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# Module 4: Erosion Mechanisms and the Revised Universal Soil Loss Equation (RUSLE)

## Introduction

Knowledge of the potential erosion problems on a construction site enables the site planner to better manage site development and erosion controls to minimize soil loss off the property. Prevention is much more effective than trying to improve water quality of the runoff. Information in this chapter enables a planner to understand basic erosion mechanisms and how they vary for different site conditions. Characteristics of construction site erosion material are highly dependent on site conditions and the local rainfall. This chapter describes how the Revised Universal Soil Loss Equation (RUSLE) can be used to predict the amount of erosion from a site, and introduces some preventative practices to minimize site erosion.

## Basic Erosion Mechanisms and Rain Energy

Soil erosion results when soil is exposed to the erosive powers of rainfall energy and flowing water (Barfield, *et al.* 1983). Rain (along with the shearing force of flowing water) acts to detach soil particles, while runoff transports the soil particles downslope. The most significant factor causing sheet erosion is raindrop impact, while the shearing force of flowing water is most important in rill and gully erosion.

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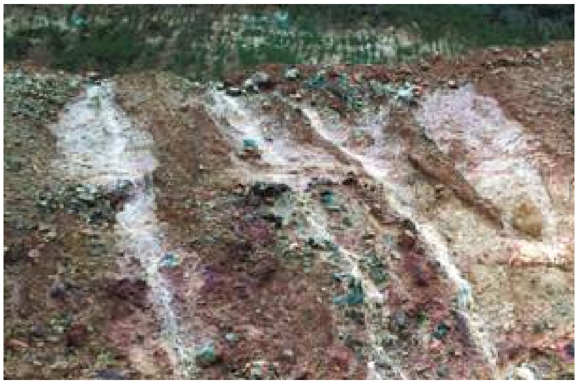
|  |  |
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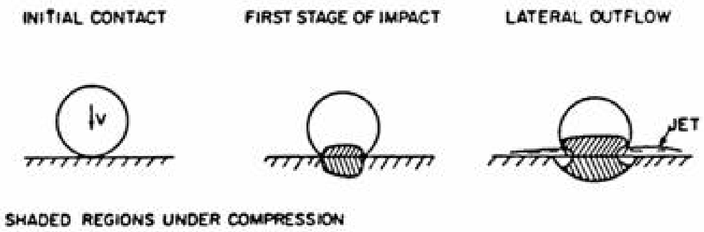
Bill Morton photo

Erosion Mechanisms

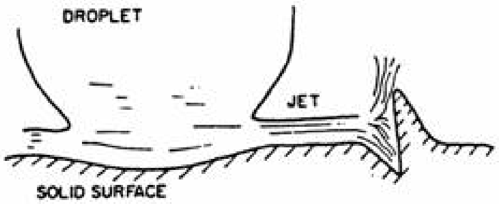
### *Erosion Mechanisms*

Soil detachment has usually been related to raindrop parameters or soil parameters (Huang, *et al*. 1982). The most important rain parameter is kinetic energy and the most important soil parameter is shear strength. Soil detachment occurs when rain energy overcomes the soil's shear strength. The use of surface mulches over bare soils can greatly decreases the transfer of energy to the soil, therefore lessening erosion losses.

When a raindrop strikes a surface, pressure acts to devitalize the particles. The raindrop impact loading function is very different from a uniform loading function (Huang, *et al*. 1982). The initial loading magnitudes are very high, but diminishes very rapidly. These loadings are also not uniform and are concentrated at the edge of the contact area. When the drop strikes a surface, lateral jet streams impinge on adjacent irregular surfaces or dirt particles, as shown on Figure 4-1, further destabilizing the surrounding area (Springer 1976). It is very difficult to model the specific drop impact forces due to these irregularities and simple approximations are usually used.



Impact of a liquid drop on an elastic surface.



Interaction between lateral jets and surface flaws.

**Figure 4-1. Raindrop impact with ground surface (from Springer 1976).**

Kinnell (1981) defines two forms of raindrop kinetic energy, the rate of expenditure of energy per unit time (Err, in units of energy per area per time) and the amount of rainfall kinetic energy expended per unit quantity of rain (Era, in units of energy per area per rain depth). Based on typical drop sizes of about 1.5 mm, known drop populations (see Figures 4-2 and 4-3) and a terminal velocity of about 5.5 m/sec, each drop contains about 3 X $10^{-4}$ joules of kinetic energy (Springer 1976). A 3 mm per hour rain delivers about 11 joules per $m^2$ per minute (Err), while a 12 mm per hour rain delivers about 30 joules per $m^2$ per minute. Err and Era are related:

$$\text{Era} = \text{Err}\ (I)^{-1}$$

where I is the rain intensity. The Universal Soil Loss Equation (Wischmeier and Smith 1965) uses a similar equation to predict rain energy.

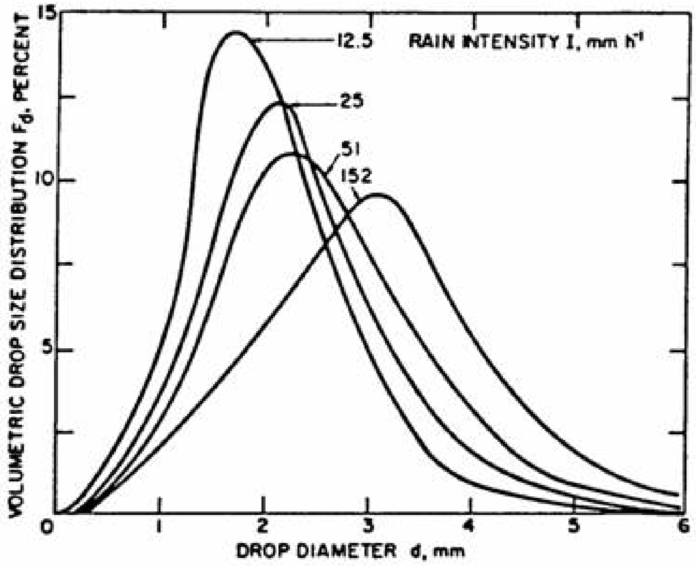


**Figure 4-2. Typical rain drop size distribution (from Springer 1976).**

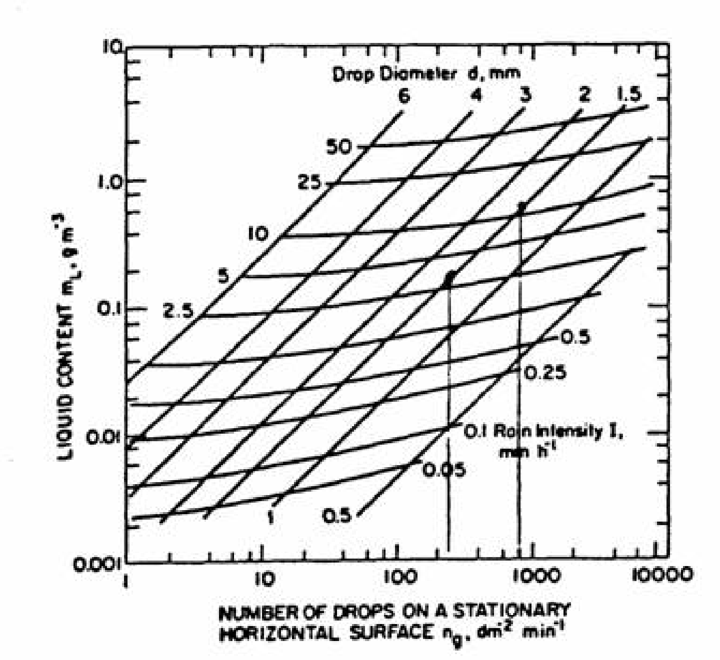


**Figure 4-3. Characteristics of an idealized natural rain consisting of constant diameter spherical droplets distributed uniformly in air (from Springer 1976).**

## The Revised Universal Soil Loss Equation and Relating Rain Energy to Erosion Yield

The Universal Soil Loss Equation (USLE) (Wischmeier and Smith 1965) was based on many years of data from about 10,000 small test plots from throughout the US. Each test plot had about 22 m flow lengths and were all operated in a similar manner, allowing the soil loss measurements to be combined into a predictive tool. The USLE has been extensively used for conservation planning in agricultural operations for many years. Many of the features, and the original database, also allow it to be used to predict erosion losses, and the benefits of some erosion controls, at construction sites. The RUSLE only predicts sheet and rill erosion, it does not predict the effects of concentrated runoff.

The Revised Universal Soil Loss Equation (RUSLE) (Renard, *et al.* 1987) was developed to incorporate new research since the earlier USLE publication in 1978 (Wischmeier and Smith 1978). The basic form of the equation has remained the same, but modifications in several of the factors have been made. There are many sources of information for the RUSLE, including the USDA's National Sedimentation Laboratory where extensive information can be obtained at: http://www.sedlab.olemiss.edu/rusle/. The RUSLE document (Renard, *et al.* 1987) and the material on this referenced web site should be consulted for much greater detail on RUSLE than given in this chapter. This chapter focuses on construction site erosion issues and is greatly simplified compared to the complete RUSLE that stresses agricultural operations, but does periodically refer to construction site issues.

The underlying assumption in the RUSLE is that detachment and deposition are controlled by the sediment content of the flow. The erosion material is not source limited, but the erosion is limited by the carrying capacity of the flow. When the sediment load reaches the carrying capacity of the flow, detachment can no longer occur. Sedimentation must also occur during the receding portion of the hydrograph as the flow rate decreases (Novotny and Chesters 1981).

The RUSLE relates the rate of erosion per unit area (A) to the erosive power of the rain (R), the soil erodibility (K), the land slope and length (LS), the degree of soil cover (C), and conservation practices (P):

$$A = (R)(K)(LS)(C)(P)$$

The important aspect of this equation to note is the linear relationship between the equation parameters. As any parameter is changed, the resulting erosion yield is similarly changed. Also, the basic values for LS, C, and P are all 1.0, and change according to specific site and management conditions change. Many of these factors will change seasonally, especially corresponding to plant growth and according to changes in rain characteristics. A modified version of RUSLE, RUSLE2, is currently being developed that will incorporate many of these seasonal changes. Some of these can be considered in RUSLE.

In this chapter, this equation is used to predict the amount of soil that may be eroded from construction sites. Specifically, it enables the most critical source areas to be identified, and allows predictions of the benefits of basic mulching and seedbed controls. Also, the erodibility of different slope and timing options can be compared for better design for prevention. In addition, RUSLE can be used to predict the amount of sediment that may enter a sediment pond. Table 4-1 includes conversion factors that can be used to predict the volume of sediment from these weight calculations. As an example, if a site is predicted to erode about 450 tons of silty clay soil, the associated volume is about 102% if this amount, or about 460 cubic yards of material.

**Table 4-1. Conversion Factors to Estimate Volume of Eroded Material**

| Soil Texture Class | Conversion Factor to Convert tons to cubic yards |
|---|---|
| Sands, loamy sands, sand loam | 0.70 |
| Sand clay loam, silt loams, loams, and silty clay | 0.87 |
| Clay loams, sandy clays, and silty clays | 1.02 |

## *Rainfall Energy (R)*

The RUSLE implies that rain energy is directly related to erosion yield. Originally, the USLE was used with an annual R value to predict annual erosion yields, but Barfield, *et al.* (1983) summarizes several procedures and studies that have shown relationships between individual storm energies and erosion yields. Therefore, the local example rain energy calculations in the following subsections are used to directly relate the probabilities of individual rain events to approximate erosion yields.

Wischmeier (1959) found that the best predictor of R was:

$$R = \frac{1}{n}\sum_{j=1}^{n}\left[\sum_{k=1}^{m}(E)(I_{30})_k\right]$$

where E is the total storm kinetic energy in hundreds of ft-tons per acre, $I_{30}$ is the maximum 30-minute rainfall intensity, j is the counter for each year used to produce the average, k is the counter for the number of storms in a year, m is the number of storms n each year, and n is the number of years used to obtain the average R.

The calculated erosion potential for an individual storm is usually designated EI. The total annual R is therefore the sum of the individual EI values for each rain in the year.

Wischmeier also found that the rain kinetic energy (E) could be predicted by:

$E = 916 + (331)\log_{10}(I)$, in ft-tons/acre per inch or rain

where I is the average rain intensity. E is given in ft-tons per acre per inch of rain, if intensities in inches per hour are used (for up to 3 in/hr). The rain energy (and R parameter) is therefore only dependent in rain intensities alone. Table 4-2 shows calculated kinetic energy per inch of rain for different rain intensities, using this equation. As an example, a rain having an average intensity of 0.37 in/hr would have a calculated kinetic energy of 773 ft-tons per acre of land, per inch of rain. The maximum calculated kinetic energy using this equation is 1074 ft-tons/acre/in. and is applied to rain intensities of 3.0 inches/hr, and greater. This equation has been used to calculate the R values and the maps in RUSLE (Renard, *et al.* 1987). However, Renard, *et al.* (1987) recommend the following equation for all future R calculations:

$E = 1099\ [1-0.72 \exp(-1.27I)]$, also in ft-tons/acre per inch or rain

They found less than a 1% difference in EI for example storms. The largest difference is for less intense events where little erosion occurs.

**Table 4-2. Kinetic Energy of Rainfall (ft-tons per acre per inch of rain) (Wischmeier and Smith 1978)**

| Intensity (in/hr) | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | 254 | 354 | 412 | 453 | 485 | 512 | 534 | 553 | 570 |
| **0.1** | 585 | 599 | 611 | 623 | 633 | 643 | 653 | 661 | 669 | 677 |
| **0.2** | 685 | 692 | 698 | 705 | 711 | 717 | 722 | 728 | 733 | 738 |
| **0.3** | 743 | 748 | 752 | 757 | 761 | 765 | 769 | 773 | 777 | 781 |
| **0.4** | 784 | 788 | 791 | 795 | 798 | 801 | 804 | 807 | 810 | 814 |
| **0.5** | 816 | 819 | 822 | 825 | 827 | 830 | 833 | 835 | 838 | 840 |
| **0.6** | 843 | 845 | 847 | 850 | 852 | 854 | 856 | 858 | 861 | 863 |
| **0.7** | 865 | 867 | 869 | 871 | 873 | 875 | 877 | 878 | 880 | 882 |
| **0.8** | 884 | 886 | 887 | 889 | 891 | 893 | 894 | 896 | 898 | 899 |
| **0.9** | 901 | 902 | 904 | 906 | 907 | 909 | 910 | 912 | 913 | 915 |

| Intensity (in/hr) | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 916 | 930 | 942 | 954 | 964 | 974 | 984 | 992 | 1000 | 1008 |
| **2** | 1016 | 1023 | 1029 | 1036 | 1042 | 1048 | 1053 | 1059 | 1064 | 1069 |
| **3** | 1074[1] | 1074 | 1074 | 1074 | 1074 | 1074 | 1074 | 1074 | 1074 | 1074 |

[1] 1074 ft-lbs/acre/inch is the maximum value and is applied for all intensities greater than 3.0 inches per hour of rain.

Wischmeier and Smith (1978) present an example for calculating the rainfall kinetic energy from a rain gage record, as illustrated in Table 4-3. In this example, the total kinetic energy of the storm = 1284 ft-tons per acre, or 12.84 hundreds of ft-tons per acre. The maximum 30 minute rainfall during this 90-minute storm was 1.08 inches, occurring from 4:27 to 4:57. The corresponding $I_{30}$ was therefore 2.16 inches per hour. If the storm duration is less than 30 minutes, the $I_{30}$ used is twice the total rain depth, with a maximum used $I_{30}$ value of 2.5 in/hr. The EI for this storm is therefore (2.16)(12.84) = 27.7.

**Table 4-3. Procedure for Calculating Kinetic Energy using a Rain Gage Record (Wischmeier and Smith 1978)**

| Rain Gage Chart Readings | | Storm Increments | | | Kinetic energy | |
|---|---|---|---|---|---|---|
| **Time** | **Accumulative depth (inches)** | **Duration (minutes)** | **Amount (inches)** | **Intensity (in/hr)** | **Per inch (ft-tons per acre per inch of rain)** | **For increment (ft-tons per acre)** |
| 4:00 | 0 | | | | | |
| 4:20 | 0.05 | 20 | 0.05 | 0.15 | 643 | 32 |
| 4:27 | 0.12 | 7 | 0.07 | 0.60 | 843 | 59 |
| 4:36 | 0.35 | 9 | 0.23 | 1.53 | 977 | 225 |
| 4:50 | 1.05 | 14 | 0.70 | 3.00 | 1074 | 752 |
| 4:57 | 1.20 | 7 | 0.15 | 1.29 | 953 | 143 |
| 5:05 | 1.25 | 8 | 0.05 | 0.38 | 777 | 39 |
| 5:15 | 1.25 | 10 | 0 | 0 | 0 | 0 |
| 5:30 | 1.30 | 15 | 0.05 | 0.20 | 685 | 34 |
| Totals: | 1.30 | 90 | 1.30 | | | 1284 |

Figure 4-4 presents values of R for the eastern US and the western states. The USDA's National Sedimentation Laboratory (at http://www.sedlab.olemiss.edu/rusle/) contains extensive information on RUSLE. The values shown in this figure are averaged from 20 to 25 years of data. The break between individual rains was defined as 6 hours, or more, having less than 0.5 inches of rain. Rains of less than 0.5 inches, separated from other showers by 6 hours, or more, were omitted from the calculation, unless the maximum 15-minute intensity was greater than 0.95 in/hr. Also, the maximum $I_{30}$ value used in the calculations was 2.5 in/hr.

Locations in the southeast experience very high values of R, compared to other US locations. As an example, the lowest values in Alabama are for the northern part of the state, with R values of about 300. Most of the state has R values between 300 and 400, while values greater than 600 are shown for Mobile and Baldwin counties. Only the southern tip of Louisiana has a larger value of R in the continental US.

