Guide to Agricultural PM_{10} Best Management Practices

Maricopa County, Arizona
PM_{10} Non-Attainment Area

Governor's Agricultural Best Management Practices Committee

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Governor's Agricultural BMP Committee

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The intent of this guide is to provide information and guidance on how to effectively implement best management practices. It is based on the best information currently available; later publications may be issued to update this document. This guide represents the first step in helping farmers reduce PM_{10} emissions from farmlands located within the Maricopa County PM_{10} non-attainment area.

First Edition February 2001

The Governor's Agricultural BMP Committee gratefully recognizes, thanks, and appreciates the input, review, suggestions, and overall support of many individuals and groups involved in this process.

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Many individuals were involved in capacities not associated with a formal work group; regardless, their contribution is worthy of gratitude.

Ron Alvarado, Jennifer Anderson, Cathy Arthur, Daniel Blair, George Bluhm, Jim Briggs, Jo Crumbaker, Andrea Domanik, Ira Domsky, Mike George, Joe Gibbs, Cheryl Goar, John Hagen, Ron Hemmer, Macario "Mac" Herrera, Michael Kidd, Julia Lester, Marilyn Martin, Gary Neuroth, Cathy O'Connell, B. Bobby Ramirez, Shannon Reif, Chris Robbins, Rick Saylor, Don Walther, and members of the National Agricultural Air Quality Task Force.

Funding support for printing of this guide was provided by Environmental Quality Incentives Program Education Assistance funds, USDA Natural Resources Conservation Service (Cooperative Agreement through Agua Fria - New River Natural Resource Conservation District); US Environmental Protection Agency Region IX; and the Arizona Department of Environmental Quality.

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Introduction

Why is the Guide to Agricultural PM_{10} Best Management Practices needed?

The Federal Clean Air Act requires that emissions from all significant sources in areas not meeting the national ambient air quality standards be controlled through effective programs. Through a study conducted by the Arizona Department of Environmental Quality (ADEQ) in 1995, agricultural activities were identified as a source that contributes to producing particulate matter (PM).

PM_{10} is particulate matter that is 10 micrometers or less in diameter. These particles are very small and can invade the natural defense mechanism of the human respiratory tract penetrating deep into the lungs (human hair is 70 micrometers in diameter). Consequently, PM_{10} can cause a wide variety of harmful health effects, especially for children, the elderly, and people with pre-existing respiratory or cardiovascular disease.

With this potential threat to human health, several groups in the Phoenix metropolitan area have developed and are implementing programs to help the area meet the Federal Clean Air Act standards for PM_{10}.

The intent of this guide is to:

- Provide agricultural operators with information and guidance on how to effectively implement individual best management practices (BMP).
- Inform the general public about the efforts Maricopa County farmers are implementing to improve air quality.
- Provide Natural Resource Conservation Districts (NRCD) and other farm organizations with background information regarding the agricultural PM_{10} general permit.
- Provide regulators with information and guidance on how to determine compliance with the agricultural PM_{10} general permit.

Why was the agricultural PM_{10} general permit created?

The Phoenix metropolitan area has not met the Federal Clean Air Act Standards for PM_{10} since the Clean Air Act was revised in 1990. On June 10, 1996, the U.S. Environmental Protection Agency (EPA) redesignated the Maricopa County non-attainment area to serious for PM_{10}, resulting in the need for emission reduction programs for previously unregulated sources, such as unpaved roads, unpaved parking lots, vacant lots and agriculture. On August 3, 1998, EPA issued a federal implementation plan (FIP) addressing these unregulated sources. The FIP included requirements to develop and enforce control measures for these source categories.

In an effort to address agriculture's contribution to PM_{10}, the Governor's Agricultural Best Management Practices Committee was created by law in 1998 (Arizona Revised Statutes (A.R.S.) §49-457)). The committee's charge was to develop an agricultural PM_{10} general permit that would address the need for controls on agricultural operations. The committee was to identify BMPs that focused on feasible, effective and common sense practices

that minimized negative impacts on local agriculture. This agricultural PM_{10} general permit requires that at least one BMP be implemented to control PM_{10} for each of the following three categories: tillage and harvest, non-cropland and cropland. The committee is composed of five local farmers, the director of ADEQ, the director of Arizona's Department of Agriculture, the state conservationist for the Natural Resources Conservation Service (NRCS), the vice dean of the University of Arizona College of Agriculture and a soil scientist from the University of Arizona.

