WEPS INTRODUCTION AND BACKGROUND

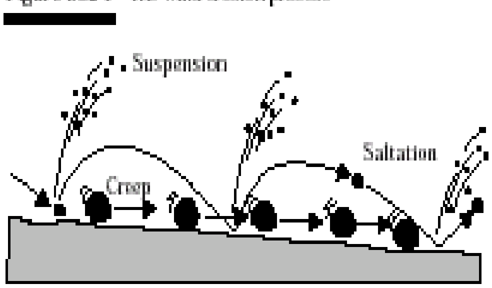
The Wind Erosion Problem

Wind is an erosive agent. It detaches and transports soil particles, sorts the finer from the coarser particles, and deposits them unevenly. Loss of the fertile topsoil in eroded areas reduces the rooting depth and, in many places, reduces crop yield. Abrasion by airborne soil particles damages plants and constructed structures. Drifting soil causes extensive damage and if deposited in drainage ditches or creeks it can impair water quality from phosphorus attached to the soil particles. Sand and dust in the air can harm animals, plants, humans, and equipment.

Wherever the soil surface is loose and dry, vegetation is sparse or absent, and the wind sufficiently strong, erosion will occur unless control measures are applied (1957 Yearbook of Agriculture). In Michigan, the regions subject to damaging wind erosion are the muck and sand textured soil types. In some areas, the primary problem caused by wind erosion is crop damage. Some crops are tolerant enough to withstand or recover from erosion damage. Other crops, including many vegetables and specialty crops, are especially vulnerable to wind erosion damage. Wind erosion may cause significant short-term economic loss even in areas where erosion rates are below the soil loss tolerance (T) levels where sensitive crops are easily damaged by abrasion and desiccation from saltation. (See Crop Tolerance to Blowing Soil-Table1).

The Wind Erosion Process

Figure 502-1 The wind erosion process



The wind erosion process is complex. It involves detaching, transporting, sorting, abrading, avalanching, and depositing of soil particles. Turbulent winds blowing over erodible soils cause wind erosion. Field conditions conducive to erosion include:

- Loose, dry, and finely granulated soil;
- Smooth soil surface that has little or no vegetation;
- Sufficiently large area susceptible to erosion; and
- Sufficient wind velocity to move soil.

The wind speed at which particle movement is initiated is called the **Threshold Velocity** and is dependent on the state of the soil surface. A soil surface that is rough or protected with non-erodible material will require a stronger wind to initiate particle movement, than a bare, smooth surface. This means that for a given field, there is no single threshold velocity but rather a range of velocities depending on the soil surface condition, including aggregation, roughness, crop status, and moisture. Most of these properties can also change during a storm due to the erosive action.

There are three ways soil particles are moved by wind: **saltation, surface creep and suspension**. Each mode of wind erosion transportation has its own characteristics and effects (Figure 502-1).

***Saltation*—**is a mode of transport where smaller individual soil particles, 1/10 to 1/2 millimeter in diameter, under the influence of wind, lift off the surface and bounce or hop along the surface.

As they bounce, they strike other particles, causing them to move. The higher the grains jump, the more energy they derive from the wind. Because of this wind-derived energy, the impact of saltating grains initiates movement of larger grains and smaller dust particles that can be suspended in the air and carried great distances. Saltating grains are like abrading *bullets that* collide with protective soil crusts and clods and cause their breakup, reducing roughness. Saltating soil particles can rebound or embed themselves initiating movement of other particles/aggregates to create the **avalanching** effect. Saltation also damages young plants, threatening their survival and can damage their fruit, reducing their marketability. Saltating particles continue to move until the wind slows or they're trapped in sheltered areas. Fifty to 80 percent of wind erosion is transported by saltation that occurs within 12 inches above the soil surface.

Surface creep occurs when sand-sized particles or aggregates are set in motion by the impact of saltating particles. Under high winds, the whole soil surface appears to be creeping slowly forward as particles are pushed and rolled by the saltation flow. This process continues until: 1.) the wind slows 2.) Rolling soil is stopped by other particles or 3.) Soil is trapped in a sheltered location, such as a furrow or a vegetated area. Surface creep generally involves particles approximately 1/2 to 1 millimeter in size, small enough to be moved by the wind but too massive to be lifted off the surface. Surface creep may account for 7 to 25 percent of total transport (Chepil 1945 and Lyles 1980).

