Part 501 Water Erosion

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Subpart 501A Introduction

501.00 Overview of water erosion

This part presents United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) policy and procedures for estimating soil erosion by water. It explains the types, the method used to estimate, and the management of soil erosion by water. NRCS technical guidance related to water erosion shall conform to policy and procedures set forth in this part.

The Agricultural Research Service (ARS) has primary responsibility for erosion prediction research within the USDA. ARS is the lead agency for developing erosion prediction technology, including the Revised Universal Soil Loss Equation version 2 (RUSLE2). The majority of the technology in RUSLE2 is documented in the publication Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE), USDA Handbook 703, hereafter referred to as the Agriculture Handbook 703. The reader is referred to the Agriculture Handbook 703 for a detailed description of RUSLE2 technology and parameter effects on soil loss,

Subpart 501B Water Erosion

501.10 Forms of water erosion

Forms of soil erosion by water include sheet and rill, ephemeral gully, classical gully, and streambank. Each succeeding type is associated with the progressive concentration of runoff water into channels as it moves downslope. Sheet erosion, sometimes referred to as interrill erosion, is the detachment of soil particles by raindrop impact and the removal of thin layers of soil from the land surface by the action of rainfall and runoff. Rill erosion is the formation of small, generally parallel channels formed by runoff water. Rills usually do not re-occur in the same place. Ephemeral gullies are concentrated flow channels formed when rills converge to form shallow channels. They can easily be filled with soil by typical tillage operations and re-formed in the same general location by subsequent runoff events. Classical gullies are also concentrated flow channels formed when rills converge. These are well defined, permanent incised drainageways that cannot be crossed by ordinary farming operations.

Other forms of erosion that are related to soil erosion by water include stream channel and geologic. Stream channel erosion refers to the degradation of channels and waterways. Geologic erosion refers to long-term erosion effects, as opposed to accelerated erosion events described in this subpart.

No reliable methods exist for predicting the rate of ephemeral gully, classical gully, stream channel, or geologic erosion. However, the science is under development to add ephemeral gully erosion estimates to water erosion prediction models. The remainder of this part deals only with prediction and control of sheet and rill erosion.

501.11 The water erosion process

Detachment, transport, and deposition of soil particles caused by raindrop impact and surface runoff are known as the processes of sheet and rill erosion.

Detachment is the removal of particles from the soil mass and is expressed in units, such as tons per acre and is referred to as sediment.

The movement of sediment downslope is sediment transport. A measure of sediment transport is sediment load. Sediment load on a slope increases with distance downslope as long as detachment is occurring. That is, detachment adds to the sediment load.

Where runoff is slowed along the slope, at the base of a slope, or by dense vegetation, deposition occurs. Deposition is the transfer of sediment from the sediment load to the soil mass. That is, deposition removes sediment from the sediment load, and accumulates on the soil surface.

Two types of deposition, remote and local, occur. Remote deposition occurs some distance away from the origin of the sediment. Depositions at the toe of a concave slope, on the uphill side of vegetative strips, and in terrace channels are examples of remote deposition. Local deposition is where sediment is deposited near, within several inches, of where it is detached. Deposition in microdepressions and low gradient furrows are also examples of local deposition.

Subpart 501C Estimating sheet and rill erosion

501.20 How, why, and by whom water erosion is estimated

NRCS estimates soil erosion by water as part of its technical assistance to land users. In conservation planning, erosion estimates are made for an existing management system and compared with alternative systems and with soil loss tolerance (T) values.

In addition, soil loss estimates are used to inventory natural resources, evaluate the effectiveness of conservation programs and land treatment, and estimate sediment production from fields that might become sediment yield in watersheds.

Title 450 National Instruction Part 300 issued in July 2002 required that RUSLE2 be fully implemented in all NRCS field offices where water erosion is a resource issue by the end of calendar year 2002. In 2002, NRCS adopted RUSLE2 as the official tool for predicting soil erosion by water. NRCS continues to use some USLE components for certain provisions of Farm Bill programs, most notably it uses USLE soil factors in determining if fields are Highly Erodible Land.

501.21 Methods of estimating sheet and rill erosion

Efforts to predict soil erosion by water started in the 1930s. Cook (1936) identified the major variables that affect erosion by water. Zingg (1940) published the first equation for calculating field soil loss. Smith and Whitt (1947) presented an erosion-estimating equation that included most of the factors present in modern soil loss equations. The Musgrave equation (Musgrave 1947) was a soil loss equation developed for farm planning. Finally, an effort was initiated to develop a national equation from the various state and regional equations that existed in the 1950s. In 1954, the ARS established the National Runoff and Soil Loss Data Center at Purdue University in West Lafayette, Indiana, to consolidate all available erosion data. Using the data assembled at the Data Center, Wischmeier and

Smith (1965) developed the Universal Soil Loss Equation (USLE).