Because A.R.S. §49-457 was developed and adopted, EPA removed the portion of the federal implementation plan for agriculture on June 29, 1999 [64 Federal Register p. 34,726].

Who must comply with the agricultural PM_{10} general permit?

Any farmer who farms more than 10 contiguous acres of land located within the Maricopa County PM_{10} non-attainment area must comply with the agricultural PM_{10} general permit. (See map on page two.)

What does the farmer have to do?

- Implement and maintain at least one approved BMP (described later in this document) for each of the three categories: tillage and harvest, non-cropland and cropland.

- Keep a record detailing the BMPs selected for each category. The commercial farmer may document the practice on the sample BMP agricultural PM_{10} permit record (see page 26) or develop a record that includes the information required by the agricultural PM_{10} general permit. The commercial farmer must make available the record to the ADEQ director within two business days of notice to the farmer.
- The committee recommends additional record keeping if implementation of the BMPs is not easily visible. Examples of additional record keeping include, but are not limited to, photographs, purchase records, receipts, job sheets, contractor invoices, employee timesheets, logs, narrative statements, individual farm policies, statements of understanding signed by employees or contractors, and training records.
- There is no fee associated with the agricultural PM_{10} general permit.

When must the agricultural PM_{10} general permit be implemented?

A farmer engaged in agricultural activities before June 10, 2000 must comply with the agricultural PM_{10} general permit by December 31, 2001. A commercial farmer who engages in agricultural activities after December 31, 2000 has 18 months to comply with the agricultural PM_{10} general permit.

What will happen if I do not comply with the agricultural PM_{10} general permit?

If the ADEQ director determines that a commercial farmer is not in compliance with the agricultural PM_{10} general permit, the following three-stage process occurs. (At each stage, the farmer will have the opportunity for a hearing.)

- If the farmer has not previously been subject to an agricultural general permit related compliance order, the farmer will be

required to submit a plan to the local Natural Resource Conservation District (NRCD). The plan must specify the BMPs that the farmer will use to comply with the general permit.

- If the farmer has previously been subject to an agricultural PM_{10} general permit related compliance order, the farmer will be required to submit a plan to ADEQ that specifies the BMPs that the farmer will use to comply with the general permit.
- If the farmer fails to comply with the plan submitted to NRCD and ADEQ, the director of ADEQ may revoke the agricultural PM_{10} general permit and require the farmer to obtain an individual fee based permit.

Where does the agricultural PM_{10} general permit apply?

Any agricultural operation greater than 10 contiguous acres within the Maricopa County PM_{10} non-attainment area, except on tribal lands, must comply with the agricultural PM_{10} general permit. (See map on page two.)

Winds in Maricopa County

Research shows that winds in Phoenix generally blow from the east during the night and early morning hours, then reverse so they blow from the west during the afternoon. This is in part related to Central Arizona terrain. The higher land areas (mountains) to the east heat up and cool off faster than the valleys. This creates air movement – toward the mountains during the day and toward the valleys at night.

Because of global climate patterns, the prevailing winds are from the west at Arizona's latitude of 30 degrees. Add in the local westerly winds and wind speeds can approach 20 mph in the afternoon during warmer months.

From October through April, storm systems enter Arizona from the Pacific Ocean. The surface winds ahead of these cold fronts typi-

Where can I learn more?