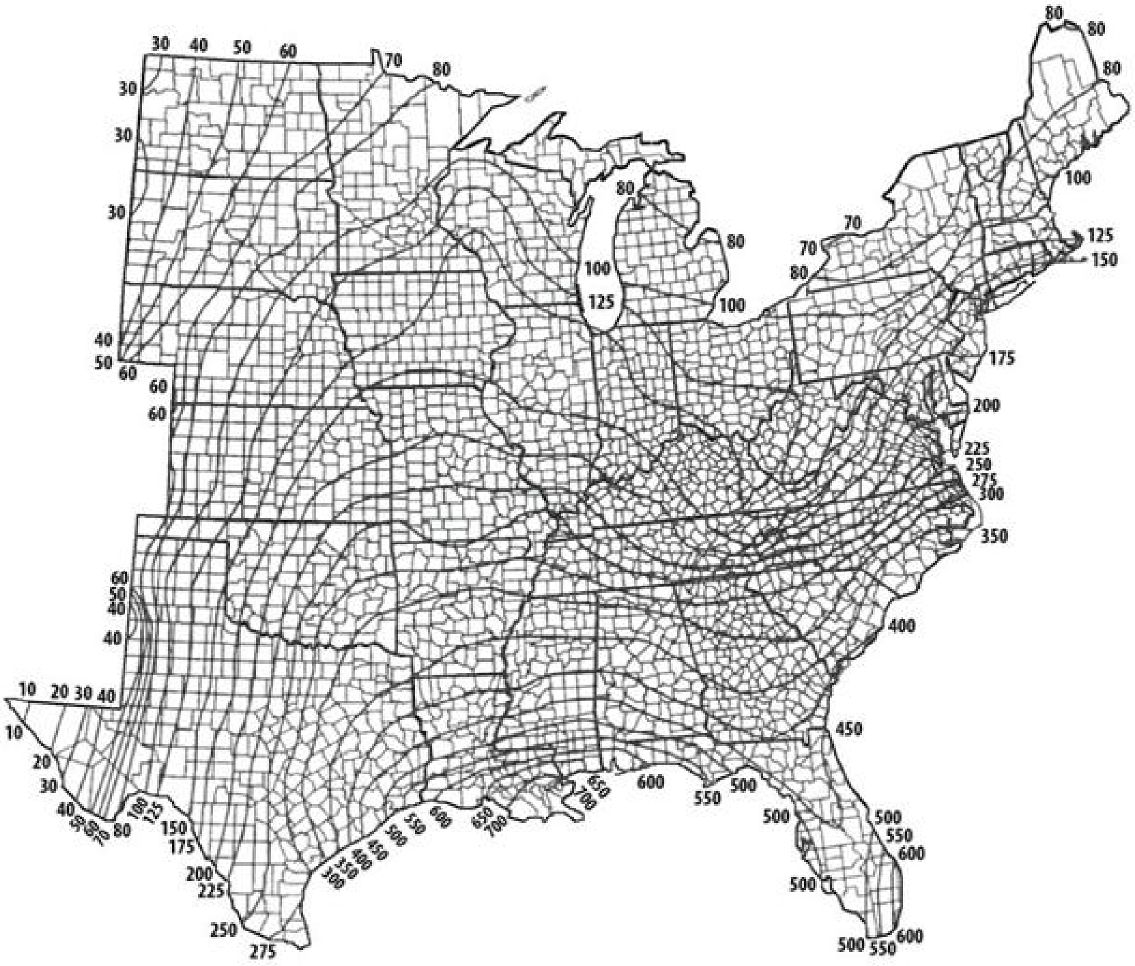


**Figure 4-4a. Isoerodent map of the Eastern U.S. (EPA 2001).**

**Figure 4-4b. Isoerodent map of the Western U.S. (EPA 2001).**

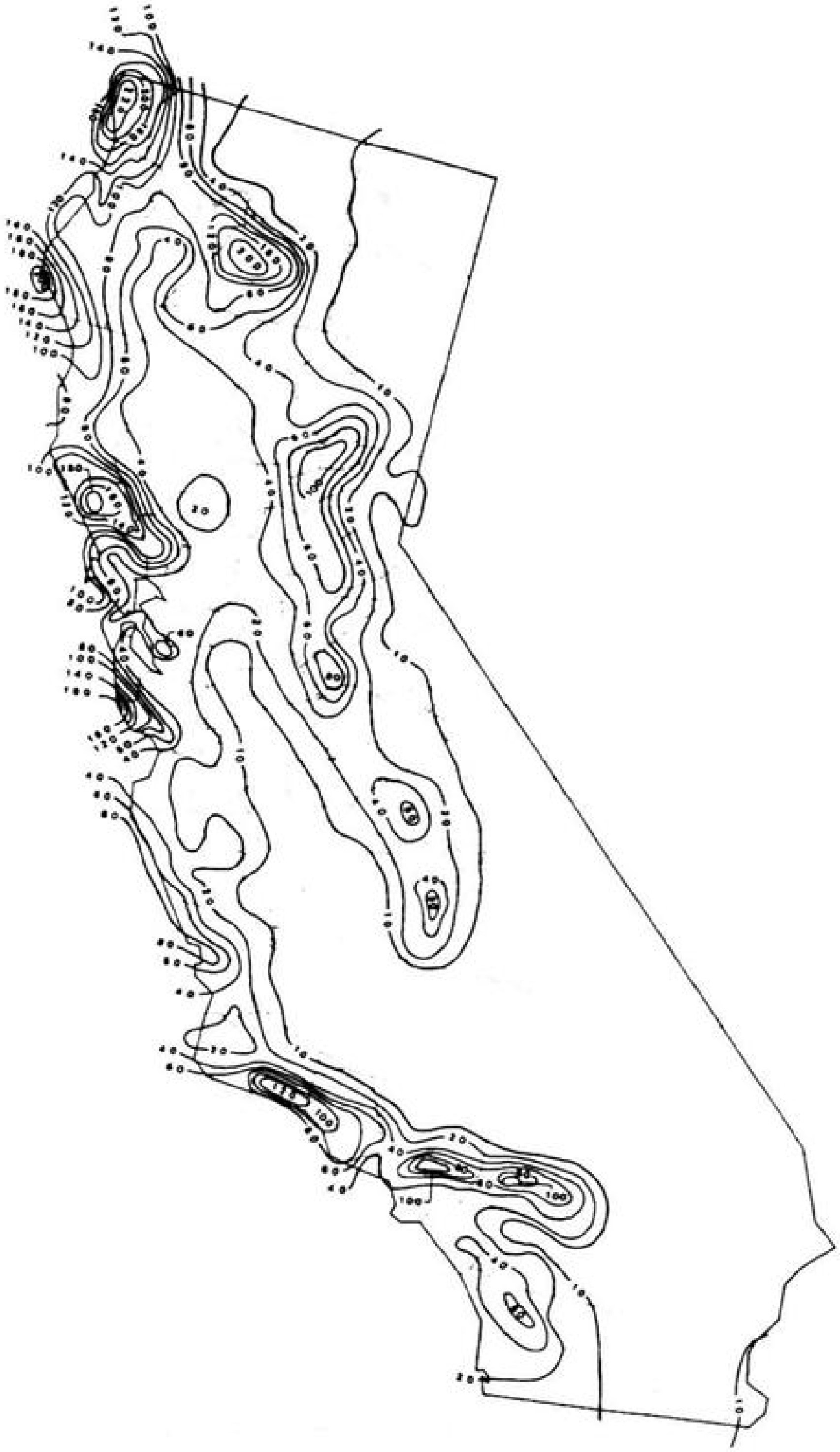


**Figure 4-4c. Isoerodent map of California (EPA 2001).**

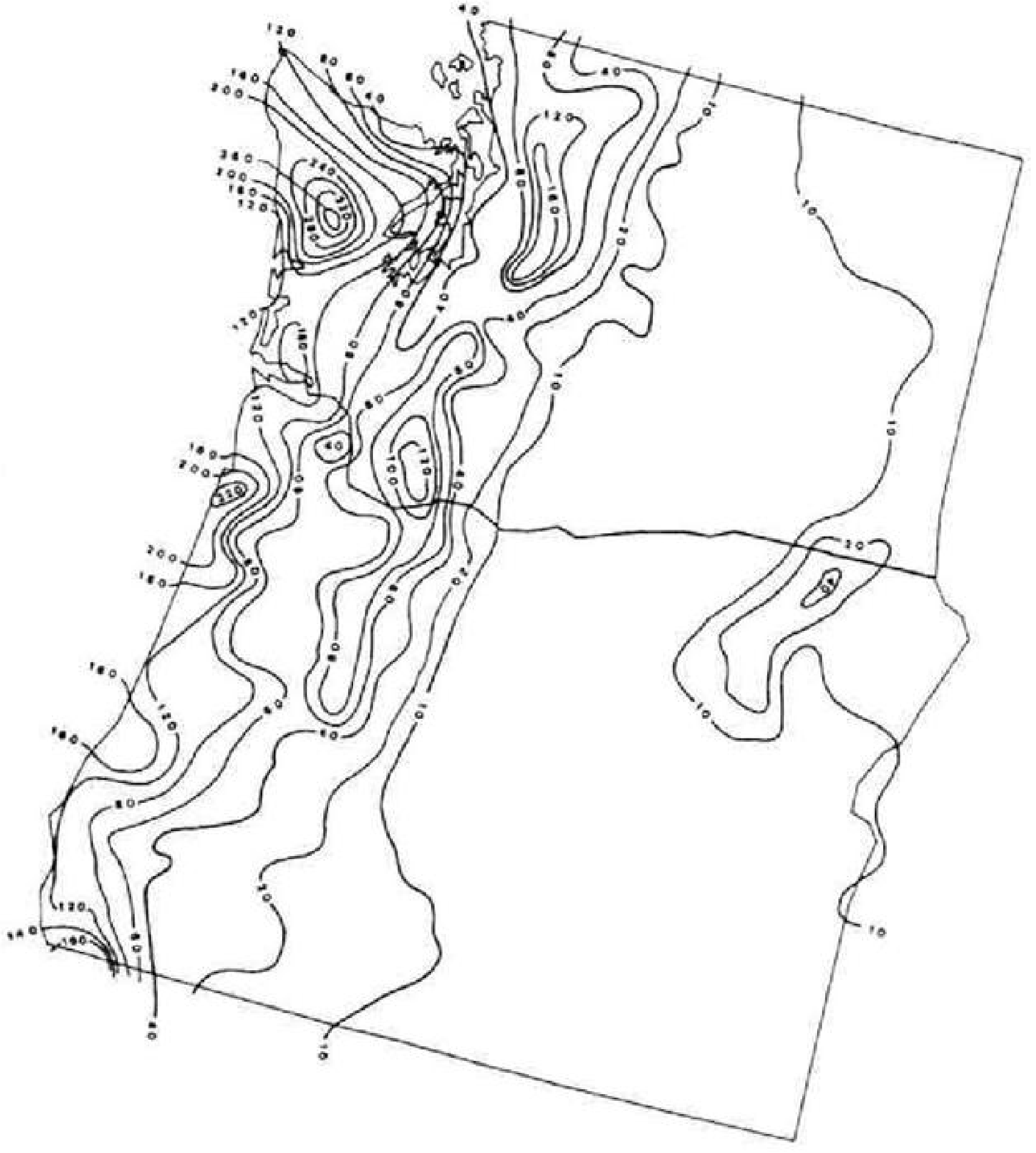


**Figure 4-4d. Isoerodent map of Oregon and Washington U.S. (EPA 2001).**

There can be large year-to-year variations in the annual R values and individual storms may be responsible for large fractions of the annual rain energy. Table 4-4 presents measured annual probabilities of the annual R values for three Alabama locations. The 50 percent probability values are the values plotted on Figure 4-4. Table 4-5 shows the expected magnitudes of calculated single storm erosion index (EI) values. There is a 5% chance that a single storm in any year could cause about half of the total annual erosion in the Birmingham and Montgomery areas, or about 1/5 of the total annual erosion in Mobile. The typical worst storm in any one year may cause about 15% of the total annual erosion in Birmingham and Mobile.

**Table 4-4. Probabilities of Annual R Values for the Calculation Period for Alabama Locations (Wischmeier and Smith 1978)**

| | Observed 22-year range | 50 percent probability | 20 percent probability | 5 percent probability |
|---|---|---|---|---|
| Birmingham | 179-601 | 354 | 461 | 592 |
| Mobile | 279-925 | 673 | 799 | 940 |
| Montgomery | 164-780 | 359 | 482 | 638 |

**Table 4-5. Probabilities of Individual Storm Erosion Index (EI) Values for Alabama Locations (Wischmeier and Smith 1978)**

| | Probability of Single Storm Exceeding EI Value in Any One Year: | | | | |
|---|---|---|---|---|---|
| | 100% | 50% | 20% | 10% | 5% |
| Birmingham | 54 | 77 | 110 | 140 | 170 |
| Mobile | 97 | 122 | 151 | 172 | 194 |
| Montgomery | 62 | 86 | 118 | 145 | 172 |

Figure 4-5 shows the rainfall erosion index values for the southeast, used to indicate the variability of the rainfall energy for different times of the year. Appendix 4A includes the erosion index map for the whole US. The USDA's National Sedimentation Laboratory webpage (at http://www.sedlab.olemiss.edu/rusle/) contains rainfall erosion index maps, and associated tables. There are five regions in Alabama, although most of the state is in regions 107 or 108. These regions are used to predict the fraction of the annual R that occurs in 2-week increments throughout the US, useful information for planning relatively rapid, but sensitive, construction practices, and to see if a potential project may be eligible for the possible "R≤5 total" exemption rule. Table 4-6 lists these distribution values for R for these areas in the state, while Appendix 4A includes the values for all regions of the US.

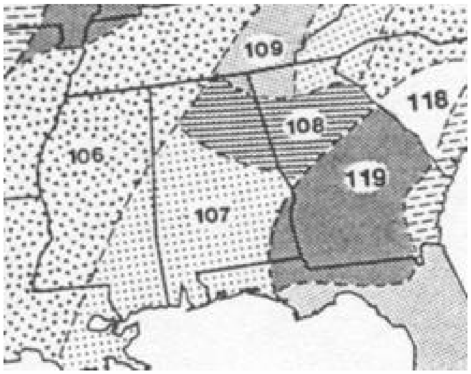


**Figure 4-5. Rainfall erosion index zones for southeastern US (Renard, *et al.* 1987).**

The values in Table 4-6 are the percentage of the total annual R values that occur in each 2 week period. If the R of ≤ 5 waiver will be available in Alabama, only the very rare construction activity may be eligible. Only small portions of region 119 may possibly qualify (if the annual R<500) and if the construction activity could be completed within a 2 week period during November, December, or January. The erosivity index values range from lows of 1% to a high of 10% per two week period. Periods greater than the average of 4.1% are shown in boldface and indicate periods when higher amounts of erosion than the overall average may occur. Depending on location, these periods are generally from the first of April through August, or September. Periods with the lowest erosion potentials are in the winter and early spring, and fall.

As indicated above, a relatively few rains can contribute much more of the annual rainfall energy than most, with the more intense rains contributing greater erosion losses per inch of runoff than the less intense rains. As an example, the most important single rain in the Birmingham area that may occur in any one year has an R value of about 54, and therefore contributes about 15 percent of the annual erosion losses. The most important single rain that may occur once every ten years has an R value of about 140 and may therefore contribute about 40 percent of the annual erosion losses for that year. This ten-year rain would only contribute about four percent of the average ten year total erosion losses in any one year, however.

An analysis was conducted using the recorded 1977 Birmingham rains to determine the distributions of erosion factors for individual rains and their recurrence intervals. This year was selected due to its similarity to the long term average rain conditions (based on total annual rain depth and the distribution of the rains throughout the year). Most of the erosion is produced by a relatively few highly erosive rains that may occur during any month. About 50 percent of the annual erosion yield is associated with only 11 individual rains (out of 96 that occurred in 1977). About 40 percent of the individual rains were responsible for more than 90 percent of the annual erosion yield, and about 25 percent of the rains were responsible for about 75 percent of the annual erosion yield.

**Table 4-6. Distribution of the Erosivity Index Values for Different Time Periods Throughout the Year for Index Zones in the Southeast**

| **Period** | **106** | **107** | **108** | **109** | **119** |
|---|---|---|---|---|---|
| Jan 1-15 | 3 | 3 | 3 | 3 | 1 |
| Jan 16-31 | 3 | 2 | 3 | 3 | 1 |
| Feb 1-15 | 3 | 2 | 3 | 4 | 2 |
| Feb 16-29 | 4 | 3 | 3 | 3 | 2 |
| Mar 1-15 | 4 | 4 | 4 | 3 | 1 |
| Mar 16-31 | 4 | 4 | 4 | 3 | 2 |
| Apr 1-15 | **6** | **5** | 4 | 4 | 3 |
| Apr 16-30 | **6** | 4 | 4 | 3 | 3 |
| May 1-15 | **5** | 4 | **5** | 3 | 3 |
| May 16-31 | **6** | 4 | **5** | 4 | **5** |
| Jun 1-15 | **5** | 4 | **5** | **6** | **8** |
| Jun 16-30 | **6** | **6** | **7** | **8** | **9** |
| Jul 1-15 | **6** | **8** | **9** | **11** | **5** |
| Jul 16-31 | **6** | **7** | **10** | **10** | **9** |
| Aug 1-15 | 4 | **7** | **6** | **7** | **6** |
| Aug 16-31 | 4 | **7** | **5** | **5** | **9** |
| Sep 1-15 | 3 | **6** | 4 | 3 | **6** |
| Sep 16-31 | 3 | 4 | 3 | 3 | **10** |
| Oct 1-15 | 3 | 2 | 3 | 2 | 4 |
| Oct 16-31 | 2 | 2 | 2 | 2 | 4 |
| Nov 1-15 | 4 | 2 | 2 | 2 | 1 |
| Nov 16-31 | 4 | 3 | 2 | 3 | 1 |
| Dec 1-15 | 3 | 2 | 2 | 2 | 1 |
| Dec 16-31 | 3 | **5** | 2 | 3 | 1 |

Source: EPA's *Construction Rainfall Erosivity Waiver,* Fact Sheet 3.1. EPA 833-F-00-014. Jan, 2001.

Calculations were also made to examine the probabilities of different highly erosive rains occurring during 7, 14, and 30 day periods for Birmingham 1977 conditions. Table 4-7 indicates these probabilities and the expected erosion yields for these time periods. Many erosion protection regulations (including the Phase II NPDES requirements) require disturbed areas inactive for more than 14 days to have suitable site erosion controls. During a 14 day period of time, more than a ton of sediment could be washed from each disturbed acre during about four different rains. There is also a 30 percent chance that this much sediment could be washed from the site during a single event during this time period. If this time period was lengthened, the amount of sediment that could be lost and the probability of highly erosive rains occurring would increase proportionately. Because of these potential significant sediment losses, the regulations also require appropriate downslope controls to capture any sediment that may move from uncontrolled disturbed areas on the site. However, downslope controls are not adequate by themselves in controlling all sediment during highly erosive rains. The on-site protection offered by mulching of inactive disturbed areas (in addition to the diversion of waters from upslope off-site areas) greatly lessens the burden on the downslope controls to allow them to remain useful during severe (but common) rains.