Suspension refers to particles less than 1/10 of a millimeter - smaller than the diameter of a human hair - that are lifted far above the surface and carried great distances. Some of these form dust clouds that race across continents, oceans, and around the world and cause visibility problems.

Also, a small fraction of suspension particles may cause health problems when inhaled. These particles are known as PM10, which are particulate matter less than 10 microns in size or smaller.

Some suspension-sized particles or aggregates are present in the soil, but many are created by abrasion of larger aggregates during erosion. From 20 to 60 percent or more of an eroding soil may be carried in suspension, depending on soil texture. Suspension generally increases downwind, and on long fields can easily exceed the amount of soil moved by saltation and surface creep. The rate of increase in soil flow along the wind direction varies directly with erodibility of field surfaces.

On an eroding field, the amount of soil movement will tend to increase with distance downwind due to the impact of saltating grains breaking up clods and initiating other particles to move. If the field is large enough, the surface creep and saltating soil reaches a maximum that a wind of a particular velocity can sustain. However, the amount of soil carried by suspension can keep increasing as soil diffuses into the atmosphere.

Estimating wind erosion

The amount of soil that erodes as surface creep, saltation, or suspension depends on the soil type. Soils that are pure sand will move almost completely by surface creep and saltation. However, if the soil is almost pure clay or muck with clods that break down under saltation, a high percentage of soil loss will be by suspension.

Wind erosion is eventful and difficult to measure. Wind moves across the land in a turbulent, erratic fashion. Soil may blow into, within, and out of a field in several directions in a single storm. The direction, velocity, duration, and variability of the wind all affect the erosion that occurs from a windstorm. Much of the soils eroding from a field bounces or rolls near the surface; however, some of the soil blown from a field may be high above the ground in a dust cloud by the time it reaches the edge of a field. (Chepil 1963).

No precise method of measuring wind erosion has been developed. Research is continuing on new techniques and new devices, on modifications to older ones, and on means to measure wind erosion.

The Wind Erosion Prediction System (WEPS) is used to estimate wind erosion rates and:

- Provide technical assistance to land users,
- Inventory natural resources, and
- Evaluate the effectiveness of conservation practices and management applied to the land.

Estimates of wind erosion can be made by assigning numerical values to the site conditions describing wind erosion conditions and expressing the relationships mathematically. This is the basis of the current Wind Erosion Prediction System (WEPS) that considers daily changes in soil erodibility, ridge roughness, climate, unsheltered distance, and vegetative cover. WEPS is a process-based, daily time-step model that simulates weather, field conditions, management and erosion. It completely replaces the Wind Erosion Equation which was in use prior to the release of WEPS. WEPS 1.2.9 consists of the WEPS science model with a user-friendly program that has the capability of simulating spatial and temporal variability of field conditions and soil loss/deposition within a field. WEPS can also simulate simple field shapes and barriers on the field boundaries. The saltation /surface creep / suspension and PM10 components of eroding material also can be reported separately by direction in WEPS.

Official WEPS Program

The official version of the WEPS program is distributed to NRCS computers electronically and may be found on the official USDA-NRCS site for WEPS at http://www.weru.ksu.edu/nrcs/.

This site allows access to the only version of WEPS to be used for official purposes by NRCS field offices. The USDA-Agricultural Research Service (ARS) is the lead agency for developing the WEPS model. The ARS is responsible for developing the science in the model and the model interface. The NRCS developed and maintains the database components on this site. These components comprise the Official NRCS WEPS Database. The official NRCS WEPS database is the only database to be used for official purposes by NRCS field office employees.

WEPS is designed to predict long-term average annual soil losses from a field having specific characteristics. WEPS will facilitate planning of soil conservation systems, aid in environmental planning and assessment evaluations, and estimate the offsite impacts of wind erosion. The WEPS model will estimate wind erosion calculations using grid areas to:

- Provide more accurate assessments of soil loss from agricultural fields
- Be a better tool for designing efficient, cost-effective erosion control systems
- Provide additional quantitative information besides just average annual soil loss
- Provide additional prediction capabilities not available with current technology
- Estimates of soil loss by wind erosion across individual field boundaries
- Estimate the direction and loss of soil by suspension
- Estimate PM-10 emissions or eventually Pm 2.5 emissions and operation dust
- Help determine offsite impacts