If you do not know whether your agricultural operation resides within the non-attainment area, or if you have questions regarding compliance or specific components of the agricultural PM_{10} general permit, contact:

Arizona Department of Environmental Quality
3003 N. Central Ave., T5109B
Phoenix, AZ 85012
Air Quality Planning Section (602) 207-2375
Air Compliance Section (602) 207-2328
(800) 234-5677
Fax (602) 207-2366

For copies of the agricultural PM_{10} general permit, visit the ADEQ Air Quality Division home page at www.adeq.state.az.us/environ/air/plan/pcp.html. Hard copies are available at:

Maricopa County Farm Bureau
4001 E. Broadway, Suite B9
Phoenix, AZ 85040
(602) 437-1330

Maricopa County Cooperative Extension
4341 E. Broadway Road
Phoenix, AZ 85040
(602) 470-8086
www.ag.arizona.edu/extension/counties/maricopa

Natural Resources Conservation Service
3003 N. Central Ave. Suite 800
Phoenix, AZ 85012
(602) 280-8801
www.az.nrcs.usda.gov

Natural Resource Conservation Districts (NRCD) can provide technical assistance regarding the selection, adoption and implementation of BMPs.

Agua Fria-New River Natural Resource Conservation District
3150 N. 35th Avenue, Suite 7
Phoenix, AZ 85017
(602) 353-0378
www.az.nrcd.org/aguafria/nrcd1.htm

East Maricopa Natural Resource Conservation District
18256 E. Williams Field Road, Suite 1
Higley, AZ 85236
(480) 988-1078

cally blow from the south or southwest and can be quite gusty – up to 40 mph. After frontal passage, the winds typically shift and can also be strong from the west or northwest.

During the summer months – usually July through September – monsoon thunderstorms can cause strong surface winds, again 40 mph or stronger. Downdrafts from the clouds can cause the winds to come from any direction, although south and southeast winds are common.

Any of these high wind conditions can increase the amount of particulate matter in the air.

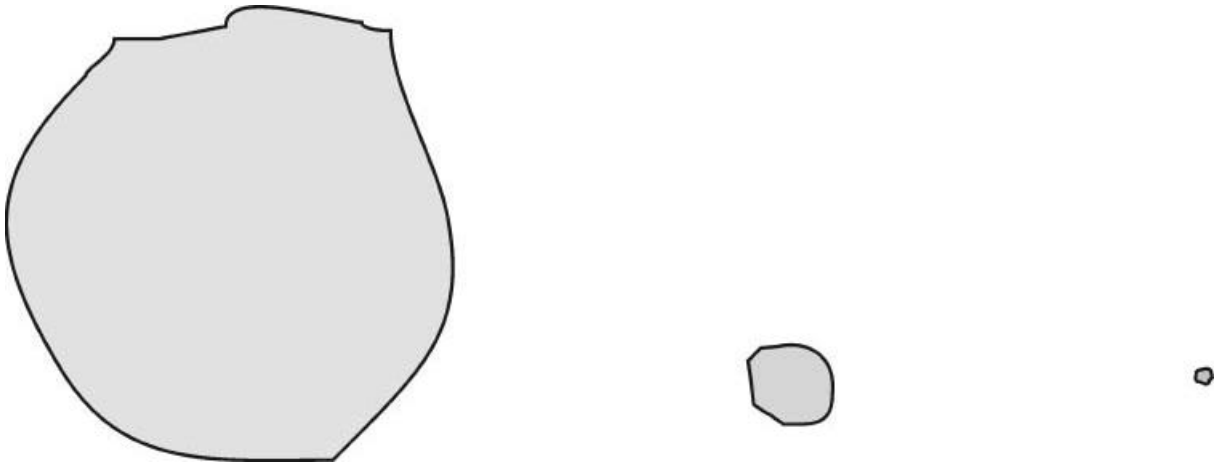
How Soils Can Become PM_{10}

Particulate matter is finely divided solid or liquid material with an aerodynamic size smaller than 100 micrometers (µm). This is commonly known as dust or even fugitive dust.

Specifically, particulate matter consists of solid or liquid substances that are visible as well as invisible. These particles vary in shape and size, ranging from large drops of liquid to microscopic dust particles to tobacco smoke to aerosols. The particles affect visibility and can be transported for long distances by winds. The small particles can be dangerous to human health because their size makes it possible to pass through nostril hairs and enter the lungs. The smaller the particle, the deeper it can penetrate into the lungs where it can become lodged and not easily, if ever, expelled.