The USLE was a consolidation of several regional soil loss equations, and was based on summarizing and statistical analyses of more than 10,000 plot-years of basic runoff and soil loss data from 49 United States locations (Agriculture Handbook 703, 1997; Wischmeier and Smith 1965, 1978).

The USLE was designed to provide a convenient working tool for conservationists. It quantifies soil erosion as a product of six factors representing rainfall and runoff erosiveness, soil erodibility, slope length, slope steepness, cover-management practices, and supporting practices.

ARS released RUSLE in 1992 as a computer program in the DOS environment. The model calculates soil loss from a field slope using values for each factor and using data elements from climate, plant, and field operation databases.

501.22 The Revised Universal Soil Loss Equation version 2 (RUSLE2)

Since implementation during 2002, RUSLE2 has been used by NRCS to estimate soil loss by water. RUSLE2 predicts long-term average annual soil loss from sheet and rill erosion. RUSLE2 is an update of the Revised Universal Soil Loss Equation (RUSLE) as described in Agriculture Handbook 703. RUSLE2 utilizes a computer program to facilitate the calculations. RUSLE2 technology reflects the analysis of research data that were unavailable when Agricultural Handbook 282 (Wischmeier and Smith 1965), Agriculture Handbook 537, and Agriculture Handbook 703 were completed, including subsequent technology development.

The average annual soil loss from sheet and rill erosion is computed based on the following equation:

$$A = R \quad K \quad L \quad S \quad C \quad P$$

where

A = the computed spatial average soil loss and temporal average soil loss per unit of area (usually expressed in units of T/a/yr)

R = the rainfall-runoff erosivity factor (the rainfall erosion index value plus a factor for any significant snowmelt runoff)

K = the soil erodibility factor (the soil loss rate per erosion index unit for a specified soil as measured on a standard plot that is 22.1 meters long with a uniform 9 percent slope in continuous clean-tilled fallow)

L = the slope length factor (the ratio of soil loss from the field slope length and soil loss from standard plot length under otherwise identical conditions)

S = the slope steepness factor (the ratio of soil loss from the field slope gradient and soil loss from standard plot gradient under otherwise identical conditions)

C = the cover-management factor (the ratio of soil loss from an area with specified cover/management and soil loss from an otherwise identical area in continuous clean-tilled fallow)

P = the support practice factor (the ratio of soil loss with a support practice like contouring, strip cropping or terracing and soil loss with straight-row farming up and down the slope)

501.23 Limitations of the equation

The term Universal distinguishes the USLE, RUSLE and RUSLE2 from State and regionally based models that preceded them. However, the use of these equations is limited to situations where factors can be accurately evaluated and to conditions for which they can be reliably applied (Wischmeier 1978; Agriculture Handbook 703, 1997).

RUSLE2 predicts long-term average annual soil loss carried by runoff from specific field slopes under specified cover and management systems. It is not appropriate to use RUSLE2 to predict specific erosion events associated with single storms or short-term random fluctuations. RUSLE2 also estimates sediment yield for the amount of eroded soil leaving the end of a slope with certain support practices. It does not predict sediment yield for the amount of sediment that is delivered to a point in a watershed, such as the edge of a field that is remote from the origin of the detached soil particles. Nor does RUSLE2 predict erosion that occurs in concentrated flow channels.

501.25 Data needed to support RUSLE2

RUSLE2 uses soil erodibility, K, values from the NASIS Soils Database. The RUSLE2 user inputs the appropriate soil type/component for the defined slope being evaluated. Climatic data (R) is obtained from National Weather Service weather stations with reliable long-term data. State and area agronomists have developed management records for the different crops in their areas from which RUSLE2 calculates cover and management factors (C).

The crop database in RUSLE2 contains plant growth and residue production parameters. Values for many of these parameters are available in a database for a wide variety of plants.

The operations database in RUSLE2 contains the soil and residue disturbance parameters. Values are available for a very large number of field operations ranging from a spade to numerous types of harvesting equipment.