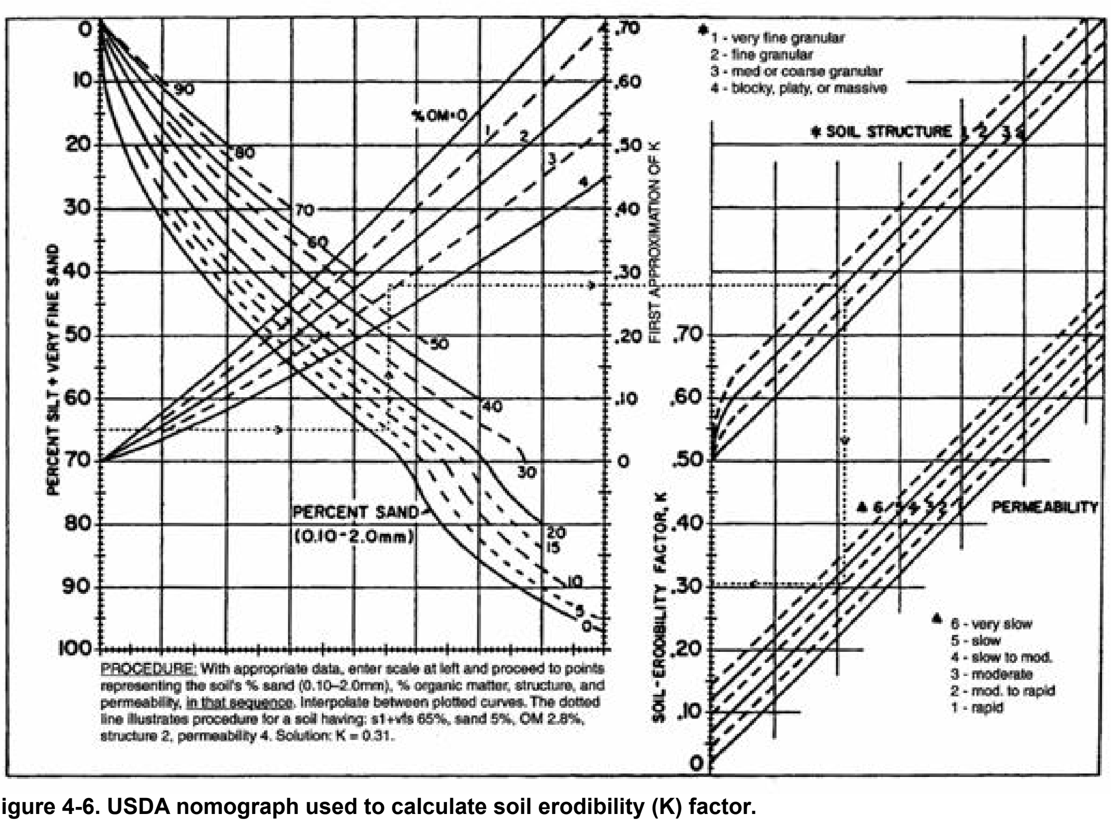
**Table 4-7. Probabilities of Highly Erosive Rains Occurring During Different Time Periods (Birmingham 1977 data)**

| **Percentage of Annual Erosion Yield During Event** | **Estimated Erosion Yield During Single Event (with some site controls) (lb/acre)** | **Probability of Event Occurring at Least Once per:** | | |
|---|---|---|---|---|
| | | **7 days** | **14 days** | **30 days** |

| | | | | |
|---|---|---|---|---|
| 7% | 3,500 | 3% | 6% | 12% |
| 5 | 3,000 | 8 | 16 | 31 |
| 3 | 1,800 | 17 | 31 | 55 |
| 2 | 1,200 | 29 | 50 | 77 |
| 1 | 600 | 45 | 70 | 92 |
| **Probable number of events per time period (out of 96):** | | 2 | 4 | 8 |
| **Probable total erosion yield per time period (lb/acre):** | | 1,200 | 2,300 | 5,000 |

## *Soil Erodibility Factor (K)*

The soil texture, and other soil characteristics, affect its susceptibility to erosion. The soil K factors were determined experimentally in test plots that were 72.6 ft long and had a uniform slope of 9%. Figure 4-6 is the nomograph used to determine the K factor for a soil, based on its texture (% silt plus very fine sand, % sand, % organic matter, soil structure, and permeability. The NRCS county soil maps list the K factors for all soils in each county. However, significant disturbance and modifications of the soil obviously occurs at construction sites and care needs to be taken to ensure that the K factor is based on the actual surface soil conditions. As an example, the organic matter (decreases as the top soils are removed), permeability (decreases with compaction with heavy equipment), and soil structure (subsurface soils more massive than surface soils) could all likely change, causing the K factor to increase for a soil undergoing modification at a construction site.



PROCEDURE: With appropriate data, enter scale at left and proceed to points representing the soil's % sand (0.10–2.0mm), % organic matter, structure, and permeability, in that sequence. Interpolate between plotted curves. The dotted line illustrates procedure for a soil having: s1+vfs 65%, sand 5%, OM 2.8%, structure 2, permeability 4. Solution: K = 0.31.

**Figure 4-6. USDA nomograph used to calculate soil erodibility (K) factor.**

### Soil Classifications

The designation for a sand or clay is given in the *Unified Soil Classification System*, ASTM D 2487. Sandy soils required that more than half of the material be larger than the No. 200 sieve, and more than half of that fraction be smaller than the No. 4 sieve. Similarly, for clayey soils, more than half of the material is required to be smaller than the No. 200 sieve. Figure 4-7 is the standard soil texture triangle defining the different soil texture categories and Table 4-8 shows the standard USDA particle size ranges for the different soil texture categories.

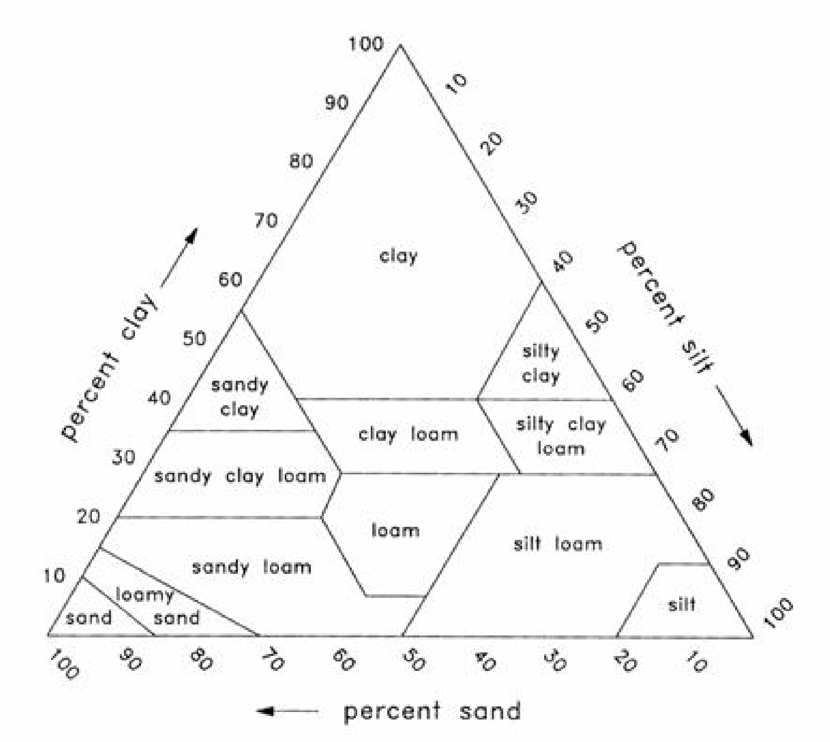


**Figure 4-7. Standard USDA soil texture triangle.**

**Table 4-8. USDA Particle Size Ranges for Different Soil Texture Categories**

| | | Size Range | |
|---|---|---|---|
| **Soil Particle** | **micrometers** | **millimeters** | **inches** |
| Cobble | 150,000 to 300,000 μm | 150 to 300 mm | 6 to 12 in. |
| Gravel | 2,000 to 150,000 | 2 to 150 | 0.08 to 6 |
| Sand[1] | 50 to 2,000 | 0.05 to 2.00 | 0.002 to 0.08 |
| Silt | 2 to 50 | 0.002 to 0.05 | 0.00008 to 0.002 |
| Clay | <2 | <0.002 | <0.00008 |

[1] “very fine sand” is in the 50 to 100 μm range

Silt particles are barely visible to the naked eye and are intermediate in many properties between sand and clay. Silt is characterized by its plasticity and stickiness. According to the USDA (1993), the silt content is an important characteristic for determining erodibility because silt-sized particles are easily detached and transported in runoff. The small particle size also makes silt difficult to capture in traps or basins. There are two major types of clays, kaolinite and montmorillonite. Kaolinite is relatively inactive and fairly stable. Montmorillonite is a very active clay that shrinks when dry and swells when wet. These characteristics affect the permeability of soils and are very important to their use and management. Clayey soils retain water that is available for plant growth, but these soils are often dense, hard, wet, airtight, acidic, and infertile. They can restrict root growth even though other factors are favorable.

The ASSHTO system classifies soils according to the properties that affect roadway construction and maintenance. The fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in silt and clay. Soils in group A-7 are fine grained. Highly organic soils are in Group A-8 and are classified on the basis of visual inspection.

**Alabama Soil Conditions**

The Alabama Soil and Water Conservation Committee produced the *Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas* in 1993 (USDA 1993). This handbook is currently being revised and the new version is expected to be available in 2003. The following discussion on Alabama soils is summarized from the 1993 version of the *Alabama Handbook* and is an example of the general information available for regional soils from the NRCS.

Soil formation in Alabama has been influenced primarily by parent materials and relief. The Appalachian Plateau, Limestone Valleys and Uplands, and Piedmont Plateau of Northern Alabama are all products of uplift and extended geologic erosion. The Coastal Plain and Blackland Prairie sections of the state represent the sedimentation and deposition product from millions of years of geologic erosion. As a result, soils differ among the major soil areas throughout the state (See Figure 4-8). The following is a very general description of the soils in these areas.

> ***Limestone Valleys and Uplands.*** Soils in this area were formed mainly in residuum weathered from limestone. Soils in the Tennessee and Coosa river valleys are weathered from pure limestones and are mainly red clayey soils with a loamy surface texture. Most of the land is open and in agricultural production. Most of the soils of the uplands are derived from cherty limestone. They typically have a cherty loamy or cherty clayey subsoil and a cherty loamy surface layer. Much of the area is used for pasture or forest.
>
> ***Appalachian Plateau.*** The Appalachian Plateau consists of Cumberland, Sand, Lookout, Gunter, Brindlee, Chandler and smaller mountains. Most of the soils are derived from sandstone or shale. The more level areas with slopes of less than 10 percent generally have a loamy subsoil and a sandy loam surface layer. The more rugged portions of the Appalachian Plateau are dominated by soils which formed in residuum from shale. These soils have either a very channery loamy, or a clayey subsoil and a loamy surface layer. Most of these areas are too steep for agriculture.
>
> ***Piedmont Plateau***. Most of the soils in this area are derived from granite, hornblende, and mica schists. They commonly have a red clayey subsoil and a sandy loam surface layer. Topography is rolling to steep. Most rolling areas were once cultivated but are now in pasture or forest.
>
> ***Coastal Plain***. Most of the soils in this area are derived from marine and fluvial sediments. The area consists of the Upper and Lower Coastal Plains. Soils of the Upper Coastal Plain generally have a loamy or clayey subsoil and a sandy loam surface layer. The topography varies from nearly level to very steep. Narrow ridgetops and broad terraces are cultivated, but most of the area is in forest. Soils of the Lower Coastal Plain generally have a loamy subsoil and a sandy loam surface layer. Most slopes are less than 10 percent.
>
> ***Blackland Prairie***. This area of central and western Alabama is known locally as the “Black Belt” because of the dark surface color of many of the soils. These soils were derived from alkaline, chalk or acid marine clays. Acid and alkaline soils are intermingled throughout the area. The alkaline soils ordinarily are clayey throughout and have a dark surface layer and a yellowish subsoil. The acid soils ordinarily are clayey throughout and have a red subsoil and a lightcolored surface layer. These clayey soils contain a large percentage of montmorillonitic clays and shrink and crack when dry and swell when wet. The area is level to undulating. Most of these soils are used for timber production and pasture.
>
> ***Major Flood Plains and Terraces.*** These soils are not extensive, but are important where they occur along streams and river terraces. They are derived from alluvium deposited by the streams. A typical area consists of cultivated crops on the nearly level terraces and bottomland hardwood forests on the flood plain of streams.
>
> ***Coastal Marshes and Beaches.*** These soils are not extensive and occur only on relatively level bottomlands and tidal flats along the Mobile River, Mobile Bay and Gulf of Mexico. Most of the soils are deep and very poorly drained.

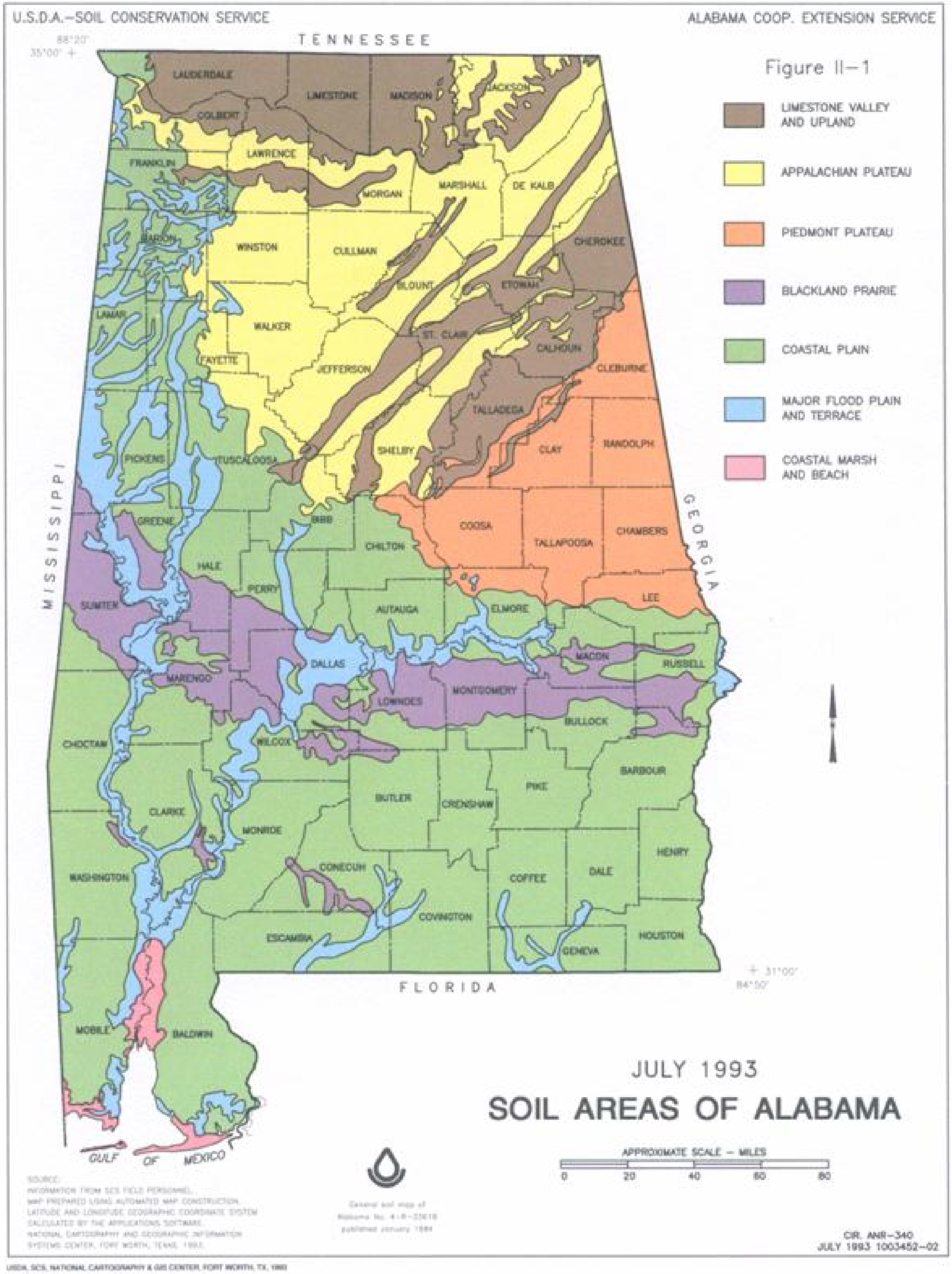


**Figure 4-8. Soil areas of Alabama (USDA 1993).**

Many characteristics of soils, including texture, organic matter, fertility, acidity, moisture retention, drainage, and slope, have an influence on the soils' vulnerability to erosion. Except for most of the Prairie area, most disturbed sites after grading end up with a surface layer of acid infertile subsoil materials. The soils of these sites can be toxic to many plants and may not be capable of supporting growth sufficient to prevent erosion. Construction activities further restrict plant growth by increasing compaction, and altering the slopes and drainage patterns. To offset these problems, the original site topsoil should be removed, stockpiled, and reapplied to the disturbed area. Soil amendments (limestone and fertilizer) should also be applied based on a soil test of the area. In some areas, special seedbed preparation will also be necessary.

County soil surveys are available from local Natural Resources Conservation Service (NRCS, formally the Soil Conservation Service, or SCS) offices. These surveys include a tremendous amount of information about local soils, including special concerns about different land uses in those areas. The following information is summarized from the Jefferson County, AL, soil survey prepared by the SCS in 1981, again as an example of the type of information available from the county soil surveys.

Soil information for the 10 most common Jefferson County, AL, soils are listed in Tables 4-9 and 3-10. These ten soils cover about 75% of the county. The urban soils currently comprise much more than the amounts shown on this table due to the urban development that has occurred during the past 20 years. The K values range from 0.17 to 0.37. No K values are available for the urban soils, as they have been dramatically disturbed. Soil samples would need to be collected and analyzed and the nomograph in Figure 4-6 would be needed to estimate appropriate K values for these urban soils. It is interesting to note that almost all of these most common soils are on moderately steep to steep slopes. Also, the soil erodibility factors are given for several soil horizons for most soils. The K values about evenly increase or decrease with depth for the different soils. The K factors for different soil horizons can be used to determine the erosion rates for a site for different stages of excavation as these other soil horizons are exposed. In areas of fill, the characteristics of the "new" exposed soil must be considered.