The potential for soil to release dust into the atmosphere depends largely on the soil particle, its size and the condition of the soil surface. Suspendible particles exist in most natural soils, although particles in the PM_{10} size range are often bonded tightly to other particles making large aggregates. Energy (usually in the form of increased wind speed and/or traffic over the soil surface) is needed to break the aggregates into smaller sized particles. The destruction of those bonds can give way to the generation of fugitive dust. PM_{10} can be suspended, while particles greater than 80 µm rarely stay in suspension because they are too heavy.

Figure 1. Relative sizes of soil minerals



Sand (2000 – 50 µm) Silt (50 – 2µm) Clay (< 2 µm)

Soils have four main constituents: mineral matter, organic matter, air and water. Minerals are the major constituent in Arizona soils and are derived from the parent material by weathering. Organic matter is derived mostly from decaying plant material that is broken down and decomposed by animals and microorganisms living in the soil. Arizona soils generally contain relatively small amounts of organic matter due to limited plant growth and rapid decomposition of dead plant matter. Air and water fill the pore spaces found between the mineral and organic matter in soils.

Mineral particles range in size from 2,000 µm to less than 2µm and are the bases upon which soil texture is determined. Soil mineral particles can be classified as sand (2000 to 50 µm), silt (50 to 2 µm) or clay (< 2 µm) (see Figure 1).

The textural class of a soil is determined by estimating the particle size distribution in the field by the "feel method" or analytically through laboratory measurement. Once the percentages of soil particles are decided, the soil textural triangle (see Figure 2) is used to classify the soil further. It is interesting to note that field determinations are commonly within 3 percent of laboratory derived values. Local soil surveys made available by the Natural Resources Conservation Service contain these textural classes.

PM_{10} originating from soil is composed of clay particles and large silt particles. Soils with high amounts of these particles have a strong potential to generate PM_{10}. High clay soils always have the potential to generate PM_{10} under the right conditions. The quantity of PM_{10} that is actually generated is closely linked to the management of those soils or the amount of mechanical disturbance. Soil disturbance changes soil structure. Soil structure is an important physical characteristic of any soil. It is produced by the aggregation of particles of sand, silt and clay into larger units called "peds." A soil with a large amount of clay particles may generate low levels of PM_{10} if disturbance is limited or soil moisture levels are elevated. However, a soil with low clay and silt contents could generate high levels of PM_{10} if frequently disturbed under dry conditions by traffic or tillage equipment.

When the natural soil structure is manipulated or disturbed by tillage, animals, weathering or vehicular traffic, the structure can be destroyed, which allows particles less than 10 µm in size to be suspended in the air easily. As soil aggregates break away from larger aggregates and become smaller, their ability to be suspended in the air increases significantly. Increased traffic or soil surface manipulation increases the potential for those smaller particles to become fugitive dust. Clay content, relative humidity, soil moisture, wind speed and direction, as well as other elements, can affect the bonding strength between particles, which, in effect, determines the amount of PM_{10} generated.

