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Soil Management Groups and Soil Erosion Control

by Stephen E. Tilmann
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INTRODUCTION

State-wide resource conservation programs have traditionally worked to prevent soil erosion by following good management practices. The *Soil Erosion and Sedimentation Control Act of 1972* provides a renewed impetus for reducing soil loss as a result of water erosion in Michigan. The Act establishes a permit procedure under which proposed earth change activities must demonstrate that adequate, on-site erosion control procedures will be in effect.

Any well-coordinated statewide erosion control strategy is a balance between regional and local on-site control programs. This report details the soil-loss equation and its application in the development of these strategies. Two examples of how to use the soil-loss equation are given; one describes a regional evaluation and the other discusses developing on-site erosion control programs.

Everyone is affected by soil erosion. Unnecessary soil loss from agricultural areas decreases the soil's productivity, increases the need for fertilizer, and contributes to increased production expenses. Excess river siltation from all sources not only degrades the river's appearance, but also deteriorates fish habitat, contributes to flooding, hampers navigation, increases the cost of river water purification, and decreases channel, reservoir, and impoundment capacity.

Maintenance costs of streets, roads, culverts, drainage ditches and channelways are increased by excessive soil erosion. Toxic chemicals, bacteria and radionuclides may adhere to sediment particles and thereby become dangerously concentrated in depositional areas or be transported to water supplies. Soil deposition also tends to seal the soil surface and inhibit ground water recharge.

Although agricultural activities have been identified as the major contributor to the nation's soil loss (1), construction activities also contribute large amounts of sediment to surface waters. Construction activities contribute far more sediment per acre than do agricultural areas (5, 6, 9, 13, 14).

One study in a small drainage basin reported that 85% of the sediment load resulted from ongoing highway construction (13). This study concluded that soil loss from highway construction sites was 10 times more than that from cropland, 200 times more than that from grassland, and 2000 times more than that from forest land. Properly managed grasslands and forest lands (areas with permanent vegetative cover) do not have appreciable soil loss.

Building construction areas also produce large amounts of sediment. Ringler and Humphreys (9) found that for the Plaster Creek watershed in west-central Michigan, construction activities associated with the urbanizing land contributed 24% of the total sediment, even though this category included only 5% of the land use.

In extreme cases, the amount of sediment derived by erosion from construction areas may exceed 20,000 to 40,000 times the amount eroded from forest land in an equivalent period of time (19). Clearly, controlling soil erosion from construction areas is of vital concern in statewide erosion control programs.

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SOIL EROSION AND SEDIMENTATION CONTROL ACT OF 1972

The *Soil Erosion and Sedimentation Control Act of 1972* (Act 347, P.A. 1972, as amended by Act 197, P.A. 1974) gives local government the authority to issue and enforce permits that require erosion control practices on most construction sites within their jurisdiction. The original thrust of this bill was to control soil erosion from all sources, but mining, logging, and agriculture have been specifically excluded from the Act (Sect. 16, as amended).

The "Guideline for Enforcing Agencies" states that "soil erosion control has become a key element in the upgrading of our State's water quality program and as such demands strong ties of cooperation and coordination between virtually all levels of environmental interest (4)."

Effective implementation of soil erosion control programs is based on a mutual understanding of goals, language, methods and limitations between regulatory agencies and those affected by the regulations. Toward this end, the Bureau of Water Management (Michigan Department of Natural Resources) has published the *Michigan Soil Erosion and Sedimentation Control Guidebook* (7). The guidebook describes various on-site management practices to control soil erosion on construction areas.

Although Act 347 and the guidebook outline the intent and methods of soil erosion control, conservation measures for a specific construction site are up to the descretion of the applicant. To efficiently devise a good sediment control program, the nature and amount of sediment to be expected from construction activities must be known.

DEVELOPING CONTROL PLANS

Soil erosion is a function of soil properties, topographic characteristics, climatic factors, vegetative cover, and applied erosion control practices. These vary widely across the state. Soil surveys contain information on soil properties, including slope classes in some after 1923 and most after 1940.

Soil maps form the basis of any soil erosion control plan. This report discusses how to use soil maps and other commonly available information, such as topographic and land use maps, when developing these plans.

The soil-loss equation is a relatively simple, yet powerful, tool to help develop soil erosion control plans. The equation is used to predict the amount of sediment expected under certain conditions. This report contains two examples of the use of the soil-loss equation. The first shows how a regional area can be evaluated to determine areas sensitive to soil erosion. By assuming that all vegetative cover is removed and that no erosion control practices are used at construction sites, the regional area can be mapped for expected construction-related soil erosion hazards in units of tons per acre per year.

The second example shows how the soil-loss equation can be used to provide basic information for designing specific, on-site soil erosion control plans. The location and amount of expected soil erosion can be estimated; as a result, the design, size and placement of erosion control devices can be made more effective. Information is also given on the effectiveness of mulches as temporary sediment control devices.

THE SOIL-LOSS EQUATION

Soil erosion can be due to either wind or water action. Of the two, water is responsible for a much greater volume of soil loss, particularly in Michigan. Many erosion control techniques will be effective for both types of erosion, but this report will focus on erosion caused by rainfall (sheet erosion).

Soil loss due to rainfall depends on six factors (16):

1) rain fall (R);
2) soil erodibility (K);
3) slope-length (L);
4) slope-gradient (S);
5) cropping-management or vegetative cover (C); and
6) erosion control practices (P).

Coordinating over 20 years of field research, a soil-loss equation was developed to predict reliably the average annual soil loss from a given area.

Because the equation is statistical some differences are expected between the predicted soil loss and that observed in the field. Past experience indicates the difference is generally 6% or less of the total predicted soil loss (11). The equation is a simple multiplicative sequence of the factors above (16):

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

The product, A, expresses the estimated amount of soil loss in tons per acre per year (T/A/Y).

The rainfall factor, R, is a composite measure of the annual average intensity, duration and erosive force of rainfall. This value ranges in Michigan from 40 to 155, but compared to nationwide variations, R is generally uniform within any particular county (Fig. 1).

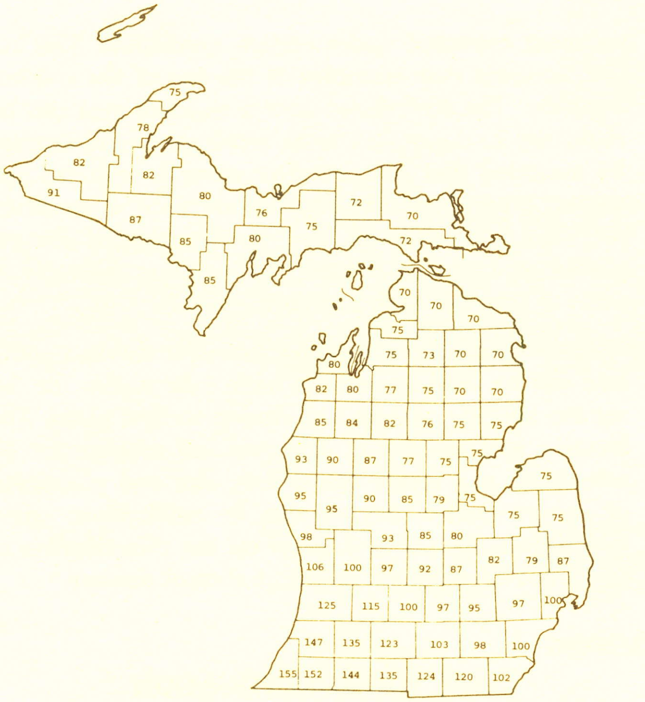


Fig. 1. Rainfall factor, R, for Michigan counties. Although this factor varies across the state, it may be considered uniform over a county-wide area.