WEPS simulates wind erosion processes of detachment, transport and deposition. WEPS incorporates elements of the Wind Erosion Equation (WEQ) to estimate average annual soil loss in tons per acre per year, using a 50 year daily erosion rate calculation per crop in the crop rotation to predict the average annual soil loss using the following factors:

I = soil erodibility index
K = soil ridge roughness factor
WEPS Climate Data is generated by the Climate Generator model (CLIGEN) and WINDGEN Wind Generator model
State and County Location
Region field size and location of stable borders
Presence of Wind barriers such a field windbreaks
Field Management factors related to daily changes due to climate or management
Prevailing Wind Direction during critical wind erosion periods
Vegetative cover is modeled by entering crops and tillage in the management editor (MCREW)

The Soil Erodibility Index or I factor is the average annual soil loss in tons per acre per year from a field area. The I factor accounts for the inherent soil properties affecting soil erodibility. These properties include: texture, organic matter, and calcium carbonate percentage. **I** is the potential annual wind erosion for a given soil under a given set of field conditions. The given set of field conditions for which **I** is referenced is that of an isolated, unsheltered, wide, bare, smooth, level, loose, and noncrusted soil surface, and at a location where the climatic factor (C) is equal to 100. I changes throughout the season with weather and other factors that affect Surface Aggregation and Surface Crusting on a daily basis. However, WEPS can calculate wind erosion for only one soil type per project run. In WEPS the Critical Dominant soil is the soil with the highest I factor in a field of a manageable size. A good rule of thumb to identify the Critical Dominant Soil of manageable size is to use the most erodible soil greater than 10% of the field or greater than 10 acres in size.

The Ridge/Roughness (K) factor is a measure of the effect of random ridge roughness made by tillage and planting implements. Ridge/roughness is obtained using the ridge spacing and height by defining the angle of deviation of the wind compared to equipment operation across the field. The model uses the tillage entered in the management screen to determine this value.

WEPS Climate Data is a daily Climate Generator Model **(CLIGEN**) and Wind Generator Model (**WINDGEN)** that runs 50 years for each crop in a crop rotation to recreate the historical weather distribution and get a stable wind erosion estimate. WEPS does not use actual data. WEPS uses statistically probable weather conditions to mimic the historical weather. WEPS climate data drives the fundamental physical processes simulated by WEPS that include daily changes in the following: field features: soil aggregation, surface roughness, surface wetness, and crop residue status. WEPS climate data also simulates processes driven by daily weather: soil water balance, climatic wind speed and direction, surface soil moisture, crop growth and residue decomposition. CLIGEN is a stochastic weather generator which produces daily estimates of precipitation, temperature, dew point, wind and solar radiation for a single geographic point using monthly parameters derived from the historical measurements. WINGEN was developed specifically for WEPS from high quality hourly wind data sets using wind thresholds, wind energy, monthly percentage of wind energy, preponderance, and prevailing wind direction.

Prevailing Wind Direction and Critical Wind Erosion Period

When planning conservation systems, it is important to consider wind direction and windy periods throughout the year. **The prevailing wind erosion direction** is that direction in which the greatest amount of soil is moved. For WEPS the prevailing wind direction uses the same 16 points on the compass and preponderance is the same as WEQ. This direction is primarily influenced by the duration and the velocity of wind from different directions and is calculated in the model by **WINDGEN.** The effectiveness of wind barriers, strip cropping, ridges, etc. in reducing wind erosion is determined by their orientation relative to the prevailing wind erosion direction for the particular month(s) that control is desired. Tables listing the prevailing wind erosion direction by month for many locations in the United States are available at the following NRCS WEQ web site address:

http:// www.weru.ksu.edu/nrcs/wepsnrcs.html

With WEPS open at the main interface, prevailing wind data by month for a location can also be found in: Tools/Display Wind Station

The critical wind erosion period is that part of the year when agricultural fields are particularly vulnerable to wind erosion due to higher wind speeds that normal and low vegetative cover on fields. In the Great Lakes states, this period is typically February-May when winds are the greatest and crops are not high enough to protect the soil surface. This period is identified by looking at the output generated by making a WEPS run for a given set of conditions at 15 day intervals in the Detailed Report: Erosion Vegetation, Residue & Crop Biomass Report.