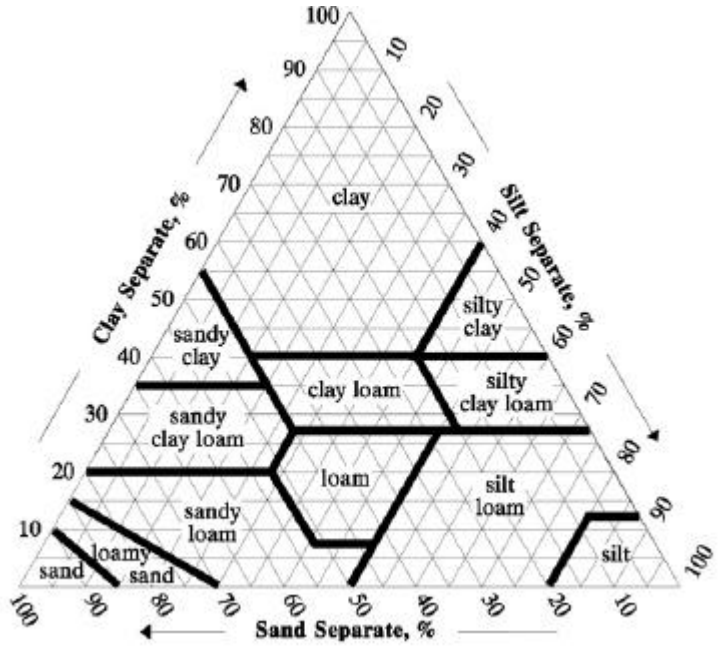


Figure 2. Soil textural triangle

Best Management Practices

The Arizona Legislature has defined a BMP for the Maricopa County PM_{10} non-attainment area as a technique verified by scientific research, that, on a case-by-case basis is practical, economically feasible and effective in reducing PM_{10} from a regulated agricultural activity. The following section summarizes BMPs approved by the Governor's Agricultural Best Management Practices Committee to reduce PM_{10} for each of the three agricultural categories: tillage and harvest, non-cropland and cropland.

A wide range of variation in soils and cropping systems exists within the Maricopa County PM_{10} non-attainment area, which can only be addressed by a wide range of flexible and adaptable management practices. Most methods for controlling PM_{10} and dust emissions parallel the controls for wind erosion. These methods are based on principles that contain or slow soil movement from fields. The BMPs are not designed to eliminate dust emissions 100 percent, but are expected to reduce wind erosion and associated PM_{10}. Not all of the BMPs will work equally well on every farm because of variations in wind, soils, cropping systems, moisture conditions and, in some cases, the management approaches of individual growers. Such factors should be considered by the individual farmer to ensure he or she implements effective BMPs. This guide represents the first step in helping farmers reduce PM_{10} emissions from farmlands located within the Maricopa County PM_{10} non-attainment area.

Tillage and Harvest

Any mechanical practice that physically disturbs cropland or crops on a commercial farm.

Best management practices for use during tillage and harvest

Chemical irrigation
Combining tractor operations
Equipment modification
Limited activity during a high wind event
Multi-year crop
Planting based on soil moisture
Reduced harvest activity
Reduced tillage system
Tillage based on soil moisture
Timing of a tillage operation

Chemical Irrigation

Rule Definition

"Chemical irrigation" means applying a fertilizer, pesticide, or other agricultural chemical to cropland through an irrigation system.

Purpose

Chemical irrigation reduces the number of passes across a field with tractors, sprayers, fertilizer applicators and machinery. Reducing the number of field operations reduces the emissions associated with those activities.

Suggestions for Implementation

- All product application recommendations should be followed to ensure proper implementation.
- The field operations eliminated should be documented to demonstrate the implementation of the practice.

Combining Tractor Operations

Rule Definition

"Combining tractor operations" means performing two or more tillage, cultivation, planting, or harvesting operations with a single tractor or harvester pass.

Purpose

Combining tractor operations reduces the number of passes or trips that a tractor, implement, harvester or other farming support vehicle makes across a field or unpaved surface, thereby reducing the amount of soil disturbed.

Suggestions for Implementation

Combining tractor operations is most effective if implemented during the time of year when PM_{10} is most likely to be produced.

- Applying fertilizer and herbicide in a single pass.
- Cultivating and fertilizing in a single pass.
- Using specialized machinery to bury stalks and make new furrows in a single pass.
- Combining multiple heavy tillage operations in a single pass, for example, pulling a ring roller behind a disc.

Equipment Modification

Rule Definition

"Equipment modification" means modifying agricultural equipment to prevent or reduce particulate matter generation from cropland.

Purpose

Modifying and maintaining an existing piece of agricultural equipment or purchasing new equipment to prevent PM_{10} from becoming airborne during tillage and harvest operations, which helps reduce PM_{10} and soil erosion.