Although the R factor is an annual average, most highly erosive rainfalls in Michigan occur during the summer months (16). By using the annual average R value (Fig. 1) to predict erosion from construction sites vulnerable only during the summer months, an extra margin of error is automatically provided for in the design of erosion control devices. R values for single-storm events with recurrence intervals of 1, 2, 5, 10 and 20 years are given in Table 1.

Table 1. Single storm R-values(a)

Recurrence interval (yr)	R-value
1	19
2	26
5	37
10	44
20	52

(a) From Wischmeier and Smith, 1965.

The R values in Table 1 are for a *single* storm, and used *only* in the peak flow design of sediment control devices. Use the average annual sum of R values (Fig. 1) for construction activities that will extend a season or more in length.

The soil erodibility factor, K, measures the influence of physical and organic properties on a soil's susceptibility to erosion. There are over 300 different soil series in Michigan. Each series has been assigned to a soil management group (groups of soils that have similar properties and behave similarly to the same management practices).

The task of designing adequate erosion control procedures is simplified using the soil management group concept. This concept has been discussed in detail (2, 8, 10). The K value can be estimated by examining five soil properties: percent silt and very fine sand; percent sand (coarser than very fine sand); percent organic matter; soil structure; and soil permeability. Using a nomograph developed by Wischmeier, Johnson, and Cross (17) which relates these properties to the K value (Fig. 2), a soil erodibility factor was determined for each soil management group and each major horizon found within these management groups (Fig. 3).

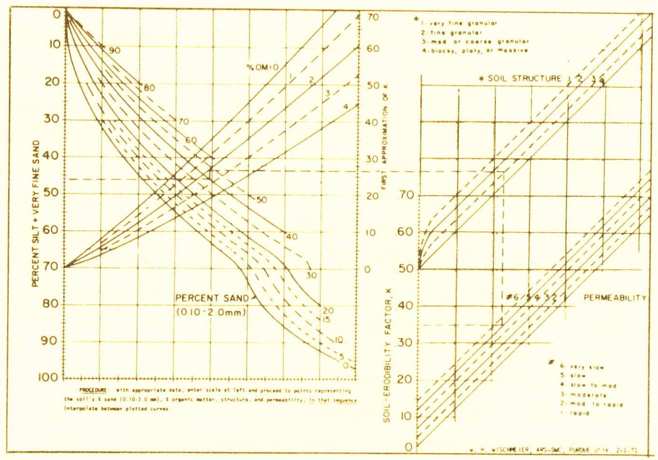


Fig. 2. Soil erodibility index, K, nomograph. The dotted line traces the path for the Nester soil series, A horizon (Table 2), in determining this soil's erodibility index. This copyrighted diagram (17) is reprinted by permission of the Soil Conservation Society of America.

The K value was determined for each major soil horizon (A-topsoil, B-subsoil and C-parent material) because construction and grading activities expose soil to varying depths. The K values shown in Fig. 3 represent nearly 400 soil samples analysed during the Michigan Agricultural Experiment Station Project Number 413, "A Physical Characterization of Representative Michigan Soils."

Most erodible soils occur in the 2.5 (loam and silt loam soils) and 3 (sandy loam soils) soil management groups (Fig. 3). The finer textured soils (soil management groups O, 1, and 1.5) are not as erodible primarily because of better adhesion between soil particles and a well developed structure. The least erodible soils occur in soil management groups 4 (loamy sands) and 5 (sands), primarily because of the coarser texture and higher permeability (Fig. 3).

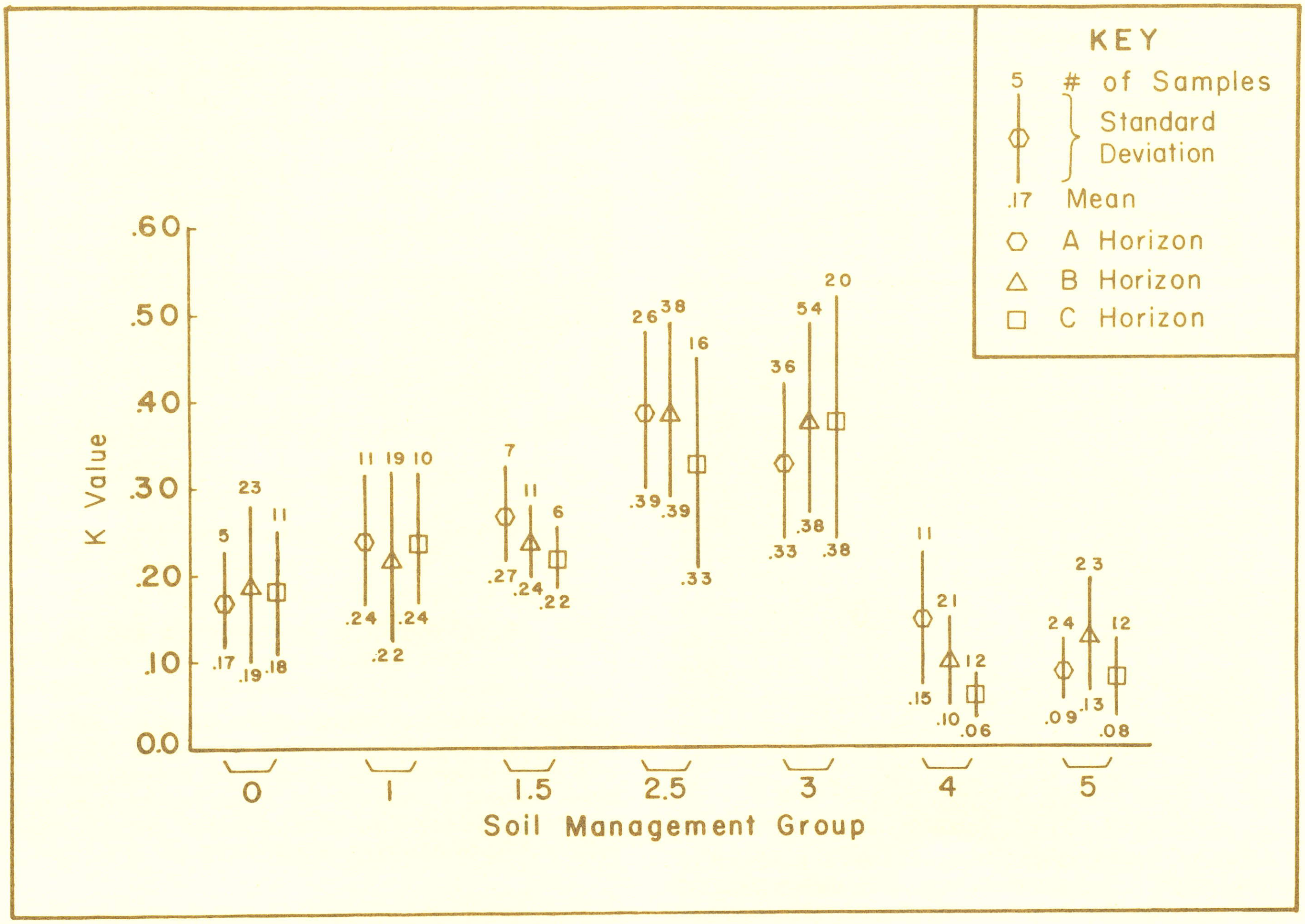


Fig. 3. Variation of mean K value for each horizon within soil management groups; data from Mich. Ag Expt. Sta. Project 413.