**Table 4-9. Ten Most Common Soils in Jefferson County, AL, in 1980**

| | | Area in Jefferson County: | | |
|---|---|---|---|---|
| **Soil name** | **Map symbol** | **Acres** | **%** | **Soil type** |
| Montevallo-Nauvoo association, steep | 29 | 260,930 | 36.3 | Montevallo<br>Nauvoo |
| Nauvoo fine sandy loam, 8 to 15% slope | 31 | 51,440 | 7.2 | Nauvoo |
| Nauvoo-Montevallo association, steep | 34 | 44,010 | 6.2 | Nauvoo<br>Montevallo |
| Palmerdale complex, steep | 35 | 29,390 | 4.1 | Palmerdale |
| Urban land | 44 | 27,080 | 3.8 | Urban land |
| Townley-Nauvoo complex, 8 to 15% slope | 40 | 25,870 | 3.6 | Townley<br>Nauvoo |
| Bodine-Birmingham association, steep | 8 | 25,560 | 3.6 | Bodine<br>Birmingham |
| Fullerton-urban land complex, 8 to 15% slopes | 18 | 21,990 | 3.1 | Fullerton<br>Urban land |
| Bodine-Fullerton association, steep | 9 | 20,720 | 2.9 | Bodine<br>Fullerton |
| Sullivan-State complex, 0 to 2% slopes | 39 | 19,600 | 2.7 | Sullivan<br>State |

**Table 4-10. Erodibility Factors, K, for the Most Common Soils in Jefferson County, AL**

| **Soil name** | **Soil horizon depth and soil erodibility K factor** | | |
|---|---|---|---|
| Birmingham | 0 to 5 inches (0.24) | 5 to 29 inches (0.28) | |
| Bodine | 0 to 72 inches (0.28) | | |
| Fullerton | 0 to 6 inches (0.28) | 6 to 35 inches (0.24) | 35 to 65 inches (0.20) |
| Montevallo | 0 to 6 inches (0.37) | 6 to 16 inches (0.32) | |
| Nauvoo | 0 to 12 inches (0.28) | 12 to 46 inches (0.32) | |
| Palmerdale | 0 to 60 inches (0.24) | | |
| State | 0 to 40 inches (0.28) | 40 to 60 inches (0.17) | |
| Sullivan | 0 to 66 inches (0.32) | | |
| Townley | 0 to 4 inches (0.37) | | |
| Urban land | No specific information | | |

These generally clayey soils in northern Alabama have surface horizon K factors of 0.24 to 0.37. With the most common Jefferson County soils (Montevallo and Nauvoo) having 0.37 and 0.28 K values. Sandy soils with low organic content and with high permeability (similar to gulf coast soils) may have K values that are less than half of these values and could conceivably be as low as 0.05, although 0.10 is the more commonly seen minimum K value for Alabama soils. K values for soils having different textures are listed below (Dion 2002):

| | |
|---|---|
| Sandy, fine sand, loamy sand | 0.10 |
| Loamy sand, loamy fine sand, sandy loam, loamy, silty loam | 0.15 |
| Loamy, silty loam, sandy clay loam, fine sandy loam | 0.24 |
| Silty clay loam, silty clay, clay, clay loam, loamy | 0.28 |

Obviously, there is a lot of overlap for the different soil textures, as there are other factors besides just texture that is used to determine the K value, as shown previously, but this list does illustrate the generally increasing K values as the soil particle sizes decrease. County soil surveys need to be consulted to determine the RUSLE K factors for the construction site soils of interest.

### *Length-Slope Factor (LS)*

The erosion of soil from a slope increases as the slope increases and lengthens. RUSLE includes a table (Table 4-11) for selecting the length-slope factor, LS, according to these site characteristics. Values of 1.0 (the base condition) correspond to the standard condition of 9% slope and about 73 ft slope length. If the length of the slope is 300 ft., or less, the LS factor would be less than 0.10 for all slopes of 0.5%, or less. Roadway side cuts of 1:2 (50%) would have LS factors greater than 1.0 for all slope lengths of about 6 ft, or longer. Long and steep slopes, frequently occurring along roadway cuts in hilly terrain, can have extremely large LS factors. It is interesting to note that more than 80% of Jefferson County, AL, land has slopes greater than 8% (1981 USDA Jefferson County Soil Survey). Land slopes are much less steep in Alabama below the fall line and approaching the gulf coast.

The RUSLE LS factors have been significantly changed compared to the original USLE LS values. There are now four separate LS tables, although Table 4-11 is the only one appropriate for construction sites (freshly prepared sites that are highly disturbed). The LS values have also been generally reduced compared to the original values, sometimes by as much as 50% for the largest values. LS values for slopes less than 20% are similar in both versions. Also, steepness and length are now more evenly sensitive to the LS factor, while previously, slope steepness was much more critical.

Figures 4-9 and 4-10 show how the slope-length factor is determined for a site. The slope length, $\lambda$, is the slope length used in RUSLE for calculating interrill (sheet) and rill erosion. This length is along the slope from the ridge to the point where deposition starts to occur near the bottom of the slope. Several example slope lengths are shown on Figure 4-10 (Renard, *et al.* 1987):

- Slope A: If undisturbed forest soil above the slope does not yield surface runoff, the top of slope starts with the edge of the undisturbed forest soil and extends down slope to the windrow, if runoff is concentrated by the windrow.
- Slope B: Point of origin of runoff to the windrow, if the runoff is concentrated by the windrow.
- Slope C: From windrow to flow concentration point.
- Slope D: Point of origin of runoff to road that concentrates runoff.
- Slope E: From road to flood plain where deposition would occur.
- Slope F: On nose of hill, from point of origin of runoff to flood plain where deposition would occur.
- Slope G: Point of origin of runoff to slight depression where runoff would concentrate

**Table 4-11. LS Values for Freshly Prepared Construction and other Highly Disturbed Soil, with Little, or no Cover (Renard, *et al.* 1987)**

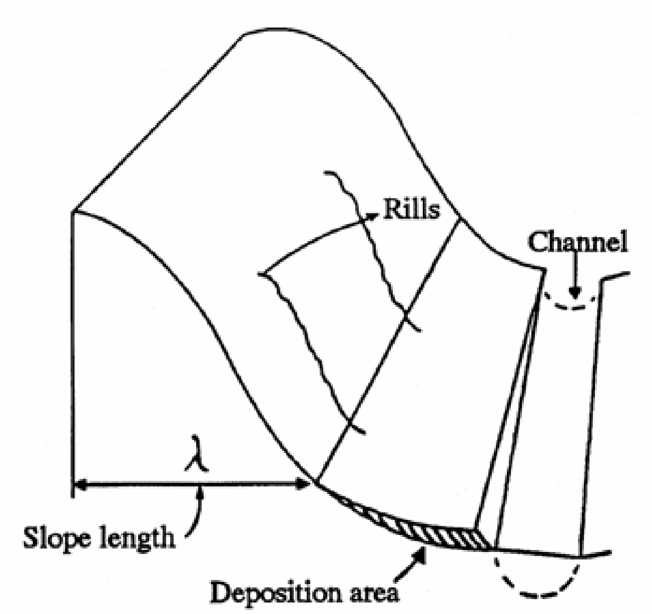


**Figure 4-9. Definition of slope length as used in RUSLE (Renard, *et al.* 1987).**

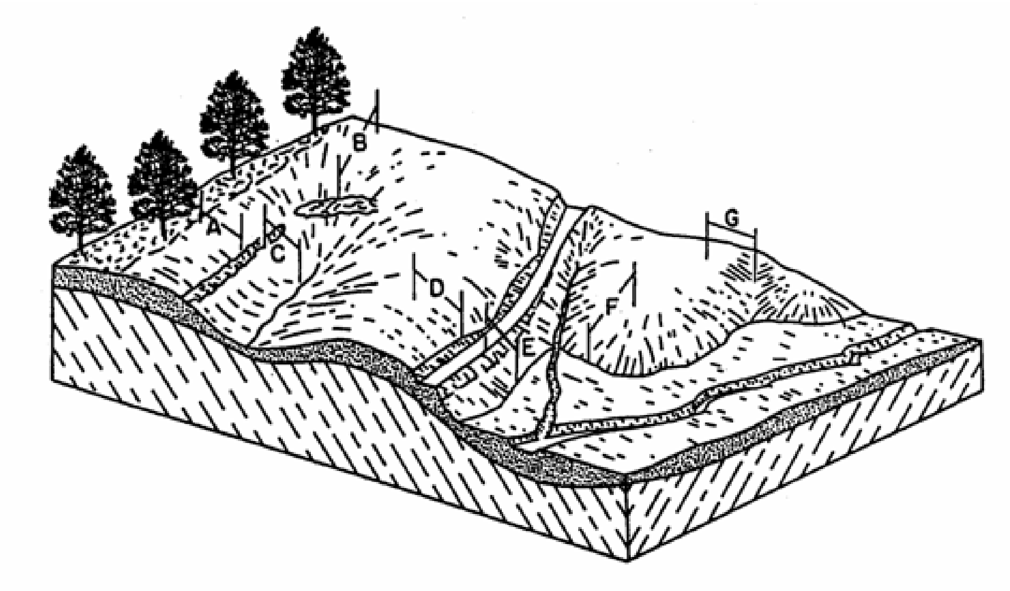


**Figure 4-10. Examples of different slope length measurements (Renard, *et al.* 1987).**

If ponding occurs on a site due to heavy rain intensities, low infiltration rates, and small slopes, the erosion loss will be substantially less than predicted using the above LS factors. The basic method to correct for this over-prediction is to estimate the land area subject to ponding and reduce the site area accordingly.

## *Cover Management Factor (C)*

The methods used to protect the soil surface will affect the amount of soil erosion that may occur. Wischmeier and Smith (1978) had some comments in their original USLE report pertaining to the model's applicability and use for construction sites. The following paragraphs are summarized from their prior discussion.

Site preparations that remove all vegetation and also the root zone of the soil not only leave the surface completely without protection, but also remove the residual effects of prior vegetation. This condition is comparable to the standard continuous fallow condition, and C = 1. Roots and residual effects of prior vegetation, and partial covers of mulch or vegetation, substantially reduce soil erosion. These reductions are reflected in the soil loss prediction by C values of less than 1.0.

### Mechanical Mulches

Applied mulches immediately restore protective cover on denuded areas and drastically reduce the C values. Where residual effects are insignificant, these values equal 1.0, the standard C factor value. Straw or hay mulches applied on steep construction slopes and not tied to the soil by anchoring and tacking equipment are usually less effective than equivalent mulch rates on relatively flat land.

Table 4-12 presents approximate C values for straw, crushed stone, and woodchip mulches on construction site slopes where no canopy cover exists. This table also shows the maximum slope lengths on which these values may be assumed to be applicable. These values are again from the original guidance from the 1978 USLE report and can now be better determined by making calculations based on specific site and rainfall conditions, as described in the following hydrology and slope stability chapters. Also, currently available mulching products and erosion control blankets offer a much greater range of options for controlling erosion on construction site slopes. However, the values given here are suitable for calculating the effects of a basic mulch.

**Table 4-12. Construction Site Mulching C Factors and Length Limits for Different Slopes (Wischmeier and Smith 1978)**

| Type of Mulch | Mulch Rate (tons per acre) | Land Slope (%) | Mulching C Factor | Length Limit (ft)[1] |
|---|---|---|---|---|
| None | 0 | all | 1.0 | n/a |
| Straw or hay, tied down by anchoring and tacking equipment | 1.0 | 1-5 | 0.20 | 200 |
| | 1.0 | 6-10 | 0.20 | 100 |
| | 1.5 | 1-5 | 0.12 | 300 |
| | 1.5 | 6-10 | 0.12 | 150 |
| | 2.0 | 1-5 | 0.06 | 400 |
| | 2.0 | 6-10 | 0.06 | 200 |
| | 2.0 | 11-15 | 0.07 | 150 |
| | 2.0 | 16-20 | 0.11 | 100 |
| | 2.0 | 21-25 | 0.14 | 75 |
| | 2.0 | 26-33 | 0.17 | 50 |
| | 2.0 | 34-50 | 0.20 | 35 |
| Crushed stone, ¼ to 1-1/2 inch | 135 | <16 | 0.05 | 200 |
| | 135 | 16-20 | 0.05 | 150 |
| | 135 | 21-33 | 0.05 | 100 |
| | 135 | 34-50 | 0.05 | 75 |
| | 240 | <21 | 0.02 | 300 |
| | 240 | 21-33 | 0.02 | 200 |
| | 240 | 34-50 | 0.02 | 150 |
| Wood chips | 7 | <16 | 0.08 | 75 |
| | 7 | 16-20 | 0.08 | 50 |
| | 12 | <16 | 0.05 | 150 |
| | 12 | 16-20 | 0.05 | 100 |
| | 12 | 21-33 | 0.05 | 75 |
| | 25 | <16 | 0.02 | 200 |
| | 25 | 16-20 | 0.02 | 150 |
| | 25 | 21-33 | 0.02 | 100 |
| | 25 | 34-50 | 0.02 | 75 |

[1] Maximum slope lengths for which the specified mulch rate is considered effective. If these limits are exceeded, either a higher application rate or mechanical shortening of the effective slope length is required (such as with terracing).

The percentage mulch cover is what generally determines the effectiveness of the mulch. This is the percentage of the soil surface that is covered by pieces of mulch laying on the surface. According to Wischmeier and Smith (1978), a simple method of estimating mulch cover is with a line at least 50 ft. long that has 100 equally spaced markings. The line is stretched over the mulched surface and the marks that contact a piece of mulch are counted. The number of counted marks indicate the percentage coverage of mulch on the site. This is repeated randomly on the site to obtain an average value along with an indication of the variation. Table 4-13 shows the approximate percentage coverage for different mulching rates for straw, along with the range of erosion control indicated in Table 4-12 (Wischmeier and Smith 1978).

**Table 4-13. Straw Mulching Rates, Approximate Coverage and Corresponding Erosion Control (data from Wischmeier and Smith 1978)**

| Straw mulch rate (tons per acre) | Percent coverage | Erosion control |
|---|---|---|
| 0.10 | 10% | |
| 0.25 | 30 | |
| 0.5 | 50 | |
| 1.0 | 70 | 80% |
| 1.5 | 84 | 88% |
| 2.0 | 92 | 80 to 94% |
| 2.5 | 96 | |
| 3.0 | 97 | |

### Vegetative Covers

It is very important to establish vegetation on denuded areas as quickly as possible. A good sod has a C value of 0.01, or less, 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 standard procedure for estimating crop stage-period soil losses. If the seeding is on topsoil, without a mulch, the soil loss ratios given in Table 4-14 are appropriate for crop stage C values.

**Table 4-14. Cover Factor C Values for Different Growth Periods for Planted Cover Crops for Erosion Control at Construction Sites (data from Wischmeier and Smith 1978)**

| | SB (seedbed preparation) | Period 1 (establishment) | Period 2 (development) | Period 3a (maturing crop) | Period 3b (maturing crop) | Period 3c (maturing crop) |
|---|---|---|---|---|---|---|
| Crop canopy[1] | 0 to 10% | 10 to 50% | 50 to 75% | 75 to 80% | 75 to 90% | 75 to 96% |
| Seeding is on topsoil, without a mulch | 0.79 | 0.62 | 0.42 | 0.17 | 0.11 | 0.06 |
| Seeding is on a desurfaced area, where residual effects of prior vegetation are no longer significant | 1.0 | 0.75 | 0.50 | 0.17 | 0.11 | 0.06 |

[1] Percent canopy cover is the percentage of the land surface that would not be hit by directly falling rain drops because the drops would be intercepted by the plant. It is the portion of the soil surface that would be covered by shadows if the sun were directly overhead.

When the seedbed is protected by a mulch, the pertinent mulch factor from Table 4-12 is applicable until good canopy cover is attained. When grass is established in small grain as a nurse crop, it can usually be evaluated as established meadow about 2 months after the grain is cut, after which values in the following discussion can be used.

Table 4-15 (from the NRCS's current National Engineering Handbook) lists cover management C factors for land covers, with no trees. This table can be applied to construction sites having temporary or permanent vegetative covers, or mulches. It indicates the improved erosion control as the ground coverage increases. With good coverage (more than 80% ground cover), the erosion control could be 95%, or greater. These values assume that the vegetation or mulch is randomly distributed over the entire area. In areas with canopies where the rain drops have much less effective drop heights, and correspondingly less energy, the C factors are further decreased. A mechanically prepared site with no topsoil and no forest residue mixed in would have a C close to 1.0, if no cover was applied. With an 80% cover of mulch, this type of site (indicative of most construction sites) would have about 90% erosion control. In comparison, the C factor for a woodland with 100 percent duff cover (partly decayed organic matter on the forest floor) would be a low 0.0001 (99.99% erosion control), the lowest reported value.

**Table 4-15. Cover Factor C Values for Established Plants (data from NEH chapter 3 and Wischmeier and Smith 1978)**

| | | | Percentage of surface covered by residue in contact with the soil: | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Percent cover[1] | Plant type | 0 % | 20 | 40 | 60 | 80 | 95+ |
| C factor for grass, grasslike plants, or decaying compacted plant litter. | 0 | Grass | 0.45 | 0.20 | 0.10 | 0.042 | 0.013 | 0.003 |
| C factor for broadleaf herbaceous plants (including most weeds with little lateral root networks), or undecayed residues. | 0 | Weeds | 0.45 | 0.24 | 0.15 | 0.091 | 0.043 | 0.011 |
| Tall weeds or short brush with average drop height[2] of ≥20 inches | 25 | Grass | 0.36 | 0.17 | 0.09 | 0.038 | 0.013 | 0.003 |
| | | Weeds | 0.36 | 0.20 | 0.13 | 0.083 | 0.041 | 0.011 |
| | 50 | Grass | 0.26 | 0.13 | 0.07 | 0.035 | 0.012 | 0.003 |
| | | Weeds | 0.26 | 0.16 | 0.11 | 0.076 | 0.039 | 0.011 |
| | 75 | Grass | 0.17 | 0.10 | 0.06 | 0.032 | 0.011 | 0.003 |
| | | Weeds | 0.17 | 0.12 | 0.09 | 0.068 | 0.038 | 0.011 |
| Mechanically prepared sites, with no live vegetation and no topsoil, and no litter mixed in. | 0 | None | 0.94 | 0.44 | 0.30 | 0.20 | 0.10 | Not given |

[1] percent cover is the portion of the total area surface that would be hidden from view by canopy if looking straight downward.

[2] drop height is the average fall height of water drops falling from the canopy to the ground.

## *Supporting Practices Factor (P)*

The method of tillage and crop rotations all affect the soil erosion rate for an agricultural operation. This factor is rarely applicable for construction sites and is therefore given a value of 1.0 for this application, although some construction site erosion decision support models use the P factor when considering the effects of on-site controls (Dion 2002). Other chapters in this book describe specific hydrologic and sediment transport functions that enable these effects to be directly calculated for specific site and design conditions.

## Summary

This chapter introduced the Revised Universal Soil Loss Equation (RUSLE) and presented some specific information for using this model for construction sites. This summary will outline and give examples of how this information can be used to calculate the estimated soil erosion losses for construction sites.

### *Basic Predictions of Soil Losses from a Construction Site*

Construction site evaluations have several dimensions: different construction phases lasting for different time periods, different soils on different locations and at different times reflecting cut and fill operations, changes in the gradients and lengths of slopes, and varying cover conditions. Therefore, in order to conduct a site evaluation, these different dimensions need to be clearly organized.

