APPENDIX A
REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

CONTENTS

List of Tables
List of Figures
Introduction .................................................................................................................. A.1
Why Use RUSLE? ......................................................................................................... A.1
Soil Erosion Estimates Using Revised Universal Soil Loss Equation For Sheet and Rill Erosion ........... A.1
Step-by-Step, How To Use RUSLE ............................................................................. A.2
Examples .................................................................................................................... A.2
References
Section prepared by:

Frederick B. Gaffney, former Conservation Agronomist
USDA—Natural Resources Conservation Service,
Syracuse, New York

and

Donald W. Lake Jr., P.E., CPESC, CPSWQ
Engineering Specialist
New York State Soil & Water Conservation Committee
# List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1</td>
<td>Approximated K Values for Some Representative Soils on Construction Sites in New York</td>
<td>A.6</td>
</tr>
<tr>
<td>A.2</td>
<td>Values for Topographic Factor, LS, for High Ratio of Rill to Interrill Erosion</td>
<td>A.11</td>
</tr>
<tr>
<td>A.3</td>
<td>Factors for Converting Soil Losses (Air-Dry) from Tons (T) to Cubic Yards (Cu. Yds.)</td>
<td>A.12</td>
</tr>
<tr>
<td>A.4</td>
<td>El Values of Certain Key Cities in the New York Area</td>
<td>A.13</td>
</tr>
<tr>
<td>A.5</td>
<td>Construction Site Mulching C Factors</td>
<td>A.14</td>
</tr>
<tr>
<td>A.6</td>
<td>Cover Factor C Values for Different Growth Periods for Planted Cover Crops for Erosion Control</td>
<td></td>
</tr>
<tr>
<td></td>
<td>at Construction Sites</td>
<td>A.14</td>
</tr>
<tr>
<td>A.7</td>
<td>Cover Factor C Values for Established Plants</td>
<td>A.15</td>
</tr>
<tr>
<td>A.8</td>
<td>Construction Site P Practice Factors</td>
<td>A.15</td>
</tr>
</tbody>
</table>
### List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1</td>
<td>Monthly Percent of Annual Erosion Index—New York</td>
<td>A.4</td>
</tr>
<tr>
<td>A.2</td>
<td>Monthly Percent of Annual Erosion Index—Long Island</td>
<td>A.4</td>
</tr>
<tr>
<td>A.3</td>
<td>AVERAGE ANNUAL RAINFALL—RUNOFF EROSIVITY FACTOR (R) for the Northeast</td>
<td>A.5</td>
</tr>
</tbody>
</table>
REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

Introduction

The science of predicting soil erosion and sediment delivery has continued to be refined to reflect the importance of different factors on soil erosion and runoff. The Revised Universal Soil Loss Equation (RUSLE) has improved the effects of soil roughness and the effects of local weather on the prediction of soil loss and sediment delivery.

The importance of estimating erosion and sediment delivery has long been recognized to minimize pollution by sediments and the chemicals carried by soil particles. The visual effects of erosion include rills and gullies along with sediment blockages found in culverts or drainage ditches. A well planned, engineered and implemented erosion control and/or water management plan will alleviate many concerns about construction site erosion and potential pollution.

Why use RUSLE?

RUSLE is a science-based tool that has been improved over the last several years. RUSLE is a computation method which may be used for site evaluation and planning purposes and to aid in the decision process of selecting erosion control measures. It provides an estimate of the severity of erosion. It will also provide quantifiable results to substantiate the benefits of planned erosion control measures, such as the advantage of adding a diversion ditch or mulch. For example, a diversion may shorten the length of slope used in calculating a LS factor. Also, the application of mulch will break raindrop impact and reduce runoff (See discussion of L,S and C factors).

This section provides a method to calculate soil loss. Following the step-by-step procedure will provide estimated erosion in 'tons per acre per year', which can be converted to the more usable measurement, cubic yards of soil.

Other erosion prediction methods such as computer models are also available. Examples are the USDA-NRCS RUSLE 2 at http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm and USDA-ARS Water Erosion Prediction Project (WEPP) at http://topsoil.nserl.purdue.edu/nserlweb/weppmain/wpslp.html

Soil Erosion Estimates Using Revised Universal Soil Loss Equation For Sheet and Rill Erosion

As mentioned above, soil losses on construction sites can be predicted by using the Revised Universal Soil Loss Equation (RUSLE). The equation is as follows:
\[ A = RK(LS)C \]

The benefit of mulch can be predicted by multiplying the above by an appropriate cover or C-value. The benefit of a diversion ditch can be illustrated by comparing the original LS with the shorter slope length LS created when adding this practice.