The vertical bars in Fig. 3 indicate the standard deviation of K values within each horizon of the soil management groups. (One unit of standard deviation includes about 60% of the observed range.) These deviations are comparable to those found within a single soil series.

The slope-length factor, L, is the effect of length of slope on soil erodibility. Slope-length is defined as that length of slope in which deposition does not occur, or the distance until the runoff enters a well defined channel. As slope-length increases, so does severity of soil erosion. For on-site applications, this value can be estimated from detailed topographic maps, or approximated from modern soil surveys. For regional evaluations, an average slope length of 200 ft may be used.

The slope-gradient factor, S, is the influence of the gradient or angle of slope on soil loss. As with the slope-length factor, an increasing slope-gradient increases the amount of soil loss. This value can be approximated from topographic maps, modern soil surveys, or field observation.

Because of the interrelationship between length and gradient of slope in soil loss, the L and S factors can be combined into a composite topographic factor, LS. Although this factor depends on the natural landscape, manmade changes in slope-length or gradient (e.g., with terraces) will affect the LS value.

For regional evaluations using a constant slope-length of 200 ft, the LS values are given in Table 2. In this Table, the LS factor is integrated with the medial slopes of the slope classes most often used by the National Cooperative Soil Survey in Michigan. For a specific site, the LS value can be determined from Fig. 4. The changes in LS value are not as sensitive to changes in slope-length for gentle slopes (2-6%) as they are for steep slopes (16-20%). Also, on gentle slopes doubling the slope gradient about doubles the LS factor, while quadrupling slope-length is needed to cause comparable increases in the LS factor.

The cropping-management factor, C, is the effect on soil erodibility from the kind of crop, tillage operation, length of exposure, vegetation or cover on

Table 2. Topographic factor, LS, for slope classes (% slope) with slope-length equal to 200 ft

Slope Class	%	LS value
A	0-2	.30
B	2-6	.60
C	6-12	1.7
D	12-18	3.7
E	18-25	7.0
F	25+	9.0

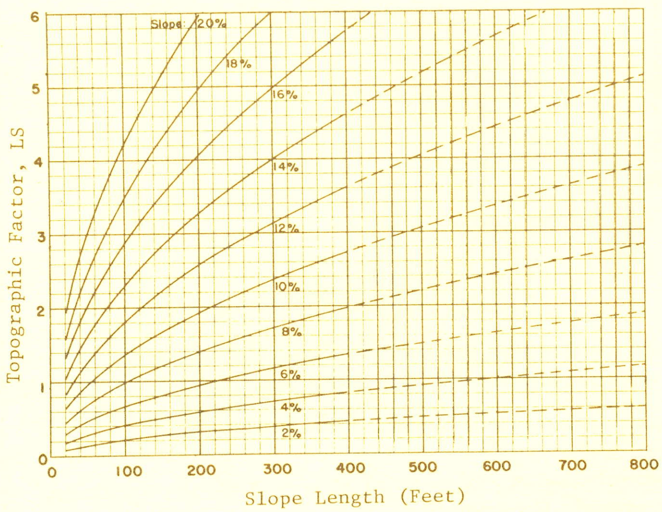


Fig. 4. Topographic factor, LS, as a function of slope-length, L, and percent slope, S. In determining LS values for this report, a constant slope-length of 200 ft was assumed. Figure from Wischmeir and Smith (16).

the site. This factor is the most sensitive and most frequently altered landscape characteristic affecting soil erosion. It is also one which is most easily controlled during construction activities.

Derivation of the C value is a complex and intricate procedure for areas undergoing intensive cultivation (1, 16). The C value for areas stripped bare of vegetation is equal to unity ($C = 1$). The easiest and least expensive cover-management practice at a construction site is to disturb as little of the vegetative cover as possible.

Of course, removing some of the vegetation is inevitable. When this occurs, other means of sediment control are needed such as mulching, sodding or trapping sediment before it leaves the site. There are various types of mulches, including wheat straw, hay, stones or woodchips. Each serve a specific purpose and have varying effectiveness as erosion control agents.

Fig. 5 shows the effectiveness of different application rates of a wheat straw mulch on bare soil. The mulch factor is equivalent to the C factor and is the ratio of soil loss on bare soil without a mulch to soil

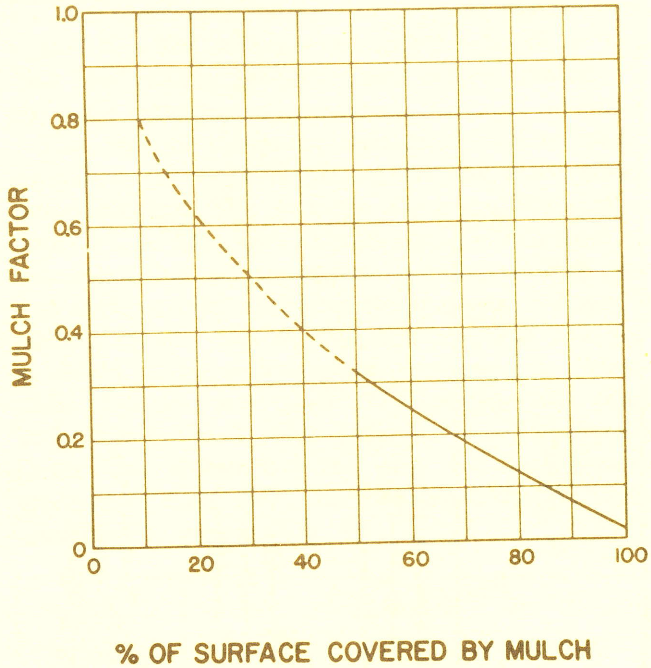


Fig. 5. Effect of wheat straw mulch on soil loss. Mulch factor (M in equation 2) is ratio of soil losses with given percentage of mulch cover to corresponding losses without a mulch cover. Figure reprinted by permission of the Soil Conservation Society and was originally published by Wischmeier, (14).

loss with a mulch cover. Straw mulching which covers less than 50% of the ground surface (about ½ ton per acre) is shown by a dashed line and not recommended. A 50% mulch cover means that one half of the ground surface can be seen through the mulch when viewed from above.

A straw mulch is good to use for temporary sediment control, such as on a graded area that will be eventually sodded or sown to grass. Straw mulch is sensitive to traffic and requires frequent routine maintenance to cover any bare spots, particularly after storms. A straw mulch seldom survives a winter season.

Table 3 gives the C values for stone or woodchip mulches. Stone (medium size gravel ½ in. or larger) is effective on areas that are to remain permanently bare, such as pathways or landscaping plots. Stone is particularly effective at application rates of 135 tons per acre (a depth of at least 1 in.), or more. A stone mulch will survive a winter season, but it must be checked annually.

A stone mulch is working when the voids between the stones fill with sediment. When the voids are nearly filled, another layer of stone is needed. A well maintained stone mulch is unaffected by slope-length (14).

A woodchip mulch (Table 3) is used primarily for ornamental or decorative purposes, such as on pathways or under shrubbery. This mulch is not as durable as stone, but is more permanent than straw. Woodchips do not hold up well under traffic and require periodic inspection for bare spots and sediment filling. Like straw mulch, woodchips lose effectiveness on long slopes; doubling slope-length about doubles the soil loss.

