able to reload the three climate files since PASIS 3.1.5 and 3.1.5a Patches were installed. Our FOCS Coordinator is attempting to reach Phil Teague for a fix.

2. RUSLE was implemented by loading FOCS RUSLE into all of the FOCSs, obtaining the climate data files for all of the Representative Climate Stations from the Water and Climate Center and loading them into all the FOCSs, developing and publishing the "California Water Erosion Prediction Guide" and issuing it via a California Technical Guide Notice, and training field staffs at two day workshops held at Redding, Ukiah, Susanville, Willows1, Willows2, Placerville, Modesto, Hollister, Hanford1, Hanford2, Santa Maria, Indio, and Riverside from August to November 1998.

3. RUSLE implementation meets policy as specified in the NFSAM except for use of new RUSLE C Factors.

4. RUSLE C Factors have not been issued yet. USLE C Factors are being used until replaced with RUSLE C FActors.

5. There are only three or four FOs that have limited capability to effectively use RUSLE and still rely on Area Office assistance primarily because they were too busy to attend their scheduled RUSLE training.

6. If and when the DOS based RUSLE Ver. 1.05q is released for state use and if the State Conservationist approves it use in California, 6 to 7 workshops will be needed to respond to those FOs that want to use it.

RUSLE training at 13 to 14 cluster based workshops will be needed when the Windows based RUSLE Ver. 2.0 is released.

--
WALT BUNTER WB
STATE AGRONOMIST
DAVIS, CALIFORNIA

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
430 G Street # 4164
Davis CA 95616
(530) 792-5628
(530) 792-5793 (Fax)

6 July 2006

Mr. Arthur Dawson, Historical Ecology Project Manager
Sonoma Ecology Center
PO Box 1486
Eldridge CA 95432-1486

Good Afternoon, Mr. Dawson:

This is in response to your recent phone message to State Conservation Agronomist Rita Bickel and my follow-up phone conversation with you on June 29. You requested RUSLE2 C factors for four vegetative conditions for use in the GIS modeling of the Sediment Source Analysis and Sediment Budget for the Sonoma Creek Watershed which will include estimates back to 1800.

The best I can do at this time is give you USLE C factors which I believe would approximate RUSLE2 values for the four vegetative conditions. The following values are based on Tables 4 and 5 from our old USLE handbook.

<u>Closed Oak Woodland</u>
Use C = 0.003 for areas with 50 to 70 % canopy cover and 95-100 % ground cover
Use C = 0.013 for areas with 50 to 70 % canopy cover and 80 % ground cover

<u>Chaparral</u>
Use C = 0.012 for areas with 50% canopy cover and 80% ground cover
Use C = 0.038 for areas with 50% canopy cover and 60% ground cover

<u>Grassland</u>
Use C = 0.042 for areas with 60% ground cover representing the 1800 period
Use C = 0.003 for areas with 95% to 100% ground cover (1900 to date)
Use C = 0.013 for areas with 80% ground cover (1900 to date)

<u>Pastureland</u>
Use C = 0.003 for areas with 95% to 100% ground cover
Use C = 0.013 for areas with 80% ground cover

Here are two local contacts who would be interested in your work:
Richard King, Ecologist, NRCS, Petaluma, phone 707-794-8692 Ext 120
Charlette Epifanio, District Conservationist, NRCS, Petaluma, phone 707-794-1242 Ext 105

Walt Bunter
Walt Bunter
NRCS Earth Team Agronomist

Attachments: 2

cc: w/attach
Rita Bickel, State Conservation Agronomist, NRCS, RTS, Davis
Jerry Reioux, State Staff Forester, NRCS, RTS, Davis
Richard King, Ecologist, NRCS, Petaluma ASO
Charlette Epifanio, District Conservationist, NRCS, Petaluma SC
Jon Gustafson, State Rangeland Management Specialist, RTS, NRCS, Davis
Diane Holcomb, State Resource Conservationist, NRCS, Davis

Table-4 "C" Values for Permanent Pasture, Rangeland, and Idle Land[1] (1)

Vegetal Canopy			Cover That Contacts the Surface					
Type and Height of Raised Canopy[2]	Canopy Cover[3] %	Type[4]	Percent Ground Cover 0	20	40	60	80	95-100
Column No.:	2	3	4	5	6	7	8	9
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5 m fall ht.)	25	G	.36	.17	.09	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.06	.031	.011	.003
		W	.17	.12	.09	.067	.038	.011
Appreciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

[1] All values shown assume: (1) random distribution of mulch or vegetation, and (2) mulch of appreciable depth where it exists.

[2] Average fall height of waterdrops from canopy to soil surface: m=meters.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection, (a bird's-eye view).

[4] G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 2 inches deep.

W: Cover at surface is mostly broadleaf herbaceous plants (as weeds) with little lateral-root network near the surface, and/or undecayed residue.