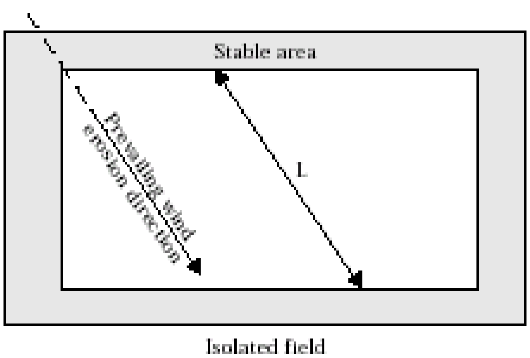
WEPS calculates wind erosion estimates for Grid Areas. The Grid Area or Region is represented by an E-W direction with an X axis measured in feet and a N-S direction with a Y axis measured in feet. The **X-length** is the **longest** (one direction) distance from a stable boundary to the opposite site of the field running **east-west** with the orientation angle set at 0. The **Y-length** is the **longest** (90 degrees to the X-length) distance from a stable boundary to the opposite side of the field running **north-south** with the orientation angel set at 0. The X and Y length are the **unsheltered distances** WEPS will use to calculate the erosion rate and ***__the length can be longer than the field dimensions if there are no stable boundaries__***

A **stable boundary** is one that stops surface creep and saltation wind erosion processes. A grass strip at least 13 ft wide and 1.5 foot high is an example of a stable boundary. Other examples of stable boundaries include: grass, hedges, roadways with grass borders at least 12 feet wide and 1 foot tall, or drainage ditches (Figure 502-7). Vegetation width, height, and porosity are to be considered in declaring a stable boundary. Most barriers such as a windbreak also can function as a stable boundary.

In WEPS, wind directions are simulated to vary from day to day throughout the simulation. Because the management outside the field is not controlled by the same owner for conservation planning purposes, the unsheltered distance should be the **longest distance** from a stable boundary through the length of the field to the down-wind edge of the field.

When planning conservation practices, consider the unsheltered distance from all directions across the area to be evaluated. The unsheltered distance starts where no surface creep or saltation occurs and ends at the downwind edge of the contributing area. If the north, south, east or west edge of the field is not stable, the measurement starts at the nearest stable point upwind.

Figure 502-5 Unsheltered distance L



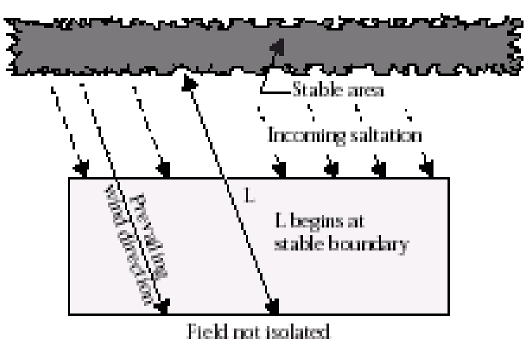


Figure 502-6 Unsheltered distance L, perennial vegetation (pasture or range)

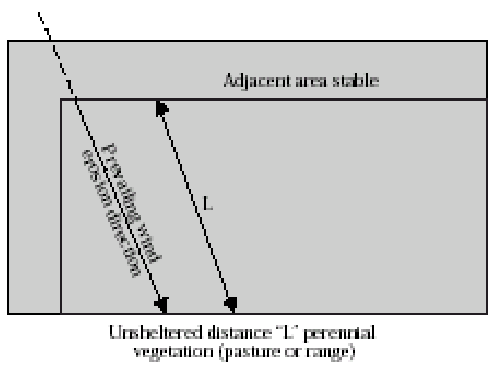
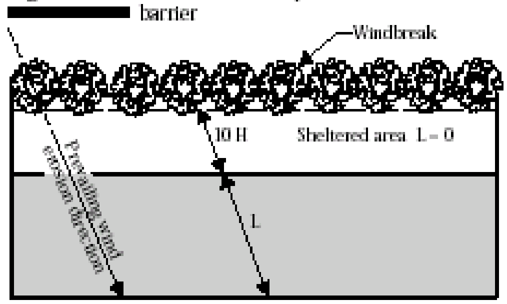


Figure 502-7 Unsheltered distaqnce L – windbreak or barrier



It is measured across the field the on a map to scale. ***__The longest E-W measurement defines the X axis. The longest N-S measurement defines the Y axis.__*** If a barrier is present on any side of the field the unsheltered distance for that wind erosion direction is adjusted for the barrier's sheltered distance by defining the barrier type (deciduous, conifer, shrub etc), row number, height, width and porosity for each side of the field in the **WEPS** Barrier window.