Trees and shrubbery also intercept and dissipate the energy of rainfall, roughly in proportion to the amount of ground area covered. Table 4 gives the C values for this effect. Shrubbery, in particular, is an effective long-term erosion control device; it also lends esthetic value to the site.

The most effective cover vegetation for erosion control is a well established sod. Table 5 gives the C values for grass in various stages of vigor. As can be seen in Table 5, a sod covering 95-100% of the ground reduces erosion to a mere fraction of that if no cover were present. Other than routine landscaping care, sod is an excellent long-term erosion control device.

Various vegetative mulching erosion control practices can be used in combination. In doing so, the effective C value (C′) can be expressed as (15):

$$C' = M_f \times C_f \qquad (2)$$

where M_f is the mulch factor (Fig. 5, Tables 3 and 5) and C_f is the *effective* canopy factor.

Table 3. C-values for stone or woodchip mulches (a)

Mulch type	Application rate (T/A/Y)	C Value
stone (b, c)	15(d)	.68
	60	.29
	135	.09
	240	.05
woodchips	2(d)	.68
	4	.21
	7	.14
	12	.05

(a) From Wischmeier and Meyer, 1973.
(b) Medium size gravel (0.5 in. to .75 in.).
(c) This low rate is not recommended.
(d) A stone mulch of 60, 135, 240 T/A corresponds to a depth of .5 in., 1 in., and 2 in., respectively.

Table 4. C-values for vegetative/canopy effect (a)

Cover type	% of ground covered 25	50	75	100
large trees (crown 4m high)	.93	.97	.80	.73
medium trees (crown 2m high)	.87	.75	.63	.50
high bushes (crown 1m high)	.83	.65	.47	.30
low bushes (crown .5m high)	.79	.58	.37	.16

(a) from Wischmeier, 1974

Table 5. C-values for sod and grass(a)

% ground cover	Establishment	C-value
95-100	well	.003
80	moderate	.012
40	poor	.10
20	very poor	.20

(a) from Wischmeier, 1974

Because the canopy affects only that portion of the ground not covered by a mulch, the values in Table 4 must be slightly modified when determining soil loss in areas having both a canopy and mulch. To determine the effective canopy factor, multiply the percent ground cover of the canopy by the percent of ground not covered by the mulch, then use this product as the percent of ground cover in Table 4.

For example, suppose an area is stabilized with a straw mulch of 70% ground cover and a canopy of shrubbery 1 m high covering 75% of the ground. The mulch factor, M_f in equation 2, is .20 from Fig. 5. The remaining 30% (1. — .70) of bare ground is covered by a 75% cover of canopy, for an effective canopy cover of 25% (.30 x .75 = .25). From Table 4, a canopy 1 m high with an effective ground cover of 25% has a canopy effect factor of .83 (C_f in equation 2).

For this particular mulch and shrubbery combination, the effective C value (C′ in equation 2 and C in equation 1) is .17 (.20 x .83 = .17). The numbers can be rounded to the nearest zero or five in the last decimal place without losing accuracy.

The erosion control practices factor, P, represents the influence of various erosion control and abatement procedures on soil loss, such as diversion ditches, sediment basins and contour plowing. Because of the complexity and variety of design of these devices, there is little data to develop values for the P factor. However, when no erosion control devices are in effect the P value becomes unity (P = 1).

It is possible to rearrange equation 1 to determine the cover-management factor (C) which will meet a given tolerance of soil loss (A):

$$C = \frac{A}{R \times K \times L \times S \times P} \qquad (3)$$

This procedure can be used to optimize sediment control strategies by determining proper application rates of a mulch for the size of sediment basin to be installed on a site or to meet local ordinance requirements.

ASSUMPTIONS AND LIMITATIONS

As with any environmental modeling and planning tool, the soil-loss equation has certain assumptions, and consequently, limitations. You must understand these limitations to apply the equation and subsequent design of erosion control facilities successfully. The soil-loss equation is a statistical summary of over 10,000 plot-years of observing the relationship between soil characteristics, climate and vegetation on soil loss. It is primarily designed to predict the long term (mean annual) erosion from an area, and the results tend to be less valid when estimating loss from short term events.

Within any particular soil series or management group, some variation is expected in the properties determining the soil erodibility factor. This variation, shown by the vertical bars in Fig. 3, is about the same for the soil management groups as for member soil series. More variation occurs in topsoil (A horizon) properties within soil management groups than in the subsoil (B horizon) and parent material (C horizon).

As a result, soil loss predictions for the subsoil and parent material tend to be more precise than predictions for topsoil loss. Remember, however, that site grading movement of machinery or heavy equipment tends to displace topsoil readily exposing subsoil to erosion.

Because of scale limitations, modern soil maps cannot show small areas of inclusions. While the proportion of inclusions vary from delineation to delineation, on the average they make up 45-55% of the mapping unit. However, some inclusions have similar properties (e.g., in the same soil management group) as the soil series in the mapping unit name. This is not a major limitation for regional evaluations of sensitive soil erosion areas (such as the Gaines Township example in this report), but for local site design (especially very small areas) a site inspection should confirm that the soil series indicated on the map is actually in the field.

The assumptions in determining the topographic factor of Table 2 are that the length of slope is 200 ft and the slope-gradient is uniform for that distance. For gentle slopes, the topographic factor, LS, is not as sensitive to slope length as for steep slopes. Michigan topography is such that gentle slopes or short steep slopes are more frequently encountered than long steep slopes.

Therefore, the values of Table 2 appear to be justified. Good slope values are also obtainable from soil maps published after 1960. Only 33 counties have recently published soils maps, or maps in various stages of completion (11). More accurate slope measurements are made by onsite inspection with very simple instruments or from detailed topographic maps. For regional studies, slope-gradient information may be estimated from U.S. Geological Survey topographic maps. Obtaining slope data from these maps is limited by the magnitude of the contour interval and scale.

Vegetation deters soil erosion (e.g., seedings of small grains), but there are many other effective ways to control soil erosion. Those discussed in this report are the more frequent and less costly ones used.

Traffic by vehicles, machinery, and people generally compact the soil, increase runoff and may increase soil loss. Increased adhesion between soil particles after compaction tends to reduce soil loss and may counter balance this effect. However, soil compaction is not a reliable erosion control practice.

Areas which meet the conditions discussed in this report include not only building construction sites, but also related site development, highway and utility corridors, sanitary landfills, fallow fields, open pit mining and certain forest harvesting procedures (e.g., clear cutting).

A REGIONAL APPLICATION IN GAINES TOWNSHIP

Statewide sediment control consists of a balance between local on-site and regional programs. This section discusses application of the soil-loss equation for determining regional areas sensitive to soil erosion during earth change activities. By identifying areas with high erosion susceptibility, specific control efforts, such as zoning ordinance and enforcement programs, can be planned for these areas.

The example given is in Gaines Township, Kent Co., Mich. This analysis technique is only one in a series being used by the West Michigan Regional Planning Commission (Region 8) in a wide ranging and innovative land use strategy development program to assist local planning groups or individuals.

Gaines Township lies on the south fringe of the Grand Rapids metropolitan area and is experiencing pressures of urban expansion and growth. The area's prior dominant land use has been agriculture, but this use is rapidly changing to residential development. This area will soon undergo extensive urbanization and related construction activities. A study in the Plaster Creek drainage basin, part of which lies in Gaines Township, shows construction activities can contribute up to 24% of the sediment load even though this comprises only 5% of the land use (9).