Development and maintenance of databases used by NRCS in erosion prediction models are the responsibility of NRCS agronomists at the State and national levels. Refer to part 509 in this manual for more detailed information on database management and instructions. The national database manager maintains a database management plan that identifies the process of developing and maintaining databases needed to support RUSLE2. Databases for all States are available in electronic format from the official RUSLE2 website (*http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm*). Length of slope (L) and steepness of slope (S) are entered by the user based on the slope and length being evaluated.

501.26 Tools for using RUSLE2

Most States and basin areas have developed county-based climatic maps for their areas. These contain the detail that is desired when applying RUSLE2 to specific field situations, and are available in NRCS State offices and, in many cases, from the Field Office Technical Guide.

Subpart 501D Principles of water erosion control

501.30 Overview of principles

The principle factors that influence soil erosion by water are climate, soil properties, topography, vegetative cover, and conservation practices. Climate and soil properties are conditions of the site and are not modified by ordinary management measures. Conservation treatment primarily involves manipulation of vegetative cover, modification of topography, and manipulation of soil conditions in the tillage zone.

The greatest deterrent to soil erosion by water is vegetative cover, living or dead, on the soil surface. Cover and cultural practices influence both the detachment of soil particles and their transport. Growing plants and plant residue absorb the energy of raindrops, decrease the velocity of runoff water, and help create soil conditions that resist erosion. Cultural practices that affect vegetative cover include crop rotations, cover crops, management of crop residue, and tillage practices.

501.31 Relation of soil loss values to RUSLE2 factors

In conservation planning, cover and management(C factor) and practice implementation (P factor) can be modified or selected in RUSLE2 to develop alternatives for erosion reduction. In addition, where slope length is reduced by installing terrace or diversion systems, the slope length and steepness factor (LS) will be reduced. Using RUSLE2 technology, estimates of erosion reduction are illustrated in the C subfactors. Benefits to erosion control are achieved in the:

- prior land use subfactor by increasing the mass of roots and buried residue and increasing periods since soil disturbance
- canopy cover subfactor by increasing the canopy cover of the field area and low raindrop fall height from the canopy

- surface cover subfactor by increasing the ground cover of plant residue, and by permanent cover such as rock fragments
- surface roughness subfactor by increasing the random surface roughness that ponds water, and thereby reduces the erosive effect of raindrops and traps sediment
- soil moisture subfactor by growing moisture-depleting crops. This benefit is only applied in RUSLE in the Northwest Wheat and Range Region of the western United States

When support practices are applied, they become integral parts of a resource management system for controlling soil erosion by water. Contour farming, contour stripcropping, and conservation buffers form ridges on or near the contour that slow runoff and trap sediment. Terraces and diversions intercept concentrated runoff flows and, in many cases, shorten the length of slope.

Some erosion control practices, such as grassed waterways and water control structures, do not substantially reduce sheet and rill erosion. While these can be effective erosion control practices for concentrated flow (in the case of grassed waterways) in a resource management system, they are not a part of the soil loss reduction that is estimated by RUSLE2.

Subpart 501E References

Cook, H.L. 1936. The nature and controlling variables of the water erosion process. Soil Sci. Soc. Am. Proc. 1:60–64.

Deer-Ascough, L.A., G.A. Weesies, J.C. Ascough, II, and J.M. Laflen. 1995. Plant parameter database for erosion prediction models. Applied Engineering in Agriculture, 11(5):659–666.

Foster, G.R., G.A. Weesies, D.K. McCool, D.C. Yoder, and K.G. Renard. 1997. Revised Universal Soil Loss Equation User's Manual. U.S. Department of Agriculture, Natural Resources Conservation Service. (unpublished draft).

Musgrave, G.W., and R.A. Norton. 1937. Soil and water conservation investigations at the Soil Conservation Experiment Station Missouri Valley Loess Region, Clarinda, Iowa, Progress Report, 1931–35. U.S. Department of Agriculture Tech. Bull. 558.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder, coordinators. 1997. Predicting soil erosion by water: a guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). U.S. Department of Agriculture Handbook No. 703, 404 pp.

Smith, D.D., and D.M. Whitt. 1947. Estimating soil losses from field areas of claypan soil. Soil Sci. Soc. Am. 12: 485–490.

Wischmeier, W.H., and D.D. Smith. 1965. Predicting rainfall-erosion losses from cropland east of the Rocky Mountains: Guide for selection of practices for soil and water conservation. U.S. Department of Agriculture Handbook No. 282.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall erosion losses: A guide to conservation planning. U.S. Department of Agriculture Handbook No. 537.

Zingg, A.W. 1940. Degree and length of land slope as it affects soil loss in runoff. Agric. Eng. 21:59–64.