When the unsheltered distance, L, *is sufficiently long, the transport capacity of the wind for saltation and creep is reached.* If the wind is moving all the soil it can carry across a given surface, the inflow into a downwind area is equal to the outflow for saltation and creep. The net soil loss from this specific area of the field is then only the suspension component. This does not imply a reduced soil erosion problem because, theoretically, there is still the estimated amount of soil loss in creep, saltation, and suspension leaving the downwind edge of the field. Surface armoring by gravel in WEPS is addressed in the **I** factor. WEPS can account for snow cover or seasonal changes in soil erodibility. WEPS can estimate erosion from single storm events.

The unsheltered distance along the prevailing wind erosion direction for the field or area is to be evaluated. Its place in the equation is to relate the *isolated, unsheltered, and wide* field condition of **me** to the size and shape of the field for which the erosion estimate is being prepared. The unsheltered distance is always considered as if the field was bare except when vegetative barriers are present. The unsheltered distances WEPS will use to calculate the erosion rate for a field are determined by the X and Y lengths described below.

The **X-length** or **the distance from a stable boundary to the opposite side of the field running in a east to west orientation angle set at** 0. ***The Y-length is the longest (90 degree to the X length) distance for a stable boundary to the opposite side of the field running north-south with the orientation angle set to 0.*** X and Y lengths begin at a point upwind where no saltation or surface creep occurs and ends at the downwind edge of the area being evaluated (figure 502–5). The point may be at a field border or stable area where vegetation is sufficient to eliminate the erosion process. An area should be considered stable only if it is able to trap or hold virtually all expected saltation and surface creep from upwind. If vegetative barriers, grassed waterways, or other stable areas divide an agricultural field being evaluated, each are will be *isolated* and shall be evaluated as a separate *field*. For a grassed area to be stable it must meet the following criteria: 1.) Width of 12-15 feet; 2.) Height of 1 to 2 foot. Refer to the appropriate NRCS Michigan Conservation Practice Standards to determine when practices are of adequate width, height, spacing, and density to create a stable area.

When erosion estimates are being calculated for cropland or other relatively unstable conditions, upwind pasture should be considered a stable border (Figure 502–6). The only case where X and Y lengths equal zero is where the area is fully sheltered by a barriers.

When a barrier is present on any side of a field, measure subtract the distance sheltered by the barrier from the X or Y length based on the prevailing wind erosion direction. Use 10 times the barrier height (10H) for the sheltered distance (Figure 502–7). During the conservation planning inventory process the planner should note the height, width, porosity, and each type of barrier.

When a properly designed wind strip cropping system is applied, alternate strips are protected during critical wind erosion period*s* by a growing crop or by crop residue. These strips are considered stable. *The X or Y length is measured across each erosion-susceptible strip*. **Prevailing wind erosion direction** is the direction from which the greatest amount of erosion occurs during the critical wind erosion period. *The direction is usually expressed as one of 16 compass points.*

Wind Barriers

A barrier is any structure designed to reduce the wind speed on the downwind side of the barrier. Barriers primarily include planting of single or multiple rows of trees, shrubs or grasses having sufficient height and density to create a sheltered zone downwind**. Barriers generally influence wind erosion for a distance 10 times the height of the barrier or 10H. Barrier height** is described as **H** or the effective height of the Barrier as the leeward distance of wind protection is directly proportional to the height of the barrier. Once H is calculated then the unsheltered distance can be reduced by **10H.**

Barrier width is defined as the distance from one side of the barrier to the other. **Barrier porosity** is the percentage of open portion of the barrier to the total area of the barrier. **Barrier density** is the percentage of the solid portion of the barrier to the total area of the barrier. **The length of a barrier** is defined by field length along the border on which the barrier is present or placed.