The staff of the Region 8 Planning Commission is compiling a regional resource inventory for the nine-county area, including Gaines Township. Information on soils, topography, land use, natural and cultural features have been entered into a computerized file. The Gaines Township file is typical within the Region 8 area.

The 36-m^2 (93 km^2) area was gridded into 4 ha (10 acres) cells, such that the location of each cell can be described by its row and column coordinates (12). At this resolution, there are 2,304 cells in a typical township. The soils map for Kent Co., completed in 1926, does not include slope-gradient information. U.S. Geological Survey 7½-min quadrangle maps, with a 10-ft contour interval, were used to estimate slope-gradient.

The idea behind a regional analysis is to identify areas having high erosion susceptibility, i.e. areas exhibiting a large amount of soil loss during construction activities if no preventive measures were taken. To achieve this, two assumptions were made: first, construction activities would remove all vegetative cover from the area; second, no erosion control practices would be used on the site. These assumptions will provide a baseline of potential erosivity against which the effectiveness of proposed erosion control programs can be evaluated.

In terms of the modeling equation (equation 1), the lack of vegetative cover without a replacement mulch cover means that the C value becomes unity ($C = 1$). Similarly, the lack of erosion control practices (diversion ditches, sediment catchment basin, etc.) means that the P factor is also set to unity ($P = 1$). Under these assumptions, equation 1 can be simplified to:

$$A = R \times K \times LS \tag{4}$$

For Kent Co., R is equal to 100 (Fig. 1). The remaining factors, K and LS, are determined from information contained in the computerized resource inventory file for each 4 ha (10-acre) parcel within the Township. The K factor was taken from the predominant soil series plus Fig. 3 and LS values were obtained from the slope information plus Table 2. A computer program was written to evaluate each cell for soil loss using equation 4.

The average soil loss for Gaines Township resulting from construction activities under the stated assumptions would be about 14 T/A/Y. The range is from 2-159 T/A/Y.

Four classes of soil erosion have been defined based on the procedures of the National Cooperative Soil Survey. **Slight** erosion is the removal of up to 25% (< 2 in.) of the plow layer. **Moderate** erosion is the removal of 25-75% (2-6 in.) of the plow layer. **Severe** erosion is the removal of more than 75% (>6 in.) of the original plow layer and part of the subsoil. **Very Severe** erosion is the removal of most of the soil profile.

Assuming 2 million pounds (1000 tons) in an acre plow layer and 100 years for the erosion to have occurred (time in which man has cultivated most of Michigan soils), the removal of 25% of the original plow layer would be at a rate of 2.5 T/A/Y. Based on these assumptions and definitions, the following quantitative soil loss classes were developed:

slight	less than 3 T/A/Y per year
moderate	3-8 T/A/Y
severe	8-13 T/A/Y
very severe	greater than 13 T/A/Y

Ringler and Humphreys (9) set the annual acceptable soil loss at 2 tons per acre.

Using these four erosion susceptibility classes, the expected soil loss for each cell in Gaines Township was estimated and mapped (Fig. 6).

Being able to predict potential erosion problems enables a local implementation official to recognize when and to what degree soil erosion control practices are needed at a construction site. Recent construction activities rarely provide erosion controls and usually damage most vegetation. With adequate precautions, however, on-site erosion can be signficantly reduced.

Areas susceptible to high erosion should be discouraged from urban development or protected by effective erosion controls at the endangered sites. The only data needed to activate this technique involves reference tables for rainfall, R, topographic, LS, and soil factors, K, (Equation 4) and maps on soils or soils and topography.

By aggregating this information into a small area grid system, such as in Gaines Township, its geographical interpretation is greatly simplified. It also makes the data amenable to relatively simple, inexpensive, and speedy computer analyses and mapping techniques.

ON-SITE APPLICATION IN LAPEER CO.

Act 347 requires that people involved with earth changing activities develop specific, on-site erosion control plans. In doing so, it is important to know where and how much sediment loss can be expected from the site and the effectiveness of various erosion control techniques. The design process requires quantitative information.

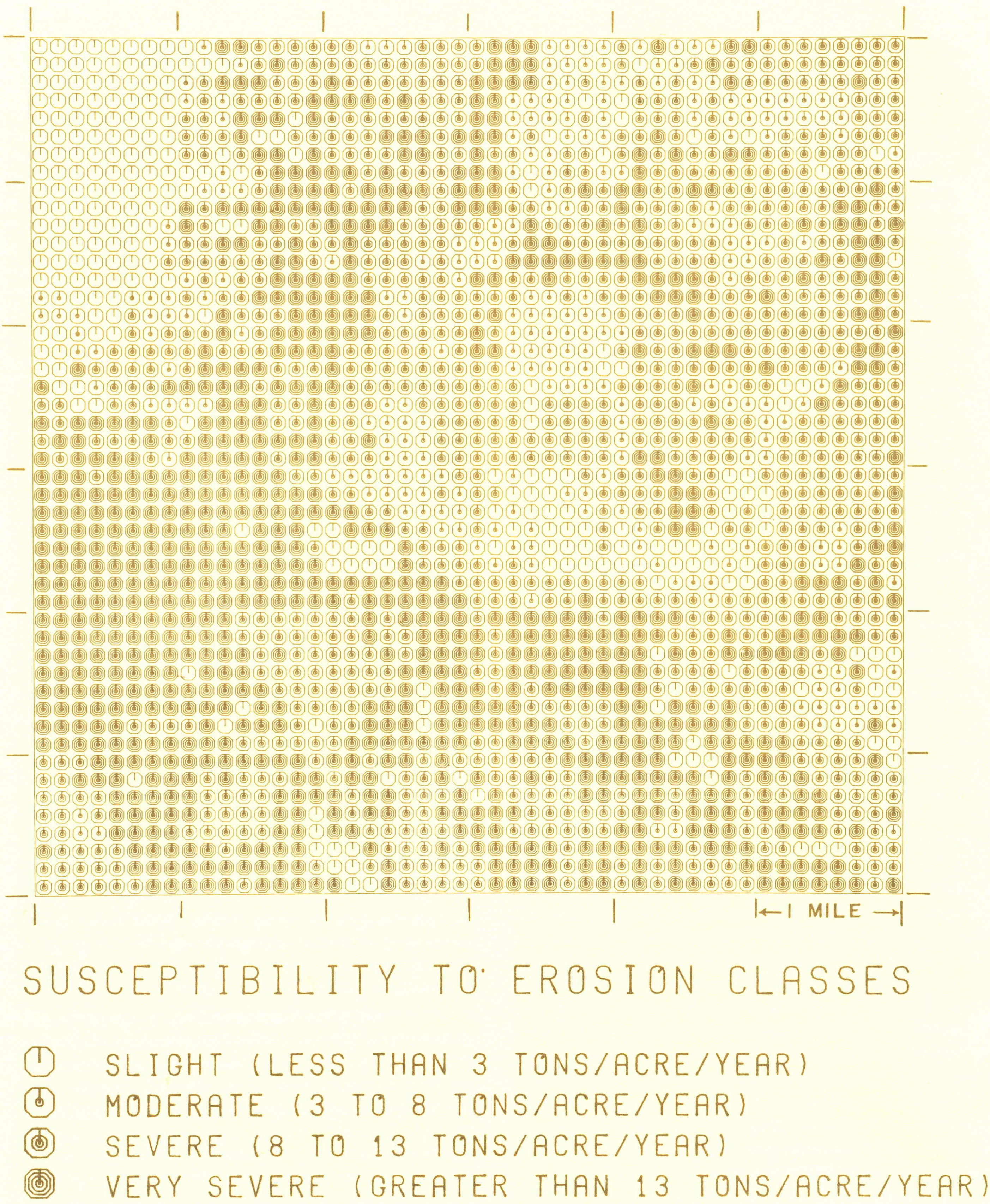


Fig. 6. Susceptibility to erosion classes for Gaines Township, Kent Co., Mich.; North is toward the top of the map. Each cell represents one 10 acre cell.