Examples of Equipment Modification

- Shields or deflectors that redirect fan or vehicle exhaust sideways or upward. This can prevent PM_{10} from becoming airborne because exhaust is not blowing downward on the soil surface.
- Dust shrouds around tillage implements and harvesters.
- Spray bars that emit a mist to knock down PM_{10}.

Limited Activity During a High-Wind Event

Rule Definition

"Limited activity during a high-wind event" means performing no tillage or soil preparation activity when the measured wind speed at 6 feet in height is more than 25 mph at the commercial farm site.

Purpose

Because this BMP falls within the tillage and harvest category, it also applies during harvest time. Wind speed, temperature and relative humidity affect the distance that PM_{10} travels and the ability for PM_{10} to be suspended in the air. Limiting activity during a high-wind event will reduce the transport of PM_{10}. Reducing farm operations during a high wind event, as well as when the wind speed is less than 25 mph, can significantly help reduce PM_{10} emissions.

Suggestions for Implementation

- A device to measure wind speed should be available at the commercial farm site.
- An individual farm policy should be developed to ensure that no tillage or soil preparation activities occur when the wind speed reaches 25 mph. Employees and family members should receive training in implementing the farm policy.

Multi-Year Crop

Rule Definition

"Multi-year crop" means a crop, pasture, or orchard that is grown, or will be grown, on a continuous basis for more than one year.

Purpose

Surface covers, such as crops, pasture and orchards that are grown and maintained for a long duration, protect the soil surface from erosive winds. The longer a crop or cover is protecting the soil surface, the less time the surface is susceptible to wind erosion.

Examples of multi-year crops include:

- Alfalfa
- Citrus
- Roses
- Livestock pastures
- Nuts (Pecans)
- Sod

Planting Based on Soil Moisture

Rule Definition

"Planting based on soil moisture" means applying water to soil before performing planting operations.

Purpose

Planting based on soil moisture reduces PM_{10} during the planting operation and is effective from the time of planting until crop establishment. Planting based on soil moisture is one of the most efficient practices to reduce PM_{10} between planting and crop emergence. Moisture causes soil to crust and therefore PM_{10} is not easily transported into the air.

Suggestions for Implementation

- Care should be taken to avoid over compaction of the soil, which could result in additional tillage operations.
- Irrigation should be applied as soon after soil preparation for planting as possible. After watering, a thin crust develops on the soil surface, which stabilizes it until planting
- The time between bed lifting, irrigation and planting should be minimized as much as possible.
- Use the soil moisture "feel method" to determine adequate soil moisture. See the Natural Resource Conservation Service publication #1619 "Estimating Soil Moisture by Feel and Appearance." This publication is available at all NRCD offices.

Reduced Harvest Activity

Rule Definition

"Reduced harvest activity" means reducing the number of harvest passes using a mechanized method to cut and remove crops from a field.

Purpose

Any time an operation takes place in a field, the soil structure can be modified and some PM_{10} could be released into the air. Reducing the number of harvest activities can keep the soil structure intact and reduce PM_{10}.

Suggestions for Implementation

An example of reduced harvest activity is the elimination of a harvest or rood pass from a cotton harvest. More PM_{10} is emitted during a normal cotton harvest season because the process requires several harvest passes to remove most of the crop from the plant. The rood process produces a significant amount of PM_{10} because of the nature of the operation.

Reduced Tillage System

Rule Definition

"Reduced tillage system" means reducing the number of tillage operations used to produce a crop.

Purpose

Any tillage operation in a field can modify the soil structure and possibly release PM_{10} into the air. Reducing the number of tillage activities can maintain the soil structure and help reduce PM_{10}.

Suggestions for Implementation

- Minimum tillage system*
- Mulch tillage system*
- Reduced tillage system*

*Consult NRCS Standard and Specifications, 329 and 344, Residue Management. This document is available at all NRCD offices.

Tillage Based on Soil Moisture

Rule Definition

"Tillage based on soil moisture" means applying water to soil before or during tillage, or delaying tillage to coincide with precipitation.