Vegetative Cover

The effect of vegetative cover in the WEPS is managed on a daily basis in MCREW by relating the kind, amount, and orientation of vegetative material to its equivalent in pounds per acre of small grain residue in reference condition Small Grain Equivalent (SGE). This condition is defined as 10-inch long stalks of small grain, parallel to the wind, lying flat in rows spaced 10 inches apart, perpendicular to the wind. ARS has tested several crops in the wind tunnel to determine their SGE. *These SGE calculations are then converted to percent residue cover found in MCREW under the Detailed Erosion & Veg Res & Biomass Report surface cover column.*

Orientation and anchoring of residue is important. In general, the finer and more upright the residue, the more effective it is for reducing wind erosion. Knowledge of these and other relationships can be used with benchmark values to estimate additional SGE values and percent cover needs.

Often the task is to predict what will be in the field in some future season or seasons. Amounts of vegetation may be predicted from production records or estimates and these amounts are then reduced by the expected or planned tillage. It may be desirable to sample and measure existing residue to determine quantity of residue. Local data should be developed to estimate surface residue per local crop yields by crop to build calibrated crop templates that are within 5% of the targeted crop yield. A side record of the **Biomass Adjustment Factors by crop** is advised to help adjust the templates to local yields.

Detailed instructions on how to use the WEPS model are in the latest WEPS Users Guide that is posted on the NRCS Michigan web site under the Electronic Field Office Technical Guide, EFOTG, Section 1, Wind Erosion Prediction. In the WEPS Guide are several example WEPS calculations that show how to evaluate conservation practice alternatives to reduce wind erosion to soil loss tolerance or crop tolerance goals.

Alternative procedures for using the WEQ with the National Resources Inventory (NRI)
The WEQ Critical Period Procedure is based on use of the Wind Erosion Equation as described by Woodruff and Siddoway in 1965 (Woodruff and Siddoway 1965). The conditions during the critical wind erosion period are used to derive the estimate of annual wind erosion. The Critical Wind Erosion Period is described as the time of year when the greatest wind erosion can be expected to occur from a field under an identified management system. It is the period when vegetative cover, soil surface conditions, and expected erosive winds result in the greatest potential for wind erosion. Erosion estimates developed using the critical period procedure are made using a single set of factor values in the equation to describe the critical wind erosion period conditions.

The critical period procedure is currently used for resource inventories. NRCS usually provides specific instructions on developing wind erosion estimates for resource inventories. See the Archived version of WEQ in the NRCS Michigan eFOTG to access instructions for using the WEQ for purposes of the NRI.

Using WEPS estimates with Revised Universal Soil Loss Equation 2 (RUSLE2) calculations
WEPS provides an estimate of average wind erosion from the field width from all directions for 50 years per crop from a defined area or grid. WEPS WINDGEN still uses the prevailing wind erosion direction entered in the calculation. RUSLE 2 calculations provide an estimate of average sheet and rill water erosion from the slope length (L) entered for water erosion calculation for a small representative watershed in a field. Although both wind and water erosion estimates are in tons per acre per year, they should be added together only when L in the two equations represent identical flow paths and land areas. Soil loss estimates using WEPS or RUSLE 2 are not added together to compare to the soil loss tolerance value (T).

Principles of Wind Erosion Control
Five principles of wind erosion control have been identified (Lyles and Swanson 1976; Woodruff et al. 1972; and Woodruff and Siddoway 1965). They are as follows:

1. Establish and maintain adequate vegetation or other land cover.
2. Reduce unsheltered distance along wind erosion direction.
3. Produce and maintain stable clods or aggregates on the land surface.
4. Roughen the land with ridge and/or random roughness.
5. Reshape the land to reduce erosion on knolls where converging wind flow causes increased velocity and shear stress.

The *cardinal rule* of wind erosion control is to strive to keep the land covered with vegetation or crop residue at all times (Chepil 1956). This leads to several principles that should be paramount as alternative controls are considered:

- Return all land unsuited to cultivation to permanent cover.
- Maintain maximum possible cover on the surface during wind erosion periods.
- Maintain stable field borders or boundaries at all times.

Tolerances in Wind Erosion Control

In both planning and inventory activities, NRCS compares estimated erosion to soil loss tolerance (T). T is expressed as the average annual soil erosion rate (tons/acre/year) that can occur in a field with little or no long-term degradation of the soil resource, thus sustaining crop productivity for an indefinite period.

Soil loss tolerances for a named soil are recorded in the soil survey database, in NASIS. The normal planning objective is to reduce soil loss by wind or water to T or lower. In situations where treatment for both wind and water erosion is needed, soil loss estimates using the WEQ or RUSLE 2 are not added together to compare to T.