Knowing that mulching bare ground is "very effective" does not help the engineer trying to design a sediment catchment basin to contain the sediment a mulch does not hold in place. Knowing that an area is "very susceptible" to erosion does not provide enough information to design a sediment catchment basin.

This section describes a relatively simple and inexpensive technique to determine where and how much sediment can be expected from a construction site. The example also shows the advantages from using common soil erosion control devices, primarily mulching. (It is beyond the scope of this report to fully develop a complete erosion control plan for the example given, for such a task requires more detailed information.)

Some background for a hypothetical example is necessary. A 160-acre example area is located in the SW ¼ of Section 22 in Marathon Township, Lapeer Co. The area is assumed to be in the process of development into medium to low density single family housing units, with central sewerage. The development plans call for a 2-year construction period in which earth change activities will occur only during the summer months.

A straw mulch will be used as the primary temporary sediment control measure. Bare ground will be sodded as soon as practical and in time for adequate establishment before winter. Gravel access roads will be covered with a bituminous surface once the roadbeds are stabilized.

The site planner wished to know the origin and quantity of sediment to be expected during the construction period. He had obtained a detailed topographic map and a modern soil survey of the area (13). The site engineer has confirmed the accuracy of the soils map.

DETERMINING SIMILAR SOIL EROSION UNITS

The following procedure is suggested to determine areas within a construction site having similar expected soil erosion characteristics. The method consists of preparing a series of overlays, of which the final overlay is a map of homogeneous soil erosion units. To begin:

1) Prepare a nine-column table with headings similar to those shown in Table 6.

2) Place acetate or tracing paper over the soils map of the area (Fig. 7A). Trace the boundaries of the soil management groups found in the area (Fig. 7B). The soil management group of an individual soil series is usually given in the guide to mapping units section and in the narrative part of the soil survey report, or can be obtained from other Research Reports (8, 10).

Use only the texture of the upper story for soils with contrasting texture in determining map unit boundaries; e.g., soil management groups 3a and 3/2a would be grouped into one unit. Use lower story texture if construction will remove the upper story. Label this overlay "Similar Profile Texture Groups."

3) Prepare second overlay (to the same scale as the soil map) from the detailed contour map (Fig. 7C). If the contour lines become crowded and confusing, draw only the 10-ft contour intervals (Fig. 7C). Indicate the major and minor drainage divides in the site by a bold solid line, or line of different color.

Indicate well-defined channelways, diversion ditches and transitions between slope categories A (0-2%) and greater than A (>2%), by a bold dashed line, or dashed line of different color (Fig. 7C). The soils map may help you determine transitions between steep (>2%) and gentle (<2%) slopes. The dashed lines indicate areas of potential deposition and are used to measure slope length.

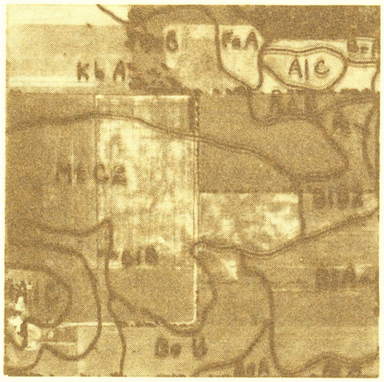
It may be helpful to indicate runoff pathways from the drainage divides (solid bold line) to the deposition areas (dashed lines). Remember, runoff pathways always cross contour lines at right angles. (Fig. 7C). Label this map "Contour Overlay" and include a legend for drainage divide, depositional area and runoff pathway lines.

4) Prepare third overlay showing similar topographic units, or areas with similar slope-length and slope-gradient. Draw lines over the drainage divides (bold lines on the Topographic Overlay) and the transition lines between A and B slope classes (dashed lines on the Contour Overlay). These lines should define closed areas (Fig. 7D).

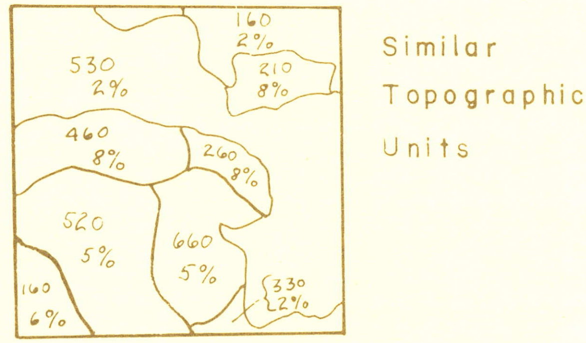
Indicate the slope-gradient on each topographic unit. Determine slope-gradient from soil maps, detailed topographic maps or from on-site inspection. Indicate slope-length (distance the runoff follows from the drainage divide to the depositional areas) on each topographic map unit (Fig. 7D).

Four or five typical runoff path measurements should be averaged for each topographic map unit. Try to follow the actual runoff path when taking these measurements: runoff rarely follows a straight line. Label this overlay "Similar Topographic Units."

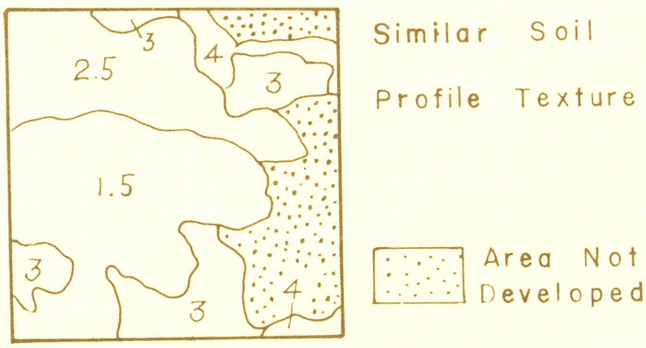
5) To prepare the final overlay of homogeneous soil erosion units, trace the boundaries between the similar profile texture groups (Fig. 7B). On the same overlay, (Fig. 7E), trace the boundaries between the similar topographic units (Fig. 7D). Areas outlined



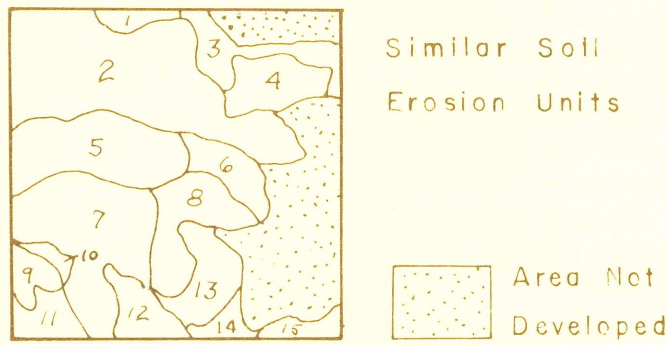
A



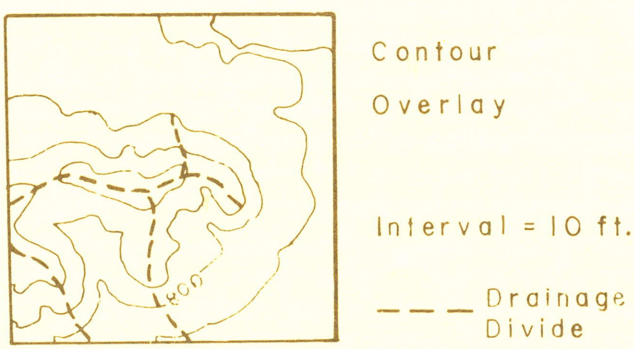
D



B



E



C

Fig. 7. A. Soils map; B. modified soil management group overlay; C. contour overlay with drainage divides (dashed lines); D. homogeneous topographic units overlay; and E. homogeneous soil erosion units overlay.

in this manner have similar soil and topographic properties and, therefore, similar soil erosion potentials. Number each map unit consecutively (Fig 7E). Label this overlay "Similar Soil Erosion Units."