**Construction Phases**

The most basic dimension is understanding the construction phasing, beginning with site clearing and grubbing to final contouring. The basic time phases of interest for erosion evaluation and control may include the following:

1) install downslope sediment controls (filter fencing and sediment ponds)
2) install upslope diversions and protect on-site channels that will remain (diversion berms and swales, channel lining, establish buffers, and filter fencing)
3) first area clearing and grubbing (minimize area exposed and time to complete phase)
4) first area final contouring (stabilize exposed areas before moving on to next area)
5) repeat above 2 steps for all other areas, dividing the whole planned disturbed construction site into areas as small as possible
6) establish roadways and parking areas and install utilities (leaving road bed base, or preliminary pavement, protect inlets, etc.)
7) building erection (provide adequate storage for materials and for construction vehicle parking, practice good housekeeping, etc.)
8) final landscaping (remove temporary controls, replace with permanent stormwater facilities, irrigate vegetation until established)

**Site Information**

Site layouts and erosion control plans are needed for each major phase that alters the construction site contours and soil cover. Specifically, RUSLE should be applied for the initial clearing and grubbing operation for the site reflecting the final contouring, and the final phases during roadway and utility construction and building erection. As indicated above, it is hoped that the site can be divided into smaller units where the clearing to final contouring operations can be completed as rapidly as possible, and temporary soil protection can then be applied before moving to the next area. Obviously, small areas, and sites where massive grading is needed over most of the site simultaneously, will prevent this type of phasing. In this situation, the objective will be to complete the grading quickly, and to hopefully schedule it during periods when the erosion potential is reduced.

During each phase, the following site information will be needed to use RUSLE:

1) expected start and finish dates, and corresponding “partial” R based on monthly rain variations
2) surface soil K values
3) different slopes areas over the site to help calculate the LS factor
4) type of mulch or vegetated cover

The LS factor may be the most confusing for a developing site. Basically, the site will need to be divided into separate sections for each slope, from the ridges to the toe of the slopes. The R factor will be uniformly applied to the whole site for each phase period, and the soil maps will help indicate the appropriate K factors. Therefore, the RUSLE will need to be applied for each separate slope. The complete site will need to be represented, even for undisturbed areas (using natural cover conditions). As an example, a site may be represented by the conditions in Table 4-16. The conditions for each site area need to be fully described, a map needs to be prepared showing the site areas, and the resulting factors, and calculated soil losses, can be displayed in a table such as this. This type of analysis also has the advantage of high-lighting areas responsible for most of the site erosion, possibly leading to further modifications. If these eroding soils are mostly clay loams, the total volume of sediment eroded from this site during this period would be approximately 1.02(49.64 tons)

= 51 cubic yards. This would be an important consideration when designing a sediment pond downstream of these eroding areas.

**Table 4-16. Example Basic RUSLE Calculations for a Construction Site Final Grading Phase**

| Site area designations | Area description | Land area (acres) | R for phase period (March 5 to July 31)[1] | K soil factor[2] | LS slope length factor | C cover factor[3] | Calculated unit area soil loss (tons/acre/period) | Calculated total area soil loss (tons/period) |
|---|---|---|---|---|---|---|---|---|
| 1a | Undisturbed area | 1.51 | 196 | 0.15 | 0.30 | 0.001 | 0.01 | 0.01 |
| 1b | Undisturbed area | 3.72 | 196 | 0.17 | 0.68 | 0.005 | 0.11 | 0.42 |
| 2 | Road cut | 0.54 | 196 | 0.28 | 2.67 | 0.02 | 2.93 | 1.58 |
| 3 | Road cut | 1.37 | 196 | 0.37 | 4.59 | 0.02 | 6.66 | 9.12 |
| 4a | Main embankment | 0.84 | 196 | 0.28 | 0.40 | 0.55 | 12.07 | 10.14 |
| 4b | Main embankment | 0.33 | 196 | 0.37 | 4.56 | 0.17 | 56.22 | 18.55 |
| 4c | Main embankment | 1.15 | 196 | 0.17 | 3.09 | 0.07 | 7.21 | 8.29 |
| 5 | Parking area | 10.5 | 196 | 0.28 | 0.06 | 0.02 | 0.07 | 0.69 |
| 6 | Building areas | 5.53 | 196 | 0.35 | 0.06 | 0.02 | 0.08 | 0.46 |
| 7a | Road segment | 0.26 | 196 | 0.17 | 0.57 | 0.02 | 0.38 | 0.10 |
| 7b | Road segment | 0.95 | 196 | 0.28 | 0.22 | 0.02 | 0.24 | 0.23 |
| 7c | Road segment | 0.37 | 196 | 0.28 | 0.10 | 0.02 | 0.11 | 0.04 |
| | | | | | | | | |
| Total site | | 27.07 | | | | | | 49.64 |

[1] 56% of annual R; annual R is 350, so project phase partial R is: (0.56)(350) = 196

[2] from county soil map and anticipated surface soils during this phase

[3] C factors based on native good cover for undisturbed areas, erosion control mats for road cuts, planted vegetation or tacked mulches on embankments, and gravel pads for parking, building, and road areas. The vegetation C factor was calculated based on plant growth stages during this construction phase.

The calculated erosion rate for this site for this period is quite low, being only about 2 tons per acre for this 5 month period. Obviously, this rate represents the established values represented by the low C factors. The erosion rates for earlier phases during active grading would be much higher. This is an example of the excellent erosion control that is possible using modern techniques.

## *Evaluating Timing Options for Construction Operations*

Timing of specific construction operations may have an important effect on the estimated soil erosion rate. As an example, the distribution of rainfall energy in Alabama (Table 4-6) indicates that for most of the state, June through September is the period having the highest erosion potential. These 4 months have about half of the total annual erosion rainfall related energy. October through February are usually the driest Alabama months, with about 30% of the annual rainfall related energy occurring during these 5 months. Therefore, if possible, construction activities near sensitive waters could beneficially be scheduled during these drier months, but highly erosive rains may still occur during any period of the year.

Planning for vegetative covers also must consider the growing season and the need for supplemental irrigation. Table 4-14 showed how the C cover factors dramatically change for different growth stages. Obviously, plants that rapidly germinate, become established, and mature early, are important for erosion control. Mature crops with extensive canopies are also desired. Local NRCS and agricultural extension services can provide suitable lists of plants with these attributes. If using erosion control mats or sod, differences in cover C factors are not very large, and excellent control is available as soon as these are installed. This is especially important for channel linings. If relying on seeded plantings, several weeks to months may pass before the C factor reduces to less than 0.25 for slopes, and much more time is needed to establish a strengthen root system to withstand flowing waters. However, because of the high costs of erosion control mats, they are usually only used in the most critical areas, and less expensive mulches over prepared seed beds are used whenever possible. Information presented in later chapters allow site hydrologic conditions and associated shear stresses to be calculated for specific site conditions, allowing the most efficient use of the different cover products.

### *Comparing Different Slope Design Options*

The information presented in Table 4-11 enables the erodibility of different slope conditions to be evaluated. In most cases, these conditions cannot be changed easily, as they were established for the most cost-effective development options. However, it is obvious that very steep slopes are not a good idea. Erosion on slopes greater than 15% can dominate the total erosion from a construction site. Similarly, efforts should be made to terrace long slopes, shortening the flow paths down their embankments. Later chapters will outline the procedures for evaluating specific erodibility and erosion control solutions for slopes.

Terracing can be considered as a control option with relatively little effect on the use of the land. Long slopes can be divided into separate sections with great benefit, with the terraces built as diversion swales to carry the accumulated water to a collection point. A reinforced drop chute can then be used to minimize the water flowing across downslope areas. Table 4-17 illustrates some options for modifying slopes with terracing. The slope angles will increase as slope length is decreased by the width of the terrace/diversion, which would somewhat offset the decrease in slope length, if no additional land was to be used for the slope. This table shows that significant reductions in expected erosion can occur with terracing, even with the increased slopes. The largest benefits are likely associated with steeper initial slopes. Of course, almost all slopes will need to be stabilized with erosion control mats (likely if steep), or at least tacked mulches (if less steep and relatively short). These slope protection calculations are presented in a later chapter and will show that terracing will also decrease the cost of this needed slope protection.

**Table 4-17. Alternative Slope Configurations and Corresponding Reductions in Erosion**

| Original Slope | | | Alternative Terrace 1 | | | | Alternative Terrace 2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Slope** | **Length** | **LS factor** | **New slope** | **Length (and terrace width)** | **Approx. new LS factor** | **Estimated erosion reduction** | **New slope** | **Length (and terrace width)** | **Approx. new LS factor** | **Estimated erosion reduction** |
| 0.5% | 300 ft. | 0.10 | 0.54% | 140 (10) ft. | 0.095 | 5% | 0.56% | 45 (5) ft. | 0.09 | 10% |
| 3.0 | 300 | 0.69 | 3.2 | 140 (10) | 0.51 | 26 | 3.3 | 45 (5) | 0.29 | 58 |
| 10 | 300 | 3.09 | 10.7 | 140 (10) | 1.9 | 39 | 11.1 | 45 (5) | 1.0 | 68 |
| 25 | 300 | 10.81 | 26.8 | 140 (10) | 6.0 | 44 | 27.8 | 45 (5) | 2.8 | 74 |
| 50 | 300 | 22.57 | 53.6 | 140 (10) | 10.6 | 53 | 55.6 | 45 (5) | 5.0 | 78 |

### *Predicting the Benefits of Alternative Mulches*

The USLE (and now the RUSLE) has long been used to estimate the benefits of different management systems on reducing the erosion rate. This has mostly been done by estimating C and P values for different control strategies. Mulches have been directly studied at many erosion test plots, enabling some basic C factors to be determined, as shown in Table 4-12. These earlier determined C factors have not included the modern erosion control mats. Many of the mat producers have sponsored independent evaluations for C factors and tolerable shear stress conditions to enable suitable selection of different materials. Later chapters present this additional information.

## Important Links

The RUSLE web site includes complete documentation and much additional information, mostly applicable for agricultural operations.

http://www.sedlab.olemiss.edu/rusle/

The Alabama Soil and Water Conservation Committee web site includes locations and contacts for local USDA/NRCS offices where soil information can be obtained. They are also preparing an updated version to the 1993 *Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas*.

http://www.swcc.state.al.us/

Both of these sites include many additional links to associated material.

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## Appendix 4-A. Erosivity Indices by Location and Erosion Variations by Season

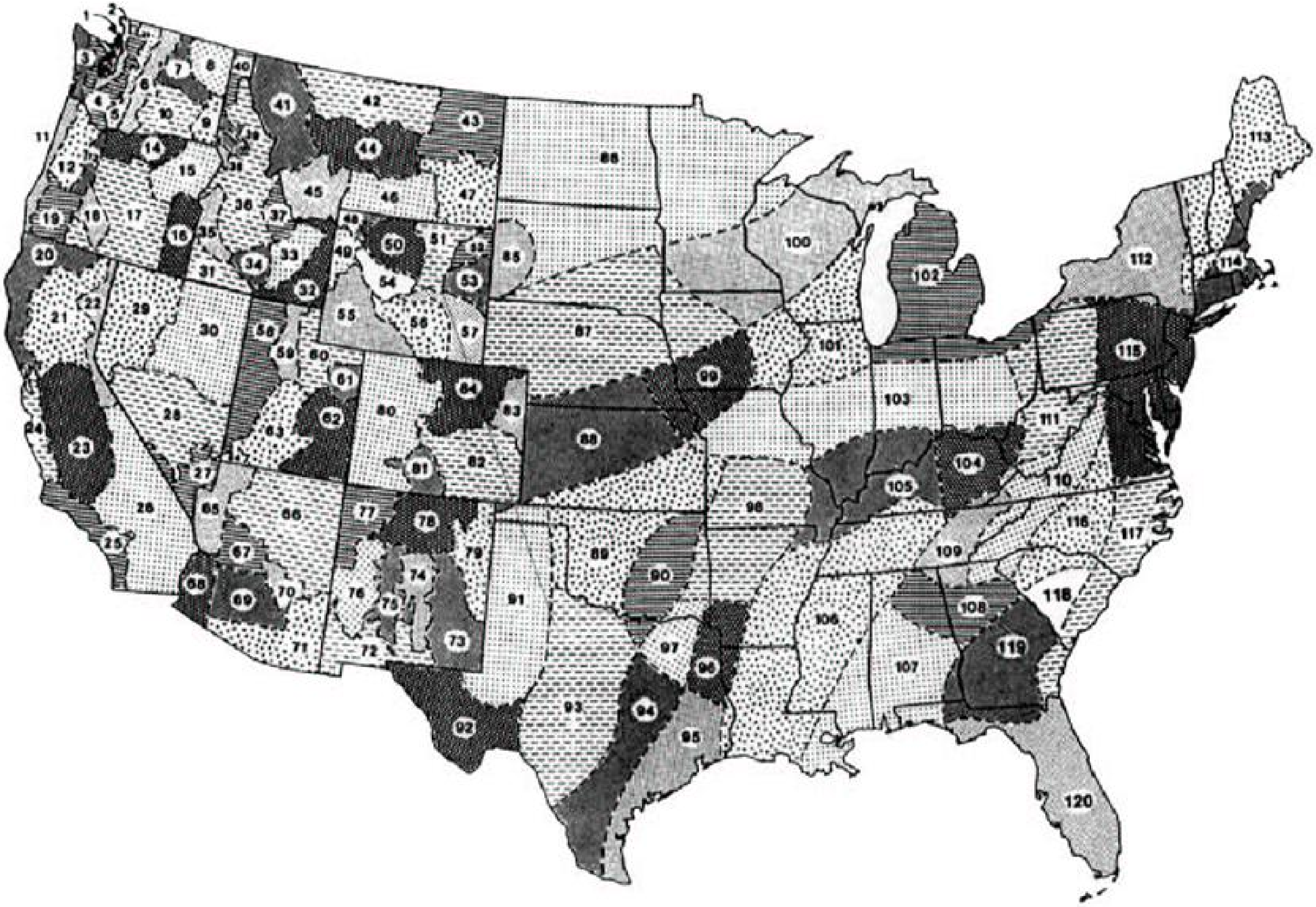
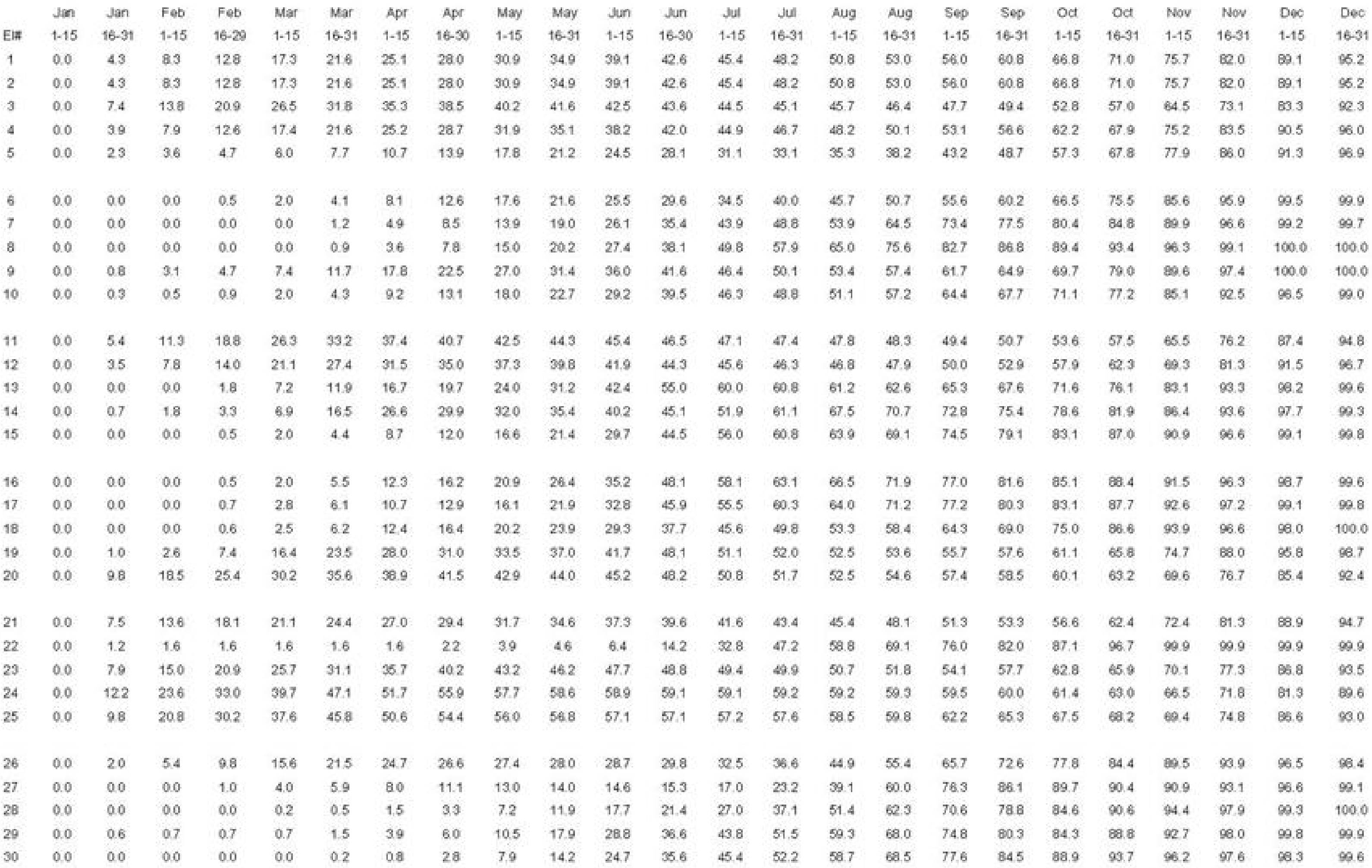