Equation:
\[ A = RK(LS)C \]

Where:
- \( A \) is the computed soil loss per acre per year in units of tons. This quantity may be converted to cubic yards by using conversion factors shown in Table A.3.
- \( R \) is the rainfall value reflecting the energy factor multiplied by the intensity factor. The R-values for each county are provided in Figure A.3. EI is the abbreviation for energy and intensity and is called the Erosion Index. The energy component is related to the size of the raindrops while the intensity is the maximum intensity for a 30-minute interval and is measured in inches per hour. EI is frequently illustrated in graphs by showing the percent of EI that occurs within a period of days or months. From the index, one can determine the period when the most intense storms are likely to occur. See Figure A.1 and A.2.
- \( K \) is the soil erodibility factor. The value for the subsoil condition, usually encountered in construction sites, can be determined based on soil texture (relative percent of sand, silt, and clay) or from most county soil surveys, found in the table providing Physical and Chemical Properties of Soils. However, \( K \) values for subsoils are not always available. If the soil survey does not list a subsoil \( K \) for the soil series encountered, use the surface \( K \) value unless there is an obvious change from sand or gravel to silt or clay. Contact the local SWCD or NRCS office for an appropriate \( K \) value when in question. Approximated \( K \) values for some representative soils on construction sites in NY can be found in Table A.1.
- \( L \) is the horizontal length of slope measured in feet. It is the point of origin where water will begin flowing down the slope to the point where concentrated flow begins, such as where water flows into a ditch, or deposition occurs and water disperses. \( S \) is the slope gradient. Slopes may be uniform, concave (flattening toward the lower end) or convex (steepening toward the lower end). Table A.2 assumes a uniform slope. If the slope is concave, the LS factor will be slightly lower. If convex, then the LS will be slightly higher. These factors are interrelated and the LS factor can be obtained from Table A.2. This LS table is specific for construction sites with little or no cover.
- \( C \) is the factor to reflect the planned cover over the soil surface. Most construction sites are void of vegetation and therefore would have a value of one (1). On construction sites where mulch or fabrics are used, the benefit derived from intercepting the erosive raindrop impact on the soil surface is calculated. For example, the value of two tons of straw uniformly covering a slope results in a C-value of 0.1.
Therefore, mulching can substantially reduce the predicted soil loss.

P is the factor that represents management operations and support practices on a construction site. Table A.8 lists P factors for surface conditions on construction sites in relation to bare soils.

**Step-by-Step, How to Use RUSLE**

1. Determine the County. Use Figure A.3 to determine the R-value.
2. Determine the soil erodibility factor based on the soil series or the texture. Look up the appropriate K-value for subsoil using Table A.1.
3. Measure the horizontal length (plan view) of slope (in feet) from the top of the slope to the bottom. The bottom is either a ditch bank (concentration of water) or flatter slope where deposition occurs and water disperses (actual field measurement).
4. Determine the percent slope (actual field measurement).
5. Look up LS value in Table A.2. Interpolate if necessary to use the measured length and percent slope obtained by field measurement.
6. Determine the Cover (C) factor—Most construction sites are void of vegetation and therefore would have a value of one (1). For values of other cover conditions, such as straw mulch, contact your local SWCD or NRCS office.
7. Multiply the R*K*(LS) to obtain soil loss in tons/acre/year.
8. Convert to cubic yards if desired. Refer to the conversion factors based on soil texture (Table A.3).
9. Review the examples that follow for specific field conditions where RUSLE may be useful.

**Examples**

The following are examples showing how the Revised Universal Soil Loss Equation is used for estimating soil losses:

Assume Syracuse, New York, as the locale of a construction site. The disturbed site is 50 acres in size, with an average gradient of 8% and an average slope length of 500 feet. The soil is a Schoharie silt loam with a K value of 0.49 in both the B and C horizons (The K value is obtained from Table A.1). The LS value is 3.11 and is obtained from Table A.2.

1. Compute soil losses from this unprotected surface for a 12 month period. The average annual rainfall erosion index (R) is 80.

\[
\begin{align*}
R &= 80 \\
C &= 1 \\
K &= 0.49 \\
LS &= 3.11 \text{ (Interpolate between 400’ and 600’ at 8%)} \\
A &= RK(LS)C = 122 \text{ T/ac/yr} \\
50 \text{ ac} \times 122 \text{ Tons/ac/yr} &= 6100 \text{ Tons/yr} \\
\text{Convert to cu yds: } 6100 \text{ T/yr} \times 0.87 \text{ cu yds /Y} &= 5307 \text{ cu yds/yr}
\end{align*}
\]

(0.87 cu yds/T is obtained from Table A.3, silt loam)

2. Compute soil losses from this unprotected surface for a 3 month period (June, July, August). This EI value is obtained as follows: Refer to the erosion index distribution curve applicable to Syracuse, New York, Figure A.1. The EI reading for June 1 is 17% and for September 1 is 76%. The percent of average annual index for this period is 76% - 17% or 59%. Since the annual erosion index for this location is 80, the EI value for the 3 month period is 59% of 80 or 47.2.

\[
\begin{align*}
R &= 80 \\
C &= 1 \\
K &= 0.49 \\
LS &= 3.11 \\
A &= (EI)K(LS)C = 72 \text{ Tons/ac/3 mo.} \\
50 \text{ ac} \times 72 \text{ Tons/ac/3 mo.} &= 3600 \text{ Tons/3 mo.} \\
\text{Convert to cu yds: } 0.87 \text{ cu yds/Tons} \times 3600 \text{ Tons/3 mo.} &= 3132 \text{ cu yds/3 mo}
\end{align*}
\]