Now Column 1 of Table 6 can be filled out. In the example given (Fig. 7E), there are 15 similar soil erosion units. The soil management group number, slope-length and slope-gradient for each soil erosion unit are entered into columns 2, 3 and 4, respectively. The K values (column 5, Table 6) can be obtained from Fig. 3 of this report. The LS Values (column 6, Table 6) can be obtained from percent slope and slope lengths in Fig. 4 of the this report.

The R values are given in Fig. 1 of this report (Lapeer Co. = 79). Calculate the maximum expected soil loss by using equation 4, and enter into column 7, Table 6. (This soil loss assumes that all vegetative cover will be removed and no erosion control practices will be in effect.)

Next, determine the number of acres in each similar soil erosion unit (Fig. 7E). This can be done with a dot grid:

Prepare a dot grid on a piece of acetate so that at least 100 fall within the size of the similar Soil Erosion Units map. Space the dot in a uniform grid fashion. Place the dot grid over the Similar Soil Erosion Unit map (Fig. 7E) in any position.

Count the number of dots that fall within each map unit. If a dot falls on a line, assign it to a unit by a flip of a coin. Do not count the same dot twice. Sum the total number of dots counted. Determine the acreage of each unit by the following formula:

$$\text{acreage of one unit} = \frac{\text{no. of dots in one unit}}{\text{total no. of dots on map}} \times \text{total acreage in construction area}$$

The acreage of each similar soil erosion unit is entered into column 8 of Table 6. Multiply column 7 by column 8 (Table 6) and enter in column 9 of Table 6. The sum of column 9 is the total tonnage of sediment that can be expected from the construction site, **if no erosion controls are used.**

DEVELOPING AN EROSION CONTROL PLAN

In the example given, construction plans call for a 2-year construction-earth changing period. The area will be divided based on the drainage, and consequently, movement of sediment within the site. A reasonable plan would be to develop similar soil erosion map units 1 through 6 (northern half of area) (Fig. 7E) during the first year, and map units 7 through 15 (southern half of area) in the second year.

Table 6. Similar soil erosion units and total soil loss from developed area

(1) Similar soil erosion unit no.	(2) Soil management group no.	(3) Slope-length	(4) Slope-gradient (%)	(5) K value	(6) LS value	(7) Expected soil loss (T/A/Y)	(8) Soil erosion unit acreage (a)	(9) Erosion unit total soil loss
1	3	130	3	.33	.30	8	1	8
2	2.5	530	2	.39	.5	15.5	36	558
3	4	160	2	.15	.30	3.5	6	21
4	3	210	8	.33	1.1	29	7	203
5	1.5	460	8	.27	1.9	40.5	16	648
6	1.5	260	8	.27	1.6	34	5	170
7	1.5	520	5	.27	1.3	28	21	588
8	1.5	660	5	.27	1.2	25.5	12	306
9	3	160	6	.33	.9	23.5	3	71
10	3	520	5	.33	1.3	34	1	34
11	1.5	160	6	.27	.9	19	4	76
12	3	520	5	.33	1.3	34	4	136
13	3	660	5	.33	1.2	31	8	248
14	3	330	2	.33	.4	10.5	3	32
15	4	330	2	.15	.4	5	3	15
							Total soil loss from developed area	3114

(a) 31 acres were not developed

Under this plan, a combination of mulching and sediment traps could be installed where needed to control excessive erosion. If no mulching was done on the site, the developer could expect about 1600 T of sediment the first year and 1500 T the second year. Designing an effective sedimentation basin for this large quantity of sediment is difficult and expensive.

Table 7 lists the expected sediment yields for each similar soil erosion unit, and that which would be expected under the stated mulching rates. For units with a moderate erosion potential (map units 3 and 15 on Fig. 7E), applying a 60% ground cover straw mulch (about ¾ tons per acre) or 4 tons per acre woodchip mulch will reduce erosion rates to under 2 T/A/Y (Table 7).

Table 7. Expected soil loss with straw mulch

(1) Similar soil erosion unit map no.	(2) % Cover with straw mulch	(3) Expected soil loss with mulch (T/A/Y)	(4) Unit acreage	(5) Total expected soil loss from unit (T)
1	80	1	1	1
2	95-100	.5	36	18
3	60	1	6	6
4	95-100	1.5	7	11
5	95-100	2	16	32
6	95-100	1.5	5	8
7	95-100	1.5	21	32
8	95-100	1	12	12
9	95-100	1	3	3
10	95-100	1	1	1
11	95-100	1	4	4
12	95-100	1.5	4	6
13	95-100	1.5	8	12
14	80	1.5	3	5
15	60	1	3	3
			Total from Area	154

For units with a severe potential of soil loss, application rates of 80% ground cover straw mulch (1¼ tons per acre) or 7 tons per acre woodchip mulch are needed to achieve similar reductions in erosion rates. Soil erosion unit 5 has the most severe erosion potential (over 39 T/A/Y). In the unit, an application of over 95% ground cover straw mulch (2½ or more tons per acre) or a woodchip mulch of 12 tons per acre is required to reduce erosion to under 2 T/A/Y (Table 7).

With this mulching schedule, **some soil erosion will still occur,** though only about 5% as much as if no mulch was used. Sediment can be contained on-site by effectively designed sedimentation basins. These basins need a combined capacity of at least 208 yd^3 to contain 154 tons of expected sediment.

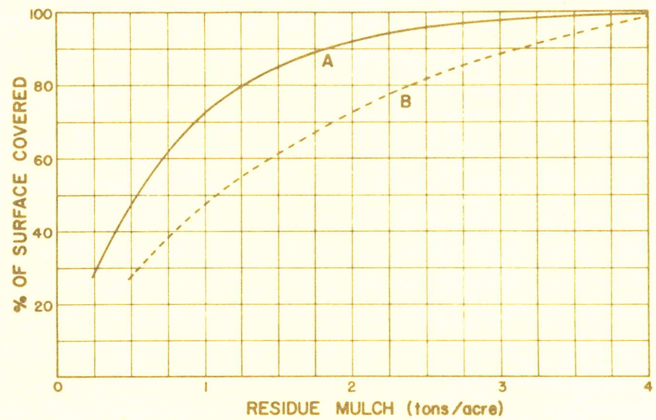


Fig. 8. Relation of percentage of surface cover to mulch rate. Curve A is for small-grain straw; curve B is for chopped cornstalks.