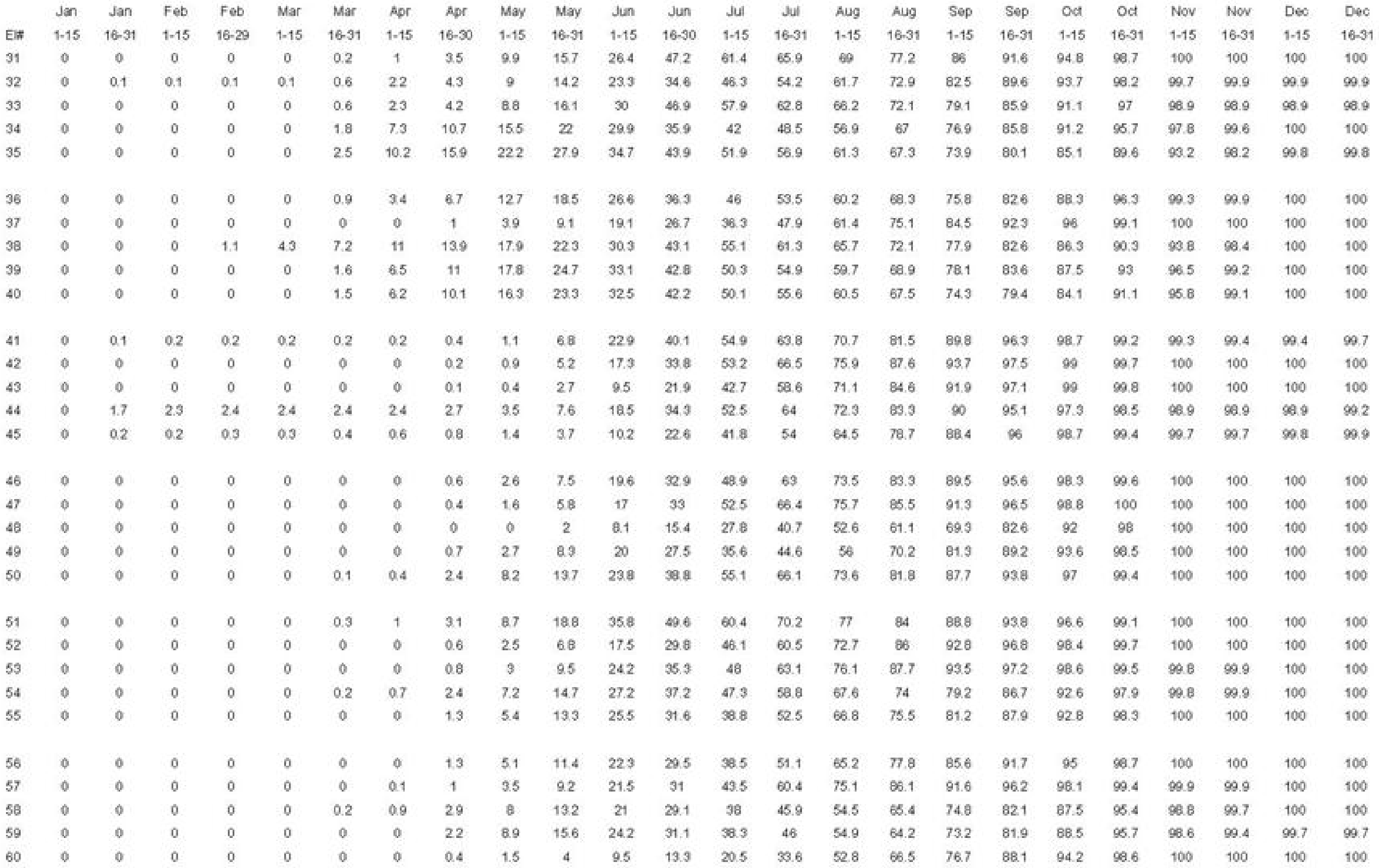
**Figure 4A. Erosivity index zone map (EPA 2001).**

**Table 4A. Erosivity Index Table (EI as a percentage of the annual average R, computed for geographical areas) (Source: EPA 2001)**



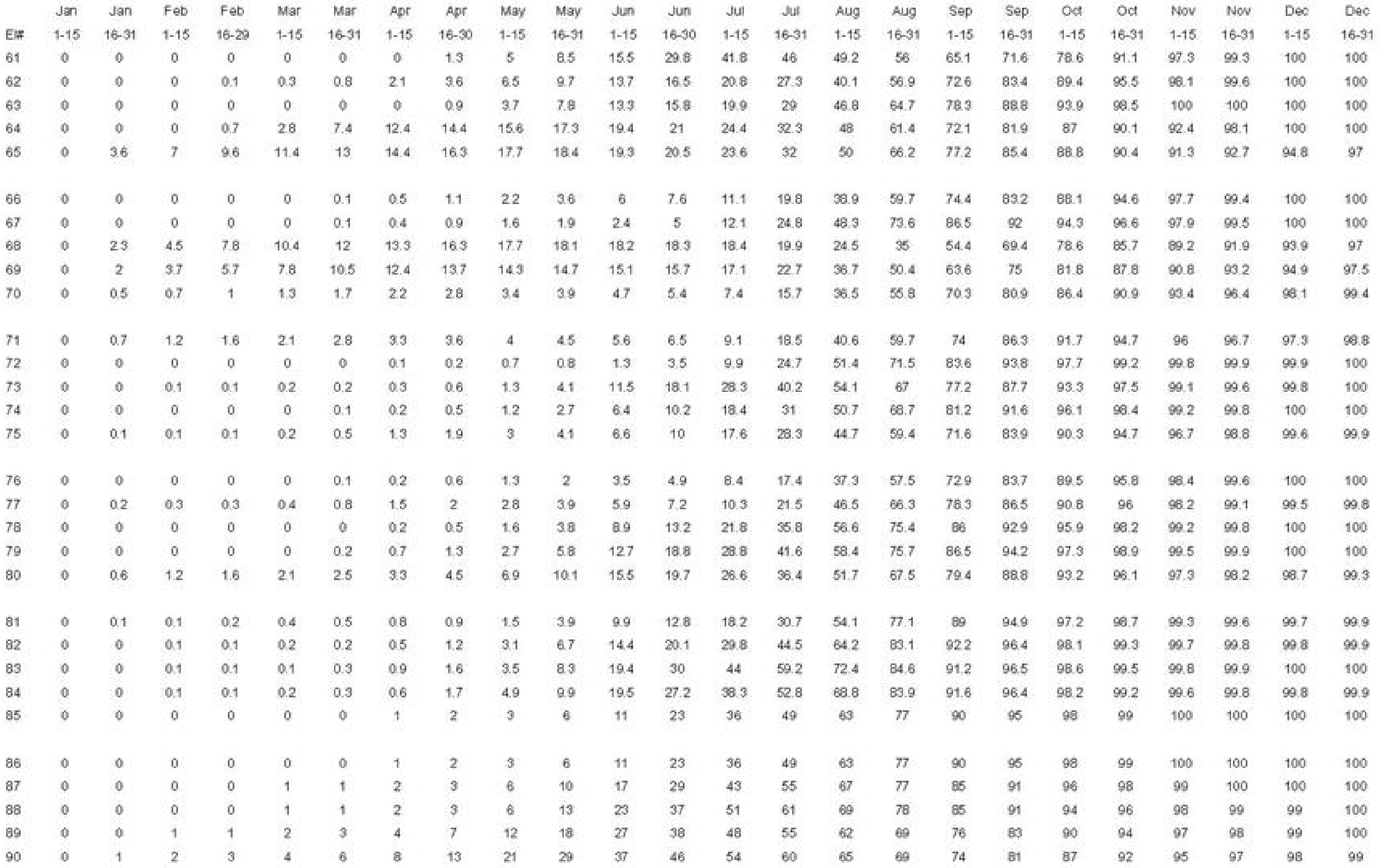
| | Jan | Jan | Feb | Feb | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sep | Sep | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI# | 1-15 | 16-31 | 1-15 | 16-29 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 |
| 1 | 0.0 | 4.3 | 8.3 | 12.8 | 17.3 | 21.6 | 25.1 | 28.0 | 30.9 | 34.9 | 39.1 | 42.6 | 45.4 | 48.2 | 50.8 | 53.0 | 56.0 | 60.8 | 66.8 | 71.0 | 75.7 | 82.0 | 89.1 | 95.2 |
| 2 | 0.0 | 4.3 | 8.3 | 12.8 | 17.3 | 21.6 | 25.1 | 28.0 | 30.9 | 34.9 | 39.1 | 42.6 | 45.4 | 48.2 | 50.8 | 53.0 | 56.0 | 60.8 | 66.8 | 71.0 | 75.7 | 82.0 | 89.1 | 95.2 |
| 3 | 0.0 | 7.4 | 13.8 | 20.9 | 26.5 | 31.8 | 35.3 | 38.5 | 40.2 | 41.6 | 42.5 | 43.6 | 44.5 | 45.1 | 45.7 | 46.4 | 47.7 | 49.4 | 52.8 | 57.0 | 64.5 | 73.1 | 83.3 | 92.3 |
| 4 | 0.0 | 3.9 | 7.9 | 12.6 | 17.4 | 21.6 | 25.2 | 28.7 | 31.9 | 35.1 | 38.2 | 42.0 | 44.9 | 46.7 | 48.2 | 50.1 | 53.1 | 56.6 | 62.2 | 67.9 | 75.2 | 83.5 | 90.5 | 96.0 |
| 5 | 0.0 | 2.3 | 3.6 | 4.7 | 6.0 | 7.7 | 10.7 | 13.9 | 17.8 | 21.2 | 24.5 | 28.1 | 31.1 | 33.1 | 35.3 | 38.2 | 43.2 | 48.7 | 57.3 | 67.8 | 77.9 | 86.0 | 91.3 | 96.9 |
| 6 | 0.0 | 0.0 | 0.0 | 0.5 | 2.0 | 4.1 | 8.1 | 12.6 | 17.6 | 21.6 | 25.5 | 29.6 | 34.5 | 40.0 | 45.7 | 50.7 | 55.6 | 60.2 | 66.5 | 75.5 | 85.6 | 95.9 | 99.5 | 99.9 |
| 7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 4.9 | 8.5 | 13.9 | 19.0 | 26.1 | 35.4 | 43.9 | 48.8 | 53.9 | 64.5 | 73.4 | 77.5 | 80.4 | 84.8 | 89.9 | 96.6 | 99.2 | 99.7 |
| 8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.9 | 3.6 | 7.8 | 15.0 | 20.2 | 27.4 | 38.1 | 49.8 | 57.9 | 65.0 | 75.6 | 82.7 | 86.8 | 89.4 | 93.4 | 96.3 | 99.1 | 100.0 | 100.0 |
| 9 | 0.0 | 0.8 | 3.1 | 4.7 | 7.4 | 11.7 | 17.8 | 22.5 | 27.0 | 31.4 | 36.0 | 41.6 | 46.4 | 50.1 | 53.4 | 57.4 | 61.7 | 64.9 | 69.7 | 79.0 | 89.6 | 97.4 | 100.0 | 100.0 |
| 10 | 0.0 | 0.3 | 0.5 | 0.9 | 2.0 | 4.3 | 9.2 | 13.1 | 18.0 | 22.7 | 29.2 | 39.5 | 46.3 | 48.8 | 51.1 | 57.2 | 64.4 | 67.7 | 71.1 | 77.2 | 85.1 | 92.5 | 96.5 | 99.0 |
| 11 | 0.0 | 5.4 | 11.3 | 18.8 | 26.3 | 33.2 | 37.4 | 40.7 | 42.5 | 44.3 | 45.4 | 46.5 | 47.1 | 47.4 | 47.8 | 48.3 | 49.4 | 50.7 | 53.6 | 57.5 | 65.5 | 76.2 | 87.4 | 94.8 |
| 12 | 0.0 | 3.5 | 7.8 | 14.0 | 21.1 | 27.4 | 31.5 | 35.0 | 37.3 | 39.8 | 41.9 | 44.3 | 45.6 | 46.3 | 46.8 | 47.9 | 50.0 | 52.9 | 57.9 | 62.3 | 69.3 | 81.3 | 91.5 | 96.7 |
| 13 | 0.0 | 0.0 | 0.0 | 1.8 | 7.2 | 11.9 | 16.7 | 19.7 | 24.0 | 31.2 | 42.4 | 55.0 | 60.0 | 60.8 | 61.2 | 62.6 | 65.3 | 67.6 | 71.6 | 76.1 | 83.1 | 93.3 | 98.2 | 99.6 |
| 14 | 0.0 | 0.7 | 1.8 | 3.3 | 6.9 | 16.5 | 26.6 | 29.9 | 32.0 | 35.4 | 40.2 | 45.1 | 51.9 | 61.1 | 67.5 | 70.7 | 72.8 | 75.4 | 78.6 | 81.9 | 86.4 | 93.6 | 97.7 | 99.3 |
| 15 | 0.0 | 0.0 | 0.0 | 0.5 | 2.0 | 4.4 | 8.7 | 12.0 | 16.6 | 21.4 | 29.7 | 44.5 | 56.0 | 60.8 | 63.9 | 69.1 | 74.5 | 79.1 | 83.1 | 87.0 | 90.9 | 96.6 | 99.1 | 99.8 |
| 16 | 0.0 | 0.0 | 0.0 | 0.5 | 2.0 | 5.5 | 12.3 | 16.2 | 20.9 | 26.4 | 35.2 | 48.1 | 58.1 | 63.1 | 66.5 | 71.9 | 77.0 | 81.6 | 85.1 | 88.4 | 91.5 | 96.3 | 98.7 | 99.6 |
| 17 | 0.0 | 0.0 | 0.0 | 0.7 | 2.8 | 6.1 | 10.7 | 12.9 | 16.1 | 21.9 | 32.8 | 45.9 | 55.5 | 60.3 | 64.0 | 71.2 | 77.2 | 80.3 | 83.1 | 87.7 | 92.6 | 97.2 | 99.1 | 99.8 |
| 18 | 0.0 | 0.0 | 0.0 | 0.6 | 2.5 | 6.2 | 12.4 | 16.4 | 20.2 | 23.9 | 29.3 | 37.7 | 45.6 | 49.8 | 53.3 | 58.4 | 64.3 | 69.0 | 75.0 | 86.6 | 93.9 | 96.6 | 98.0 | 100.0 |
| 19 | 0.0 | 1.0 | 2.6 | 7.4 | 16.4 | 23.5 | 28.0 | 31.0 | 33.5 | 37.0 | 41.7 | 48.1 | 51.1 | 52.0 | 52.5 | 53.6 | 55.7 | 57.6 | 61.1 | 65.8 | 74.7 | 88.0 | 95.8 | 98.7 |
| 20 | 0.0 | 9.8 | 18.5 | 25.4 | 30.2 | 35.6 | 38.9 | 41.5 | 42.9 | 44.0 | 45.2 | 48.2 | 50.8 | 51.7 | 52.5 | 54.6 | 57.4 | 58.5 | 60.1 | 63.2 | 69.6 | 76.7 | 85.4 | 92.4 |
| 21 | 0.0 | 7.5 | 13.6 | 18.1 | 21.1 | 24.4 | 27.0 | 29.4 | 31.7 | 34.6 | 37.3 | 39.6 | 41.6 | 43.4 | 45.4 | 48.1 | 51.3 | 53.3 | 56.6 | 62.4 | 72.4 | 81.3 | 88.9 | 94.7 |
| 22 | 0.0 | 1.2 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 2.2 | 3.9 | 4.6 | 6.4 | 14.2 | 32.8 | 47.2 | 58.8 | 69.1 | 76.0 | 82.0 | 87.1 | 96.7 | 99.9 | 99.9 | 99.9 | 99.9 |
| 23 | 0.0 | 7.9 | 15.0 | 20.9 | 25.7 | 31.1 | 35.7 | 40.2 | 43.2 | 46.2 | 47.7 | 48.8 | 49.4 | 49.9 | 50.7 | 51.8 | 54.1 | 57.7 | 62.8 | 65.9 | 70.1 | 77.3 | 86.8 | 93.5 |
| 24 | 0.0 | 12.2 | 23.6 | 33.0 | 39.7 | 47.1 | 51.7 | 55.9 | 57.7 | 58.6 | 58.9 | 59.1 | 59.1 | 59.2 | 59.2 | 59.3 | 59.5 | 60.0 | 61.4 | 63.0 | 66.5 | 71.8 | 81.3 | 89.6 |
| 25 | 0.0 | 9.8 | 20.8 | 30.2 | 37.6 | 45.8 | 50.6 | 54.4 | 56.0 | 56.8 | 57.1 | 57.1 | 57.2 | 57.6 | 58.5 | 59.8 | 62.2 | 65.3 | 67.5 | 68.2 | 69.4 | 74.8 | 86.6 | 93.0 |
| 26 | 0.0 | 2.0 | 5.4 | 9.8 | 15.6 | 21.5 | 24.7 | 26.6 | 27.4 | 28.0 | 28.7 | 29.8 | 32.5 | 36.6 | 44.9 | 55.4 | 65.7 | 72.6 | 77.8 | 84.4 | 89.5 | 93.9 | 96.5 | 98.4 |
| 27 | 0.0 | 0.0 | 0.0 | 1.0 | 4.0 | 5.9 | 8.0 | 11.1 | 13.0 | 14.0 | 14.6 | 15.3 | 17.0 | 23.2 | 39.1 | 60.0 | 76.3 | 86.1 | 89.7 | 90.4 | 90.9 | 93.1 | 96.6 | 99.1 |
| 28 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.5 | 1.5 | 3.3 | 7.2 | 11.9 | 17.7 | 21.4 | 27.0 | 37.1 | 51.4 | 62.3 | 70.6 | 78.8 | 84.6 | 90.6 | 94.4 | 97.9 | 99.3 | 100.0 |
| 29 | 0.0 | 0.6 | 0.7 | 0.7 | 0.7 | 1.5 | 3.9 | 6.0 | 10.5 | 17.9 | 28.8 | 36.6 | 43.8 | 51.5 | 59.3 | 68.0 | 74.8 | 80.3 | 84.3 | 88.8 | 92.7 | 98.0 | 99.8 | 99.9 |
| 30 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.8 | 2.8 | 7.9 | 14.2 | 24.7 | 35.6 | 45.4 | 52.2 | 58.7 | 68.5 | 77.6 | 84.5 | 88.9 | 93.7 | 96.2 | 97.6 | 98.3 | 99.6 |