3. Compute soil losses for the 1 year out of 5 when the rainfall intensity (R) will increase from the normal average annual value of 80 to an annual value of 129 (the latter value is from Table A.4).

\[
\begin{align*}
R &= 129 \text{ (Change R from 80 to 129)} \\
C &= 1 \\
K &= 0.49 \\
LS &= 3.11 \\
A &= RK(LS)C \\
A &= 129 \times 0.49 \times 3.11 = 197 \text{ Tons/ac/yr} \\
50 \text{ ac} \times 197 \text{ Tons/ac/yr} &= 9850 \text{ Tons/yr} \\
\text{Convert to cu yds: } 0.87 \text{ cu yds/Tons} \times 9850 \text{ Tons/yr} &= 8570 \text{ cu yds/yr}
\end{align*}
\]

4. Compute soil losses for the 1 year out of 20 when the rainfall intensity (R) will increase from the average annual R of 80 to an R of 197 (the latter value is from Table A.4).

\[
\begin{align*}
R &= 197 \text{ (Change R from 80 to 197)} \\
C &= 1 \\
K &= 0.49 \\
LS &= 3.11 \\
A &= RK(LS)C \\
A &= 197 \times 0.49 \times 3.11 = 300 \text{ Tons/ac/yr} \\
50 \text{ ac} \times 300 \text{ Tons/ac/yr} &= 15,000 \text{ Tons/yr} \\
\text{Convert to cu yds: } 0.87 \text{ cu yds/Tons} \times 15,000 \text{ Tons/yr} &= 13,050 \text{ cu yds/yr}
\end{align*}
\]
Examples (continued)

5. Compute soil losses from the expected magnitude of a single storm that may occur once in 5 years. Looking at Table A.4, the expected magnitude, or EI value, is 38.

\[
\begin{align*}
\text{EI (R)} & = 38 \\
K & = 0.49 \\
\text{LS} & = 3.11
\end{align*}
\]

\[
A = (\text{EI})K(\text{LS})C = 38 \times 0.49 \times 3.11 = 58 \text{ Tons/ac/yr}
\]

50 ac x 58 Tons/ac/yr = 2900 Tons/yr

Convert to cu yds = \(0.87 \text{ cu yds/Tons} \times 1650 \text{ Tons/yr} = 2523 \text{ cu yds/yr}\)

6. Compute soil losses from the expected magnitude of a single storm that may occur once in 10 years. The EI value of this storm is 51. (Obtained from Table A.4.)

\[
\begin{align*}
\text{EI (R)} & = 51 \\
K & = 0.49 \\
\text{LS} & = 3.11
\end{align*}
\]

\[
A = (\text{EI})K(\text{LS})C = 78 \text{ Tons/ac/yr}
\]

50 ac x 78 Tons/ac/yr = 3900 Tons/yr

Convert to cu yds = \(0.87 \text{ cu yds/Tons} \times 1650 \text{ Tons/yr} = 3393 \text{ cu yds/yr}\)

7. Compute soil losses from the expected magnitude of a single storm that may occur once in 20 years. The EI value of this storm is 65. (Obtained from Table A.4.)

\[
\begin{align*}
\text{EI (R)} & = 65 \\
K & = 0.49 \\
\text{LS} & = 3.11
\end{align*}
\]

\[
A = (\text{EI})K(\text{LS})C = 99 \text{ Tons/ac/yr}
\]

50 ac x 99 Tons/ac/yr = 4950 Tons/yr

Convert to cu yds = \(0.87 \text{ cu yds} \times 4950 \text{ Tons/yr} = 4307 \text{ cu yds/yr}\)

---

Sediment Yield—MUSLE

The Modified Universal Soil Loss Equation (MUSLE), developed by Williams and Berndt, 1976, can be used to calculate sediment yields from drainage basins to specific locations for selected storm events.

The formula is given as:

\[
T = 95(V \times Qp)^{0.56} \times K \times LS \times C \times P
\]

Where:

- \(T\) = sediment yield per storm event in tons
- \(V\) = volume of runoff per storm event in acre-feet
- \(Q_p\) = peak flow per storm event in cubic feet per second
- \(K\), \(LS\), \(C\), and \(P\) are RUSLE factors

Values for \(V\) and \(Q_p\) are determined from the site drainage analysis.

Example

Compute the sediment yield volume to a basin from a drainage area of 10 acres under construction (all disturbed) for a 2 inch rainfall.

The soil (sandy loam) \(K = 0.43\), \(LS = 2.34\), the volume of runoff is 1.5 acre-feet and the peak discharge for the storm is 5 cubic feet per second.

\[
T = 95(1.5 \times 5)^{0.56}(0.43)(2.34)(1)(1)
\]

\(T = 295.4\) tons

295.4 tons x 0.70 cy/ton = 206.99 cubic yards
Figure A.1 (USDA - NRCS)
Monthly Percent of Annual Erosion Index—New York

New York State except Long Island

Figure A.2 (USDA - NRCS)
Monthly Percent of Annual Erosion Index—Long Island