Consider additional potential offsite damaging impacts of wind erosion such as air and water pollution or the deposition of soil particles.

Also, crop tolerance to soil blowing is an important consideration in wind erosion control. Wind or blowing soil, or both, can have an adverse effect on growing crops. Most crops are more susceptible to abrasion or other wind damage at certain growth stages than at others. Damage can result from desiccation and twisting of plants by the wind.

Crop tolerance is defined as the maximum wind erosion that a growing crop can tolerate, from crop emergence to field stabilization, without an economic loss to crop stand, crop yield, or crop quality.

(a) Blowing soil effects on crops

Some of the adverse effects of soil erosion and blowing soil on crops include:

- Excessive wind erosion that removes planted seeds, tubers, or seedlings;
- Exposure of plant root systems; and
- Burial of plants by drifting soil.

Sand blasting and plant abrasion resulting in:

- crop injury
- crop mortality
- lower crop yields
- lower crop quality
- Wind damage to seedlings, vegetables, and orchard crops.

(b) Crop tolerance to blowing soil or wind (See Table 1 Crop Tolerance to blowing soil)

Many common crops have been categorized based on their tolerance to blowing soil. These categories of some typical crops are listed in Table 1. Crops may tolerate greater amounts of blowing soil than shown in Table 1, but yield and quality may be adversely affected.

(c) The effects of wind erosion on water quality

Some of the adverse effects of wind erosion on water quality include:

- Deposition of phosphorus (P) into surface water
- Increased Biochemical Oxygen Demand (BOD) in surface water
- Reduced stream conveyance capacity because of deposited sediment in streams and drainage canals.

Local water quality guidelines under Total Maximum Daily Loads (TDML) for nutrients may require that wind erosion losses be less than the soil loss tolerance (T) in order to achieve local phosphorus (P) or other pollutant reduction goals. For a phosphorus (P) entrapment estimation procedure, see the NRCS Core 4 Conservation Practices Manual, Chapter 3c, Cross Wind Trap Strips, and Phosphorus Entrapment Estimate and NRCS MI Agronomy Tech Note 62 and Total P loss Calculator Excel spreadsheet referenced to AGTN 62.

Crop Tolerances* to Blowing Soil – Table 1

Tolerant **“T”**	**Mod. Tolerance** **2 t/ac**	**Low Tolerance** **1 t/ac**	**Very Low Tolerance** **0 - 0.5 t/ac**
Barley	Alfalfa (mature)	Broccoli	Alfalfa (seedlings)
Buckwheat	Corn	Cabbage	Asparagus
Flax	Onions (>30 days)	Cotton	Cantaloupe
Grain Sorghum	Orchard crops	Cucumbers	Carrots
Millet	Soybeans	Garlic	Celery
Oats	Sunflowers	Green/Snap Beans	Eggplant
Rye	Sweet corn	Lima Beans	Flowers
Wheat		Peanuts	Kiwi Fruit
		Peas	Lettuce
		Potatoes	Muskmelons
		Sweet Potatoes	Onions (seedlings)
		Tobacco	Peppers
			Spinach
			Squash
			Strawberries
			Sugar Beets
			Table Beets
			Tomatoes
			Watermelons

* **Crop tolerance** is defined as the maximum wind erosion (tons/acre) that a growing crop can tolerate, from crop emergence to field stabilization, without an economic loss to crop stand, crop yield, or quality. Crops can be damaged by blowing soil particles, exposure of plant roots, burial of plants by drifting soil or desiccation and twisting of plants by the wind. Crop tolerances to abrasion are usually less than soil loss tolerance.

Crops may tolerate greater amounts of blowing soil than shown above, but yield and quality will be adversely affected. When crop damage is a major concern, the wind erosion control system should be designed to reduce wind erosion below the crop tolerance level during the seedling period of the affected crop.

References:

USDA- NRCS. 2000. *National Agronomy Manual, Part 502-Wind Erosion, 190-V Nam. 3rd. Edition.* Washington,
D. C.

USDA-NRCS. 1999. *CORE 4 Conservation Practices, The Common Sense Approach to Natural Resource Conservation, Chapter 3C, Cross Wind trap Strips.* Washington, D. C.