**Table 4A. Erosivity Index Table (cont.)**



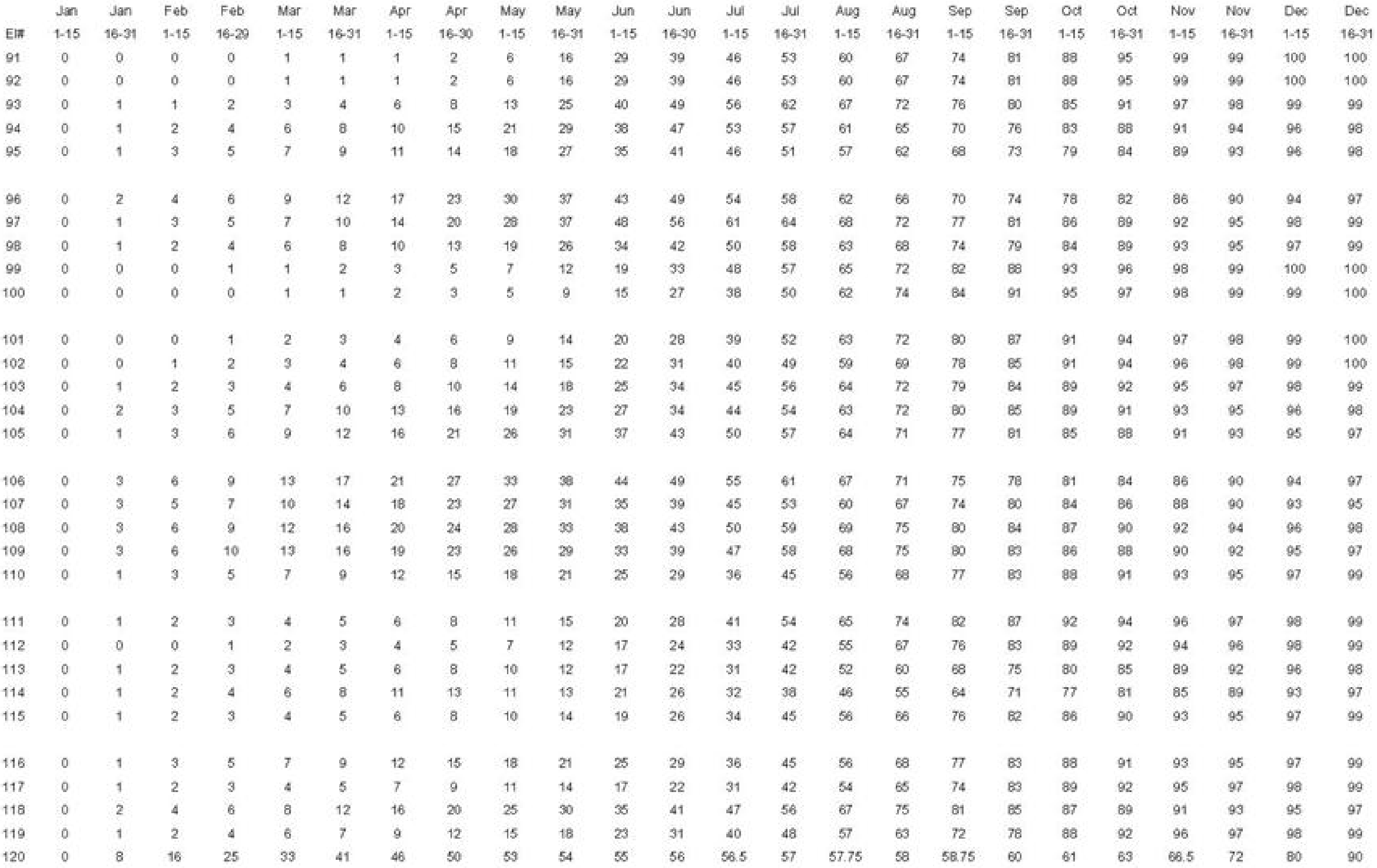
| | Jan | Jan | Feb | Feb | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sep | Sep | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI# | 1-15 | 16-31 | 1-15 | 16-29 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0.2 | 1 | 3.5 | 9.9 | 15.7 | 26.4 | 47.2 | 61.4 | 65.9 | 69 | 77.2 | 86 | 91.6 | 94.8 | 98.7 | 100 | 100 | 100 | 100 |
| 32 | 0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.6 | 2.2 | 4.3 | 9 | 14.2 | 23.3 | 34.6 | 46.3 | 54.2 | 61.7 | 72.9 | 82.5 | 89.6 | 93.7 | 98.2 | 99.7 | 99.9 | 99.9 | 99.9 |
| 33 | 0 | 0 | 0 | 0 | 0 | 0.6 | 2.3 | 4.2 | 8.8 | 16.1 | 30 | 46.9 | 57.9 | 62.8 | 66.2 | 72.1 | 79.1 | 85.9 | 91.1 | 97 | 98.9 | 98.9 | 98.9 | 98.9 |
| 34 | 0 | 0 | 0 | 0 | 0 | 1.8 | 7.3 | 10.7 | 15.5 | 22 | 29.9 | 35.9 | 42 | 48.5 | 56.9 | 67 | 76.9 | 85.8 | 91.2 | 95.7 | 97.8 | 99.6 | 100 | 100 |
| 35 | 0 | 0 | 0 | 0 | 0 | 2.5 | 10.2 | 15.9 | 22.2 | 27.9 | 34.7 | 43.9 | 51.9 | 56.9 | 61.3 | 67.3 | 73.9 | 80.1 | 85.1 | 89.6 | 93.2 | 98.2 | 99.8 | 99.8 |
| 36 | 0 | 0 | 0 | 0 | 0 | 0.9 | 3.4 | 6.7 | 12.7 | 18.5 | 26.6 | 36.3 | 46 | 53.5 | 60.2 | 68.3 | 75.8 | 82.6 | 88.3 | 96.3 | 99.3 | 99.9 | 100 | 100 |
| 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3.9 | 9.1 | 19.1 | 26.7 | 36.3 | 47.9 | 61.4 | 75.1 | 84.5 | 92.3 | 96 | 99.1 | 100 | 100 | 100 | 100 |
| 38 | 0 | 0 | 0 | 1.1 | 4.3 | 7.2 | 11 | 13.9 | 17.9 | 22.3 | 30.3 | 43.1 | 55.1 | 61.3 | 65.7 | 72.1 | 77.9 | 82.6 | 86.3 | 90.3 | 93.8 | 98.4 | 100 | 100 |
| 39 | 0 | 0 | 0 | 0 | 0 | 1.6 | 6.5 | 11 | 17.8 | 24.7 | 33.1 | 42.8 | 50.3 | 54.9 | 59.7 | 68.9 | 78.1 | 83.6 | 87.5 | 93 | 96.5 | 99.2 | 100 | 100 |
| 40 | 0 | 0 | 0 | 0 | 0 | 1.5 | 6.2 | 10.1 | 16.3 | 23.3 | 32.5 | 42.2 | 50.1 | 55.6 | 60.5 | 67.5 | 74.3 | 79.4 | 84.1 | 91.1 | 95.8 | 99.1 | 100 | 100 |
| 41 | 0 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.4 | 1.1 | 6.8 | 22.9 | 40.1 | 54.9 | 63.8 | 70.7 | 81.5 | 89.8 | 96.3 | 98.7 | 99.2 | 99.3 | 99.4 | 99.4 | 99.7 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.9 | 5.2 | 17.3 | 33.8 | 53.2 | 66.5 | 75.9 | 87.6 | 93.7 | 97.5 | 99 | 99.7 | 100 | 100 | 100 | 100 |
| 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.4 | 2.7 | 9.5 | 21.9 | 42.7 | 58.6 | 71.1 | 84.6 | 91.9 | 97.1 | 99 | 99.8 | 100 | 100 | 100 | 100 |
| 44 | 0 | 1.7 | 2.3 | 2.4 | 2.4 | 2.4 | 2.4 | 2.7 | 3.5 | 7.6 | 18.5 | 34.3 | 52.5 | 64 | 72.3 | 83.3 | 90 | 95.1 | 97.3 | 98.5 | 98.9 | 98.9 | 98.9 | 99.2 |
| 45 | 0 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.6 | 0.8 | 1.4 | 3.7 | 10.2 | 22.6 | 41.8 | 54 | 64.5 | 78.7 | 88.4 | 96 | 98.7 | 99.4 | 99.7 | 99.7 | 99.8 | 99.9 |
| 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 | 2.6 | 7.5 | 19.6 | 32.9 | 48.9 | 63 | 73.5 | 83.3 | 89.5 | 95.6 | 98.3 | 99.6 | 100 | 100 | 100 | 100 |
| 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 | 1.6 | 5.8 | 17 | 33 | 52.5 | 66.4 | 75.7 | 85.5 | 91.3 | 96.5 | 98.8 | 100 | 100 | 100 | 100 | 100 |
| 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8.1 | 15.4 | 27.8 | 40.7 | 52.6 | 61.1 | 69.3 | 82.6 | 92 | 98 | 100 | 100 | 100 | 100 |
| 49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.7 | 2.7 | 8.3 | 20 | 27.5 | 35.6 | 44.6 | 56 | 70.2 | 81.3 | 89.2 | 93.6 | 98.5 | 100 | 100 | 100 | 100 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.4 | 2.4 | 8.2 | 13.7 | 23.8 | 38.8 | 55.1 | 66.1 | 73.6 | 81.8 | 87.7 | 93.8 | 97 | 99.4 | 100 | 100 | 100 | 100 |
| 51 | 0 | 0 | 0 | 0 | 0 | 0.3 | 1 | 3.1 | 8.7 | 18.8 | 35.8 | 49.6 | 60.4 | 70.2 | 77 | 84 | 88.8 | 93.8 | 96.6 | 99.1 | 100 | 100 | 100 | 100 |
| 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.6 | 2.5 | 6.8 | 17.5 | 29.8 | 46.1 | 60.5 | 72.7 | 86 | 92.8 | 96.8 | 98.4 | 99.7 | 100 | 100 | 100 | 100 |
| 53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.8 | 3 | 9.5 | 24.2 | 35.3 | 48 | 63.1 | 76.1 | 87.7 | 93.5 | 97.2 | 98.6 | 99.5 | 99.8 | 99.9 | 100 | 100 |
| 54 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.7 | 2.4 | 7.2 | 14.7 | 27.2 | 37.2 | 47.3 | 58.8 | 67.6 | 74 | 79.2 | 86.7 | 92.6 | 97.9 | 99.8 | 99.9 | 100 | 100 |
| 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.3 | 5.4 | 13.3 | 25.5 | 31.6 | 38.8 | 52.5 | 66.8 | 75.5 | 81.2 | 87.9 | 92.8 | 98.3 | 100 | 100 | 100 | 100 |
| 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.3 | 5.1 | 11.4 | 22.3 | 29.5 | 38.5 | 51.1 | 65.2 | 77.8 | 85.6 | 91.7 | 95 | 98.7 | 100 | 100 | 100 | 100 |
| 57 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 1 | 3.5 | 9.2 | 21.5 | 31 | 43.5 | 60.4 | 75.1 | 86.1 | 91.6 | 96.2 | 98.1 | 99.4 | 99.9 | 99.9 | 100 | 100 |
| 58 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.9 | 2.9 | 8 | 13.2 | 21 | 29.1 | 38 | 45.9 | 54.5 | 65.4 | 74.8 | 82.1 | 87.5 | 95.4 | 98.8 | 99.7 | 100 | 100 |
| 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.2 | 8.9 | 15.6 | 24.2 | 31.1 | 38.3 | 46 | 54.9 | 64.2 | 73.2 | 81.9 | 88.5 | 95.7 | 98.6 | 99.4 | 99.7 | 99.7 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.4 | 1.5 | 4 | 9.5 | 13.3 | 20.5 | 33.6 | 52.8 | 66.5 | 76.7 | 88.1 | 94.2 | 98.6 | 100 | 100 | 100 | 100 |

**Table 4A. Erosivity Index Table (cont.)**



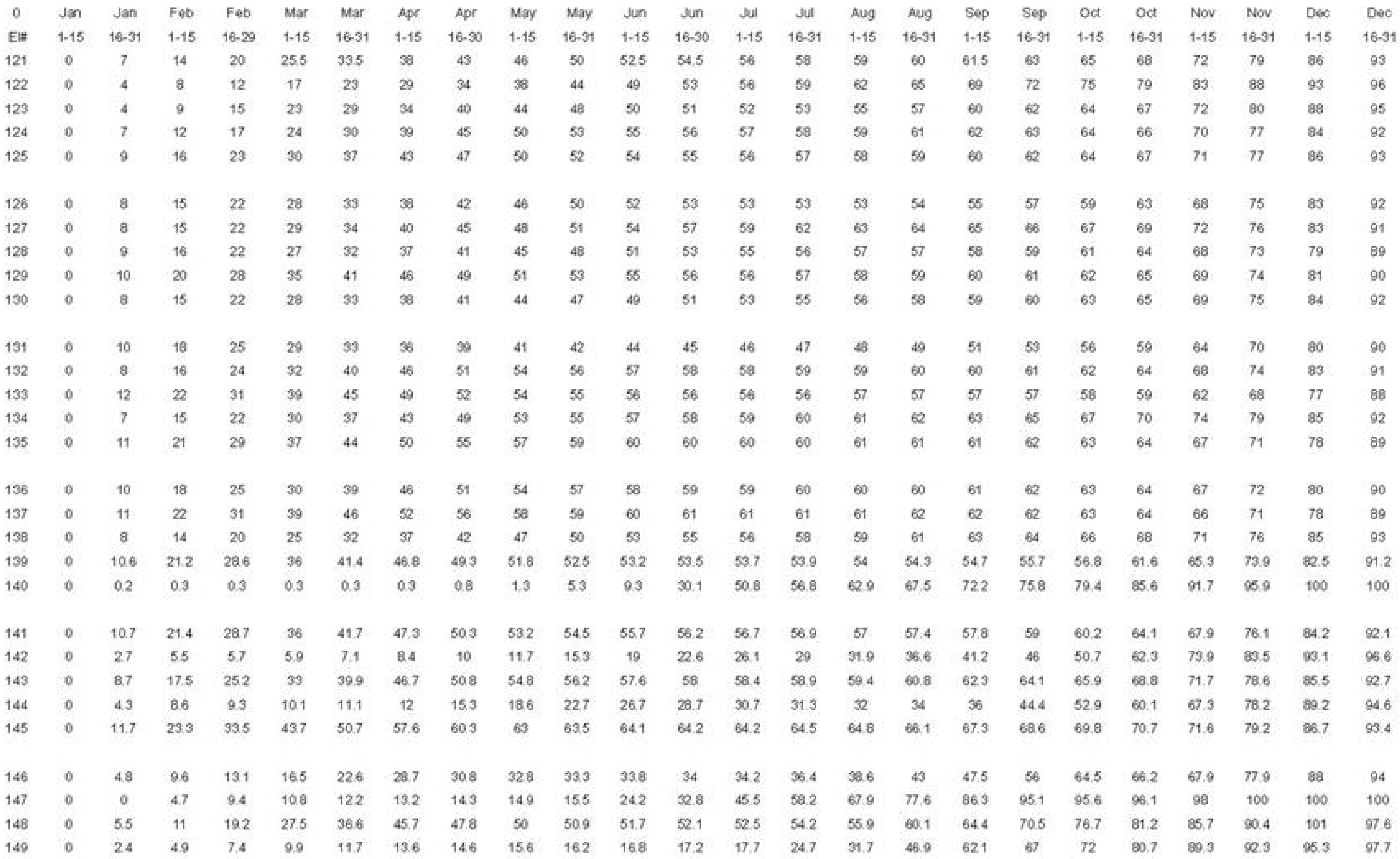
| | Jan | Jan | Feb | Feb | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sep | Sep | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI# | 1-15 | 16-31 | 1-15 | 16-29 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 |
| 61 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1.3 | 5 | 8.5 | 15.5 | 29.8 | 41.8 | 46 | 49.2 | 56 | 65.1 | 71.6 | 78.6 | 91.1 | 97.3 | 99.3 | 100 | 100 |
| 62 | 0 | 0 | 0 | 0.1 | 0.3 | 0.8 | 2.1 | 3.6 | 6.5 | 9.7 | 13.7 | 16.5 | 20.8 | 27.3 | 40.1 | 56.9 | 72.6 | 83.4 | 89.4 | 95.5 | 98.1 | 99.6 | 100 | 100 |
| 63 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.9 | 3.7 | 7.8 | 13.3 | 15.8 | 19.9 | 29 | 46.8 | 64.7 | 78.3 | 88.8 | 93.9 | 98.5 | 100 | 100 | 100 | 100 |
| 64 | 0 | 0 | 0 | 0.7 | 2.8 | 7.4 | 12.4 | 14.4 | 15.6 | 17.3 | 19.4 | 21 | 24.4 | 32.3 | 48 | 61.4 | 72.1 | 81.9 | 87 | 90.1 | 92.4 | 98.1 | 100 | 100 |
| 65 | 0 | 3.6 | 7 | 9.6 | 11.4 | 13 | 14.4 | 16.3 | 17.7 | 18.4 | 19.3 | 20.5 | 23.6 | 32 | 50 | 66.2 | 77.2 | 85.4 | 88.8 | 90.4 | 91.3 | 92.7 | 94.8 | 97 |
| 66 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.5 | 1.1 | 2.2 | 3.6 | 6 | 7.6 | 11.1 | 19.8 | 38.9 | 59.7 | 74.4 | 83.2 | 88.1 | 94.6 | 97.7 | 99.4 | 100 | 100 |
| 67 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.4 | 0.9 | 1.6 | 1.9 | 2.4 | 5 | 12.1 | 24.8 | 48.3 | 73.6 | 86.5 | 92 | 94.3 | 96.6 | 97.9 | 99.5 | 100 | 100 |
| 68 | 0 | 2.3 | 4.5 | 7.8 | 10.4 | 12 | 13.3 | 16.3 | 17.7 | 18.1 | 18.2 | 18.3 | 18.4 | 19.9 | 24.5 | 35 | 54.4 | 69.4 | 78.6 | 85.7 | 89.2 | 91.9 | 93.9 | 97 |
| 69 | 0 | 2 | 3.7 | 5.7 | 7.8 | 10.5 | 12.4 | 13.7 | 14.3 | 14.7 | 15.1 | 15.7 | 17.1 | 22.7 | 36.7 | 50.4 | 63.6 | 75 | 81.8 | 87.8 | 90.8 | 93.2 | 94.9 | 97.5 |
| 70 | 0 | 0.5 | 0.7 | 1 | 1.3 | 1.7 | 2.2 | 2.8 | 3.4 | 3.9 | 4.7 | 5.4 | 7.4 | 15.7 | 36.5 | 55.8 | 70.3 | 80.9 | 86.4 | 90.9 | 93.4 | 96.4 | 98.1 | 99.4 |
| 71 | 0 | 0.7 | 1.2 | 1.6 | 2.1 | 2.8 | 3.3 | 3.6 | 4 | 4.5 | 5.6 | 6.5 | 9.1 | 18.5 | 40.6 | 59.7 | 74 | 86.3 | 91.7 | 94.7 | 96 | 96.7 | 97.3 | 98.8 |
| 72 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0.7 | 0.8 | 1.3 | 3.5 | 9.9 | 24.7 | 51.4 | 71.5 | 83.6 | 93.8 | 97.7 | 99.2 | 99.8 | 99.9 | 99.9 | 100 |
| 73 | 0 | 0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.6 | 1.3 | 4.1 | 11.5 | 18.1 | 28.3 | 40.2 | 54.1 | 67 | 77.2 | 87.7 | 93.3 | 97.5 | 99.1 | 99.6 | 99.8 | 100 |
| 74 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0.5 | 1.2 | 2.7 | 6.4 | 10.2 | 18.4 | 31 | 50.7 | 68.7 | 81.2 | 91.6 | 96.1 | 98.4 | 99.2 | 99.8 | 100 | 100 |
| 75 | 0 | 0.1 | 0.1 | 0.1 | 0.2 | 0.5 | 1.3 | 1.9 | 3 | 4.1 | 6.6 | 10 | 17.6 | 28.3 | 44.7 | 59.4 | 71.6 | 83.9 | 90.3 | 94.7 | 96.7 | 98.8 | 99.6 | 99.9 |
| 76 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.2 | 0.6 | 1.3 | 2 | 3.5 | 4.9 | 8.4 | 17.4 | 37.3 | 57.5 | 72.9 | 83.7 | 89.5 | 95.8 | 98.4 | 99.6 | 100 | 100 |
| 77 | 0 | 0.2 | 0.3 | 0.3 | 0.4 | 0.8 | 1.5 | 2 | 2.8 | 3.9 | 5.9 | 7.2 | 10.3 | 21.5 | 46.5 | 66.3 | 78.3 | 86.5 | 90.8 | 96 | 98.2 | 99.1 | 99.5 | 99.8 |
| 78 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.5 | 1.6 | 3.8 | 8.9 | 13.2 | 21.8 | 35.8 | 56.6 | 75.4 | 86 | 92.9 | 95.9 | 98.2 | 99.2 | 99.8 | 100 | 100 |
| 79 | 0 | 0 | 0 | 0 | 0 | 0.2 | 0.7 | 1.3 | 2.7 | 5.8 | 12.7 | 18.8 | 28.8 | 41.6 | 58.4 | 75.7 | 86.5 | 94.2 | 97.3 | 98.9 | 99.5 | 99.9 | 100 | 100 |
| 80 | 0 | 0.6 | 1.2 | 1.6 | 2.1 | 2.5 | 3.3 | 4.5 | 6.9 | 10.1 | 15.5 | 19.7 | 26.6 | 36.4 | 51.7 | 67.5 | 79.4 | 88.8 | 93.2 | 96.1 | 97.3 | 98.2 | 98.7 | 99.3 |
| 81 | 0 | 0.1 | 0.1 | 0.2 | 0.4 | 0.5 | 0.8 | 0.9 | 1.5 | 3.9 | 9.9 | 12.8 | 18.2 | 30.7 | 54.1 | 77.1 | 89 | 94.9 | 97.2 | 98.7 | 99.3 | 99.6 | 99.7 | 99.9 |
| 82 | 0 | 0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.5 | 1.2 | 3.1 | 6.7 | 14.4 | 20.1 | 29.8 | 44.5 | 64.2 | 83.1 | 92.2 | 96.4 | 98.1 | 99.3 | 99.7 | 99.8 | 99.8 | 99.9 |
| 83 | 0 | 0 | 0.1 | 0.1 | 0.1 | 0.3 | 0.9 | 1.6 | 3.5 | 8.3 | 19.4 | 30 | 44 | 59.2 | 72.4 | 84.6 | 91.2 | 96.5 | 98.6 | 99.5 | 99.8 | 99.9 | 100 | 100 |
| 84 | 0 | 0 | 0.1 | 0.1 | 0.2 | 0.3 | 0.6 | 1.7 | 4.9 | 9.9 | 19.5 | 27.2 | 38.3 | 52.8 | 68.8 | 83.9 | 91.6 | 96.4 | 98.2 | 99.2 | 99.6 | 99.8 | 99.8 | 99.9 |
| 85 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 6 | 11 | 23 | 36 | 49 | 63 | 77 | 90 | 95 | 98 | 99 | 100 | 100 | 100 | 100 |
| 86 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 6 | 11 | 23 | 36 | 49 | 63 | 77 | 90 | 95 | 98 | 99 | 100 | 100 | 100 | 100 |
| 87 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 6 | 10 | 17 | 29 | 43 | 55 | 67 | 77 | 85 | 91 | 96 | 98 | 99 | 100 | 100 | 100 |
| 88 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 6 | 13 | 23 | 37 | 51 | 61 | 69 | 78 | 85 | 91 | 94 | 96 | 98 | 99 | 99 | 100 |
| 89 | 0 | 0 | 1 | 1 | 2 | 3 | 4 | 7 | 12 | 18 | 27 | 38 | 48 | 55 | 62 | 69 | 76 | 83 | 90 | 94 | 97 | 98 | 99 | 100 |
| 90 | 0 | 1 | 2 | 3 | 4 | 6 | 8 | 13 | 21 | 29 | 37 | 46 | 54 | 60 | 65 | 69 | 74 | 81 | 87 | 92 | 95 | 97 | 98 | 99 |