Table 8. Conversion Table

1 ha = 2.5 acres	1 m = 1.08 yd = 3.28 ft
1 acre = .4 ha	1 yd = .91 m
1 metric ton = 1.10 short ton	1 m^3 = 1.32 yd^3
1 short ton = .91 metric ton	1 yd^3 = .76 m^3
1 ton per acre = 2.24 metric ton/ha	
1 metric ton/ha = .45 tons per acre	
60 tons per acre stone will cover soil to depth of .5 in.	
135 tons per acre stone will cover soil to depth of 1 in.	
240 tons per acre stone will cover soil to depth of 2 in.	
1 ton of sediment = 36.5 ft^3 = 1.35 yd^3	

SUMMARY

The soil-loss equation (p. 3) can be a useful tool in developing regional and specific site erosion control plans. This equation can be used in conjunction with available data sources, such as soils and topographic maps supplemented with simple on-site observations. The two application methods described in this report can provide a baseline and method of communication between regulatory agencies and those being regulated.

Only by such communication can the spirit and intent of the *Soil Erosion and Sedimentation Control Act of 1972* prove of benefit to this, and future, generations.

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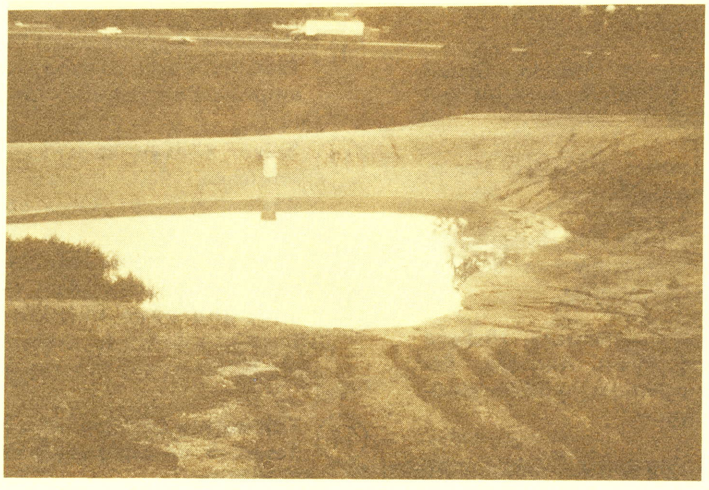
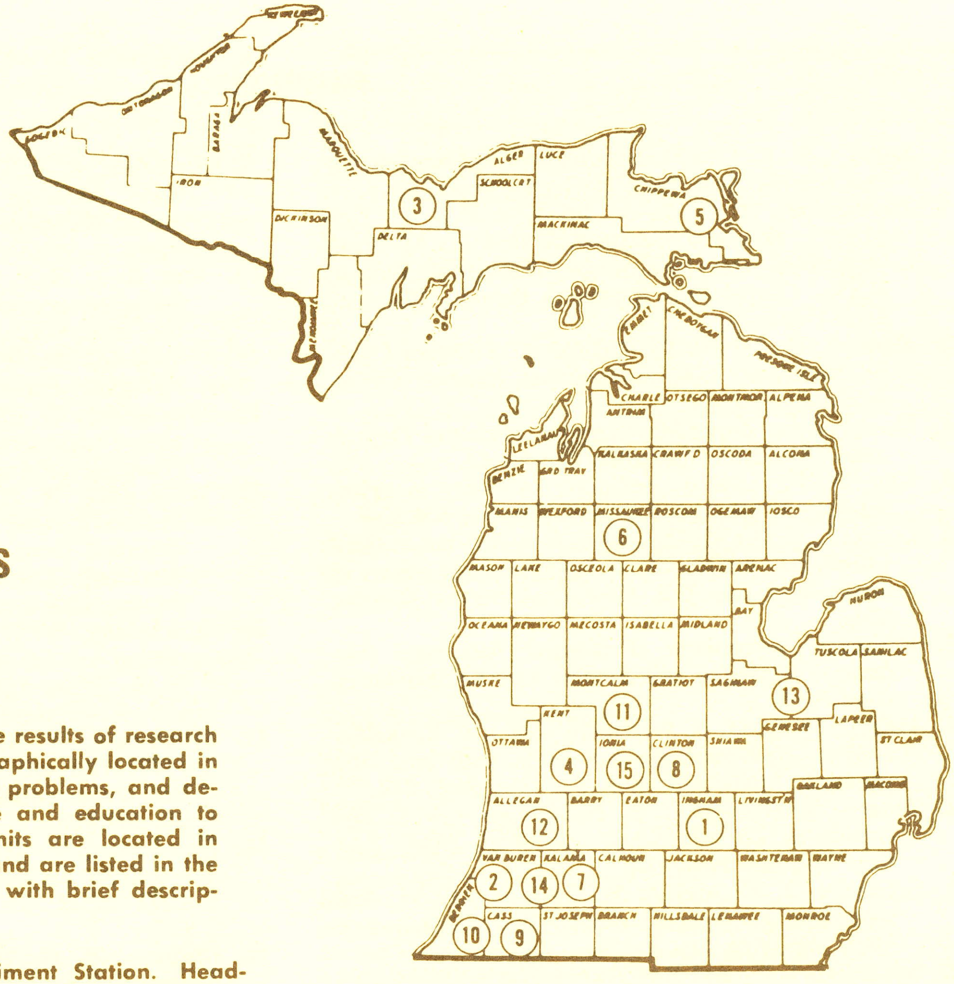


Fig. 9 Catchment basin to collect sediment from a construction site.



Outlying Field Research Stations

These research units bring the results of research to the users. They are geographically located in Michigan to help solve local problems, and develop a closeness of science and education to the producers. These 15 units are located in important producing areas, and are listed in the order they were established with brief descriptions of their roles.

1. Michigan Agricultural Experiment Station. Headquarters, 101 Agriculture Hall. Established 1888. Research work in all phases of Michigan agriculture and related fields.

2. South Haven Experiment Station, South Haven. Established 1890. Breeding peaches, blueberries, apricots. Small fruit management.

3. Upper Peninsula Experiment Station, Chatham. Established 1907. Beef, dairy, soils and crops. In addition to the station proper, there is the Jim Wells Forest.

4. Graham Horticultural Experiment Station, Grand Rapids. Established 1919. Varieties, orchard soil management, spray methods.

5. Dunbar Forest Experiment Station, Sault Ste. Marie. Established 1925. Forest management.

6. Lake City Experiment Station, Lake City. Established 1928. Breeding, feeding and management of beef cattle and fish pond production studies.

7. W. K. Kellogg Farm and Bird Sanctuary, Hickory Corners, and W. K. Kellogg Forest, Augusta. Established 1928. Forest management, wildlife studies, mink and dairy nutrition.

8. Muck Experimental Farm, Laingsburg. Plots established 1941. Crop production practices on organic soils.

9. Fred Russ Forest, Cassopolis. Established 1942. Hardwood forest management.

10. Sodus Horticultural Experiment Station, Sodus. Established 1954. Production of small fruit and vegetable crops. (land leased)

11. Montcalm Experimental Farm, Entrican. Established 1966. Research on crops for processing, with special emphasis on potatoes. (land leased)

12. Trevor Nichols Experimental Farm, Fennville. Established 1967. Studies related to fruit crop production with emphasis on pesticides research.

13. Saginaw Valley Beet and Bean Research Farm, Saginaw. Established 1971, the farm is owned by the beet and bean industries and leased to MSU. Studies related to production of sugar beets and dry edible beans in rotation programs.

14. Kalamazoo Orchard, Kalamazoo. Established 1974. Research on integrated pest control of fruit crops.

15. New Horticultural Field Station, Clarksville. Established 1974. Research on all types of tree fruits, vegetable crops, and ornamental plants. Site development began during 1975.

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