From: USDA - SCS - CA USLE HANDBOOK

Table-5 "C" Factors for Woodland (1)

Tree Canopy[1] % of Area	Forest Litter[2] % of Area	Undergrowth[3]	"C" Factor
100-75	100-90	Managed[4]	.001
		Unmanaged[4]	.003-.011
70-40	85-75	Managed	.002-.004
		Unmanaged	.01-.04
35-20	70-40	Managed	.003-.009
		Unmanaged	.02-.09[5]

[1] When tree canopy is less than 20%, the area will be considered as grassland, or cropland for estimating soil loss. See Table 4.

[2] Forest litter is assumed to be at least two inches deep over the percent ground surface area covered.

[3] Undergrowth is defined as shrubs, weeds, grasses, vines, etc., on the surface area not protected by forest litter. Usually found under canopy openings.

[4] Managed—grazing and fires are controlled. Unmanaged—stands that are overgrazed or subjected to repeated burning.

[5] For unmanaged woodland with litter cover of less than 75%, C values should be derived by taking 0.7 of the appropriate values in Table-4. The factor of 0.7 adjusts for the much higher soil organic matter on permanent woodland.

tion and developmental areas can be obtained from table 5 if good judgment is exercised in comparing the surface conditions with those of agricultural conditions specified in lines of the table. Time intervals analogous to cropstage periods will be defined to begin and end with successive construction or management activities that appreciably change the surface conditions. The procedure is then similar to that described for cropland.

Establishing vegetation on the denuded areas as quickly as possible is highly important. A good sod has a **C** value of 0.01 or less (table 5-B), but such a low **C** value can be obtained quickly only by laying sod on the area, at a substantial cost. When grass or small grain is started from seed, the probable soil loss for the period while cover is developing can be computed by the procedure outlined for estimating cropstage-period soil losses. If the seeding is on topsoil, without a mulch, the soil loss ratios given in line 141 of table 5 are appropriate for cropstage **C** values. If the seeding is on a desurfaced area, where residual effects of prior vegetation are no longer significant, the ratios for periods SB, 1 and 2 are 1.0, 0.75 and 0.50, respectively, and line 141 applies for cropstage 3. When the seedbed is protected by a mulch, the pertinent mulch factor from the upper curve of figure 6 or table 9 is applicable until good canopy cover is attained. The combined effects of vegetative mulch and low-growing canopy are given in figure 7. When grass is established in small grain, it can usually be evaluated as established meadow about 2 mo after the grain is cut.

C Values for Pasture, Range, and Idle Land

Factor **C** for a specific combination of cover conditions on these types of land may be obtained from table 10 (57). The cover characteristics that must be appraised before consulting this table are defined in the table and its footnotes. Cropstage periods and **EI** monthly distribution data are generally not necessary where perennial vegetation has become established and there is no mechanical disturbance of the soil.

Available soil loss data from undisturbed land were not sufficient to derive table 10 by direct comparison of measured soil loss rates, as was done for development of table 5. However, analyses of the assembled erosion data showed that the research information on values of **C** can be extended to completely different situations by combining subfactors that evaluate three separate and distinct, but interrelated, zones of influence: (a) vegetative cover in direct contact with the soil surface, (b) canopy cover, and (c) residual and tillage effects.

Subfactors for various percentages of surface cover by mulch are given by the upper curve of

TABLE 10.—*Factor* **C** *for permanent pasture, range,* ~~and~~ *idle land*, or grazed woodland.[1]

Vegetative canopy: Type and height[2]	Percent cover[3]	Type[4]	Cover that contacts the soil surface — Percent ground cover: 0	20	40	60	80	95+
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.091	.043	.011
Tall grass, weeds or ~~short brush~~ bushes with average drop fall height of ~~20 in~~ less than 3 ft.[5]	25	G	.36	.17	.09	.038	.013	.003
		W	.36	.20	.13	.083	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.076	.039	.011
	75	G	.17	.10	.06	.032	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, with average drop fall height of 6½ ft	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.087	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.082	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.078	.040	.011
Trees, but no appreciable low brush. Average drop fall height of 13 ft	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.089	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.087	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.084	.041	.011

[1] ~~The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.~~ See below.

[2] Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3] Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4] G: cover at surface is grass, grasslike plants, or decaying compacted duff. ~~or litter at least 2 in deep.~~

W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

Footnote [1]: The listed C values assume that the vegetation and mulch are randomly distributed over the entire area.

For grazed woodland with high buildup of organic matter in the topsoil under permanent forest conditions, multiply the table values by 0.7.

For areas that have been mechanically disturbed by root plow-

Add footnote [5]: [5] The portion of a grass or weed cover that contacts the soil surface during a rainstorm and interferes with water flow over the soil surface is included in "cover at the surface." The remainder is included in canopy cover. Use table 5-B for nearly complete grass covers. Include in "cover at the surface" those parts of the plant up to 3 inches in height.