Purpose

Moisture binds soil particles and helps reduce the amount of PM_{10} released into the air. Fine dry soil can easily erode with increased wind speeds. Sufficient moisture levels can be achieved by irrigating before tillage or tilling after rain. Moisture can also allow large soil clods to form, after tillage, which reduces wind erosion.

Suggestions for Implementation

- Fields should be irrigated to the depth of proposed cut prior to soil disruption, or

tillage should be conducted to coincide with precipitation.

- The application of moisture or the date of tillage that coincided with precipitation should be documented.
- The soil moisture "feel method" should be used as a way to determine adequate soil moisture. See the Natural Resource Conservation Service publication #1619 "Estimating Soil Moisture by Feel and Appearance." This publication is available at all NRCD offices.

Timing of a Tillage Operation

Rule Definition

"Timing of a tillage operation" means performing tillage operations at a time that will minimize the soil's susceptibility to generate PM_{10}.

Purpose

Adjusting the time of tillage operations can minimize the amount of time the soil surface is susceptible to wind erosion and generation of PM_{10}. When a field's surface is smooth, dry, and consists of finer grained soil particles, the field is most susceptible to wind erosion, resulting in PM_{10}.

Some examples of timing of tillage operations to reduce PM_{10} generation include:

- Reducing time between leveling (land planing) and bedding, which is when the beds act as miniature windbreaks. For example, a cotton production system where fields are tilled in the fall, land planed, then bedded, would be less susceptible to wind erosion and PM_{10}.
- Leaving the field surface with large soil clods for as long as possible prior to preparation of seed beds.

Non-Cropland

Any commercial farm land that:

- ***is no longer used for agricultural production,***
- ***is no longer suitable for production of crops,***
- ***is subject to a restrictive easement or contract that prohibits use for the production of crops, or***
- ***includes a private farm road, ditch, ditch bank, equipment yard, storage yard or well head.***

Best management practices for use on non-cropland

Access Restriction
Aggregate Cover
Artificial Wind Barrier
Critical Area Planting
Manure Application
Reduce Vehicle Speed
Synthetic Particulate Suppressant
Track-out Control System
Tree, Shrub or Windbreak Planting
Watering

Access Restriction

Rule Definition

"Access restriction" means restricting or eliminating public access to non-cropland with signs or physical obstruction.

Purpose

Reducing the number of trips driven on agricultural aprons and access roads can reduce that area's susceptibility to PM_{10}.

Examples of methods to restrict access include, but are not limited to:

- Installing physical barriers such as gates, fencing, posts, signs, shrubs, trees or other physical obstructions to prevent or control access to the area.
- Installing "no trespassing" or "limited use area" signs.

Aggregate Cover

Rule Definition

"Aggregate cover" means gravel, concrete, recycled road base, caliche or other similar material applied to non-cropland.

Purpose

Applying an aggregate cover to unpaved farm roads, parking areas and canal banks helps reduce the amount of soil particles exposed to the surface, thus helping to reduce the generation of PM_{10}. Aggregate cover acts as a surface barrier to erosive forces like wind or vehicle traffic.

Suggestions for Implementation

- The aggregate should be one inch or larger in diameter.
- The aggregate should be applied a minimum of four inches deep.
- The aggregate material should be clean, hard and durable.

Artificial Wind Barrier

Rule Definition

"Artificial wind barrier" means a physical barrier to the wind.

Purpose

Artificial wind barriers disrupt the erosive flow of wind over unprotected areas thus helping to reduce PM_{10}.

Suggestions for Implementation

- Continuous board fences, burlap fences, crate walls, bales of hay and similar material can be used to control air currents and blowing soil.
- Barriers should be aligned across the prevailing wind direction. While 90 degrees or perpendicular is preferred, benefits can still be realized when barriers are aligned as close to perpendicular as possible.
- The distance of 10 times the barrier height is considered the protected area downwind of the barrier.

Critical Area Planting

Rule Definition

"Critical area planting" means using trees, shrubs, vines, grasses, or other vegetative cover on non-cropland.