**Table 4A. Erosivity Index Table (cont.)**



| | Jan | Jan | Feb | Feb | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sep | Sep | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI# | 1-15 | 16-31 | 1-15 | 16-29 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 |
| 91 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 6 | 16 | 29 | 39 | 46 | 53 | 60 | 67 | 74 | 81 | 88 | 95 | 99 | 99 | 100 | 100 |
| 92 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 6 | 16 | 29 | 39 | 46 | 53 | 60 | 67 | 74 | 81 | 88 | 95 | 99 | 99 | 100 | 100 |
| 93 | 0 | 1 | 1 | 2 | 3 | 4 | 6 | 8 | 13 | 25 | 40 | 49 | 56 | 62 | 67 | 72 | 76 | 80 | 85 | 91 | 97 | 98 | 99 | 99 |
| 94 | 0 | 1 | 2 | 4 | 6 | 8 | 10 | 15 | 21 | 29 | 38 | 47 | 53 | 57 | 61 | 65 | 70 | 76 | 83 | 88 | 91 | 94 | 96 | 98 |
| 95 | 0 | 1 | 3 | 5 | 7 | 9 | 11 | 14 | 18 | 27 | 35 | 41 | 46 | 51 | 57 | 62 | 68 | 73 | 79 | 84 | 89 | 93 | 96 | 98 |
| 96 | 0 | 2 | 4 | 6 | 9 | 12 | 17 | 23 | 30 | 37 | 43 | 49 | 54 | 58 | 62 | 66 | 70 | 74 | 78 | 82 | 86 | 90 | 94 | 97 |
| 97 | 0 | 1 | 3 | 5 | 7 | 10 | 14 | 20 | 28 | 37 | 48 | 56 | 61 | 64 | 68 | 72 | 77 | 81 | 86 | 89 | 92 | 95 | 98 | 99 |
| 98 | 0 | 1 | 2 | 4 | 6 | 8 | 10 | 13 | 19 | 26 | 34 | 42 | 50 | 58 | 63 | 68 | 74 | 79 | 84 | 89 | 93 | 95 | 97 | 99 |
| 99 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 5 | 7 | 12 | 19 | 33 | 48 | 57 | 65 | 72 | 82 | 88 | 93 | 96 | 98 | 99 | 100 | 100 |
| 100 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 5 | 9 | 15 | 27 | 38 | 50 | 62 | 74 | 84 | 91 | 95 | 97 | 98 | 99 | 99 | 100 |
| 101 | 0 | 0 | 0 | 1 | 2 | 3 | 4 | 6 | 9 | 14 | 20 | 28 | 39 | 52 | 63 | 72 | 80 | 87 | 91 | 94 | 97 | 98 | 99 | 100 |
| 102 | 0 | 0 | 1 | 2 | 3 | 4 | 6 | 8 | 11 | 15 | 22 | 31 | 40 | 49 | 59 | 69 | 78 | 85 | 91 | 94 | 96 | 98 | 99 | 100 |
| 103 | 0 | 1 | 2 | 3 | 4 | 6 | 8 | 10 | 14 | 18 | 25 | 34 | 45 | 56 | 64 | 72 | 79 | 84 | 89 | 92 | 95 | 97 | 98 | 99 |
| 104 | 0 | 2 | 3 | 5 | 7 | 10 | 13 | 16 | 19 | 23 | 27 | 34 | 44 | 54 | 63 | 72 | 80 | 85 | 89 | 91 | 93 | 95 | 96 | 98 |
| 105 | 0 | 1 | 3 | 6 | 9 | 12 | 16 | 21 | 26 | 31 | 37 | 43 | 50 | 57 | 64 | 71 | 77 | 81 | 85 | 88 | 91 | 93 | 95 | 97 |
| 106 | 0 | 3 | 6 | 9 | 13 | 17 | 21 | 27 | 33 | 38 | 44 | 49 | 55 | 61 | 67 | 71 | 75 | 78 | 81 | 84 | 86 | 90 | 94 | 97 |
| 107 | 0 | 3 | 5 | 7 | 10 | 14 | 18 | 23 | 27 | 31 | 35 | 39 | 45 | 53 | 60 | 67 | 74 | 80 | 84 | 86 | 88 | 90 | 93 | 95 |
| 108 | 0 | 3 | 6 | 9 | 12 | 16 | 20 | 24 | 28 | 33 | 38 | 43 | 50 | 59 | 69 | 75 | 80 | 84 | 87 | 90 | 92 | 94 | 96 | 98 |
| 109 | 0 | 3 | 6 | 10 | 13 | 16 | 19 | 23 | 26 | 29 | 33 | 39 | 47 | 58 | 68 | 75 | 80 | 83 | 86 | 88 | 90 | 92 | 95 | 97 |
| 110 | 0 | 1 | 3 | 5 | 7 | 9 | 12 | 15 | 18 | 21 | 25 | 29 | 36 | 45 | 56 | 68 | 77 | 83 | 88 | 91 | 93 | 95 | 97 | 99 |
| 111 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 11 | 15 | 20 | 28 | 41 | 54 | 65 | 74 | 82 | 87 | 92 | 94 | 96 | 97 | 98 | 99 |
| 112 | 0 | 0 | 0 | 1 | 2 | 3 | 4 | 5 | 7 | 12 | 17 | 24 | 33 | 42 | 55 | 67 | 76 | 83 | 89 | 92 | 94 | 96 | 98 | 99 |
| 113 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 12 | 17 | 22 | 31 | 42 | 52 | 60 | 68 | 75 | 80 | 85 | 89 | 92 | 96 | 98 |
| 114 | 0 | 1 | 2 | 4 | 6 | 8 | 11 | 13 | 11 | 13 | 21 | 26 | 32 | 38 | 46 | 55 | 64 | 71 | 77 | 81 | 85 | 89 | 93 | 97 |
| 115 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 8 | 10 | 14 | 19 | 26 | 34 | 45 | 56 | 66 | 76 | 82 | 86 | 90 | 93 | 95 | 97 | 99 |
| 116 | 0 | 1 | 3 | 5 | 7 | 9 | 12 | 15 | 18 | 21 | 25 | 29 | 36 | 45 | 56 | 68 | 77 | 83 | 88 | 91 | 93 | 95 | 97 | 99 |
| 117 | 0 | 1 | 2 | 3 | 4 | 5 | 7 | 9 | 11 | 14 | 17 | 22 | 31 | 42 | 54 | 65 | 74 | 83 | 89 | 92 | 95 | 97 | 98 | 99 |
| 118 | 0 | 2 | 4 | 6 | 8 | 12 | 16 | 20 | 25 | 30 | 35 | 41 | 47 | 56 | 67 | 75 | 81 | 85 | 87 | 89 | 91 | 93 | 95 | 97 |
| 119 | 0 | 1 | 2 | 4 | 6 | 7 | 9 | 12 | 15 | 18 | 23 | 31 | 40 | 48 | 57 | 63 | 72 | 78 | 88 | 92 | 96 | 97 | 98 | 99 |
| 120 | 0 | 8 | 16 | 25 | 33 | 41 | 46 | 50 | 53 | 54 | 55 | 56 | 56.5 | 57 | 57.75 | 58 | 58.75 | 60 | 61 | 63 | 66.5 | 72 | 80 | 90 |

**Table 4A. Erosivity Index Table (cont.)**



| 0 | Jan | Jan | Feb | Feb | Mar | Mar | Apr | Apr | May | May | Jun | Jun | Jul | Jul | Aug | Aug | Sep | Sep | Oct | Oct | Nov | Nov | Dec | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EI# | 1-15 | 16-31 | 1-15 | 16-29 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-30 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 | 1-15 | 16-31 |
| 121 | 0 | 7 | 14 | 20 | 25.5 | 33.5 | 38 | 43 | 46 | 50 | 52.5 | 54.5 | 56 | 58 | 59 | 60 | 61.5 | 63 | 65 | 68 | 72 | 79 | 86 | 93 |
| 122 | 0 | 4 | 8 | 12 | 17 | 23 | 29 | 34 | 38 | 44 | 49 | 53 | 56 | 59 | 62 | 65 | 69 | 72 | 75 | 79 | 83 | 88 | 93 | 96 |
| 123 | 0 | 4 | 9 | 15 | 23 | 29 | 34 | 40 | 44 | 48 | 50 | 51 | 52 | 53 | 55 | 57 | 60 | 62 | 64 | 67 | 72 | 80 | 88 | 95 |
| 124 | 0 | 7 | 12 | 17 | 24 | 30 | 39 | 45 | 50 | 53 | 55 | 56 | 57 | 58 | 59 | 61 | 62 | 63 | 64 | 66 | 70 | 77 | 84 | 92 |
| 125 | 0 | 9 | 16 | 23 | 30 | 37 | 43 | 47 | 50 | 52 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 62 | 64 | 67 | 71 | 77 | 86 | 93 |
| 126 | 0 | 8 | 15 | 22 | 28 | 33 | 38 | 42 | 46 | 50 | 52 | 53 | 53 | 53 | 53 | 54 | 55 | 57 | 59 | 63 | 68 | 75 | 83 | 92 |
| 127 | 0 | 8 | 15 | 22 | 29 | 34 | 40 | 45 | 48 | 51 | 54 | 57 | 59 | 62 | 63 | 64 | 65 | 66 | 67 | 69 | 72 | 76 | 83 | 91 |
| 128 | 0 | 9 | 16 | 22 | 27 | 32 | 37 | 41 | 45 | 48 | 51 | 53 | 55 | 56 | 57 | 57 | 58 | 59 | 61 | 64 | 68 | 73 | 79 | 89 |
| 129 | 0 | 10 | 20 | 28 | 35 | 41 | 46 | 49 | 51 | 53 | 55 | 56 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 65 | 69 | 74 | 81 | 90 |
| 130 | 0 | 8 | 15 | 22 | 28 | 33 | 38 | 41 | 44 | 47 | 49 | 51 | 53 | 55 | 56 | 58 | 59 | 60 | 63 | 65 | 69 | 75 | 84 | 92 |
| 131 | 0 | 10 | 18 | 25 | 29 | 33 | 36 | 39 | 41 | 42 | 44 | 45 | 46 | 47 | 48 | 49 | 51 | 53 | 56 | 59 | 64 | 70 | 80 | 90 |
| 132 | 0 | 8 | 16 | 24 | 32 | 40 | 46 | 51 | 54 | 56 | 57 | 58 | 58 | 59 | 59 | 60 | 60 | 61 | 62 | 64 | 68 | 74 | 83 | 91 |
| 133 | 0 | 12 | 22 | 31 | 39 | 45 | 49 | 52 | 54 | 55 | 56 | 56 | 56 | 56 | 57 | 57 | 57 | 57 | 58 | 59 | 62 | 68 | 77 | 88 |
| 134 | 0 | 7 | 15 | 22 | 30 | 37 | 43 | 49 | 53 | 55 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 65 | 67 | 70 | 74 | 79 | 85 | 92 |
| 135 | 0 | 11 | 21 | 29 | 37 | 44 | 50 | 55 | 57 | 59 | 60 | 60 | 60 | 60 | 61 | 61 | 61 | 62 | 63 | 64 | 67 | 71 | 78 | 89 |
| 136 | 0 | 10 | 18 | 25 | 30 | 39 | 46 | 51 | 54 | 57 | 58 | 59 | 59 | 60 | 60 | 60 | 61 | 62 | 63 | 64 | 67 | 72 | 80 | 90 |
| 137 | 0 | 11 | 22 | 31 | 39 | 46 | 52 | 56 | 58 | 59 | 60 | 61 | 61 | 61 | 61 | 62 | 62 | 62 | 63 | 64 | 66 | 71 | 78 | 89 |
| 138 | 0 | 8 | 14 | 20 | 25 | 32 | 37 | 42 | 47 | 50 | 53 | 55 | 56 | 58 | 59 | 61 | 63 | 64 | 66 | 68 | 71 | 76 | 85 | 93 |
| 139 | 0 | 10.6 | 21.2 | 28.6 | 36 | 41.4 | 46.8 | 49.3 | 51.8 | 52.5 | 53.2 | 53.5 | 53.7 | 53.9 | 54 | 54.3 | 54.7 | 55.7 | 56.8 | 61.6 | 65.3 | 73.9 | 82.5 | 91.2 |
| 140 | 0 | 0.2 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.8 | 1.3 | 5.3 | 9.3 | 30.1 | 50.8 | 56.8 | 62.9 | 67.5 | 72.2 | 75.8 | 79.4 | 85.6 | 91.7 | 95.9 | 100 | 100 |
| 141 | 0 | 10.7 | 21.4 | 28.7 | 36 | 41.7 | 47.3 | 50.3 | 53.2 | 54.5 | 55.7 | 56.2 | 56.7 | 56.9 | 57 | 57.4 | 57.8 | 59 | 60.2 | 64.1 | 67.9 | 76.1 | 84.2 | 92.1 |
| 142 | 0 | 2.7 | 5.5 | 5.7 | 5.9 | 7.1 | 8.4 | 10 | 11.7 | 15.3 | 19 | 22.6 | 26.1 | 29 | 31.9 | 36.6 | 41.2 | 46 | 50.7 | 62.3 | 73.9 | 83.5 | 93.1 | 96.6 |
| 143 | 0 | 8.7 | 17.5 | 25.2 | 33 | 39.9 | 46.7 | 50.8 | 54.8 | 56.2 | 57.6 | 58 | 58.4 | 58.9 | 59.4 | 60.8 | 62.3 | 64.1 | 65.9 | 68.8 | 71.7 | 78.6 | 85.5 | 92.7 |
| 144 | 0 | 4.3 | 8.6 | 9.3 | 10.1 | 11.1 | 12 | 15.3 | 18.6 | 22.7 | 26.7 | 28.7 | 30.7 | 31.3 | 32 | 34 | 36 | 44.4 | 52.9 | 60.1 | 67.3 | 78.2 | 89.2 | 94.6 |
| 145 | 0 | 11.7 | 23.3 | 33.5 | 43.7 | 50.7 | 57.6 | 60.3 | 63 | 63.5 | 64.1 | 64.2 | 64.2 | 64.5 | 64.8 | 66.1 | 67.3 | 68.6 | 69.8 | 70.7 | 71.6 | 79.2 | 86.7 | 93.4 |
| 146 | 0 | 4.8 | 9.6 | 13.1 | 16.5 | 22.6 | 28.7 | 30.8 | 32.8 | 33.3 | 33.8 | 34 | 34.2 | 36.4 | 38.6 | 43 | 47.5 | 56 | 64.5 | 66.2 | 67.9 | 77.9 | 88 | 94 |
| 147 | 0 | 0 | 4.7 | 9.4 | 10.8 | 12.2 | 13.2 | 14.3 | 14.9 | 15.5 | 24.2 | 32.8 | 45.5 | 58.2 | 67.9 | 77.6 | 86.3 | 95.1 | 95.6 | 96.1 | 98 | 100 | 100 | 100 |
| 148 | 0 | 5.5 | 11 | 19.2 | 27.5 | 36.6 | 45.7 | 47.8 | 50 | 50.9 | 51.7 | 52.1 | 52.5 | 54.2 | 55.9 | 60.1 | 64.4 | 70.5 | 76.7 | 81.2 | 85.7 | 90.4 | 101 | 97.6 |
| 149 | 0 | 2.4 | 4.9 | 7.4 | 9.9 | 11.7 | 13.6 | 14.6 | 15.6 | 16.2 | 16.8 | 17.2 | 17.7 | 24.7 | 31.7 | 46.9 | 62.1 | 67 | 72 | 80.7 | 89.3 | 92.3 | 95.3 | 97.7 |