Purpose

Critical area plantings helps control soil movement and protect the soil surface when adequate cover does not exist. Ground covers reduce dust and wind erosion by shielding the soil with vegetation and anchoring the soil with roots. This practice applies to field aprons, equipment parking areas, turn rows, canal banks, canal excavation spoil piles and bare areas where vegetation is difficult to establish by usual planting methods.

Suggestions for Implementation

- Critical area planting consists of any vegetative cover that maintains more than 60 percent ground cover.

Manure Application

Rule Definition
"Manure application" means applying animal waste or biosolids to a soil surface.

Purpose
Applying manure to maintain or improve chemical and biological condition of the soil can help reduce wind erosion and PM_{10}.

Suggestions for Implementation
- If the application or storage of manure is near a water source, precautions should be taken to prevent accidental leakage, spillage or runoff that will result in undesirable effects on soil, water and plants.
- Caution should be used when applying manure to ensure that state and local regulations are not violated.
- Caution should be used when certain manures are applied as they can volatilize and contribute to odor and ammonia emissions.
- Manures should be incorporated as quickly as possible to reduce odor and ammonia emissions, and to preserve nutrient value if the area is to be cropped in the future.

Reduce Vehicle Speed

Rule Definition
"Reduce vehicle speed" means operating farm vehicles or farm equipment on unpaved private farm roads at speeds not to exceed 20 mph.

Purpose
Reduced speeds can decrease the amount of PM_{10} generated by vehicles or equipment on unpaved farm roads.

Examples of methods to reduce vehicle speed include, but are not limited to:
- Posting speed limit signs.
- Informing all employees, contractors and sub-contractors of speed limits.
- Placing signs in all farm vehicles stating the speed limits on farm roads.
- Installing speed bumps.

Synthetic Particulate Suppressant

Rule Definition
"Synthetic particulate suppressant" means a manufactured product such as lignosulfate, calcium chloride, magnesium chloride, an emulsion of a petroleum product, an enzyme product, and polyacrylamide that is used to control particulate matter.

Purpose
Synthetic particulate suppressants provide a surface barrier or bind soil particles together to retard PM_{10} on unprotected areas, such as unpaved roads, rights-of-way and abandoned fields.

Examples of synthetic particulate suppressant include, but are not limited to:
- Calcium chloride (CaCl)
- Soybean feedstock (SBF) processing by-products
- Calcium lignosulfonate (lignin)
- Polyvinyl acrylic polymer emulsion (PVA)
- Polyacrymide (PAM)
- Emulsified petroleum resin

Differences in traffic type and volume, soil types, roadway surface characteristics and topography between sites requiring dust control can cause product performance to vary.

Consult the NRCD office or a dust control contractor for specific recommendations.

All products should be applied strictly in accordance with manufacturers' specifications.

Track-Out Control System

Rule Definition

"Track-out control system" means a device to remove mud or soil from a vehicle before the vehicle enters a paved public road.

Purpose

Using a track-out control system helps remove mud and soil from the tires of farm equipment and vehicles before they enter a paved public road, where the mud or soil can be crushed into fine particles and easily suspended in the air by passing vehicles.

Suggestions for Implementation

Some examples of track-out control systems are:

- Grizzly - a device similar to a cattle guard, which is used to dislodge mud, dirt or debris from the tires and undercarriage of equipment and vehicles prior to leaving a farm.
- Gravel pad - a pad of crushed stone, coarse gravel or recycled road base located at the point of intersection of a paved public roadway and a farm entrance. It is recommended that:
  a) The stone or gravel is one inch or larg er in diameter.
  b) The gravel pad is applied a minimum of four inches deep.
  c) The gravel pad is the full width of the farm entrance.
  d) The gravel pad is a minimum of 50 feet long.
- Pavement – an area of asphalt, concrete or similar material applied to a farm road at the intersection of a paved public roadway and a farm entrance. It is recommended that:
  a) The pavement is the width of the farm road.
  b) The pavement is a minimum of 100 feet long from the point of intersection with a paved public roadway.

The farm entrance should be maintained in a condition that will prevent tracking of mud and soil onto paved public roads. The farmer should conduct periodic inspections, maintenance, re-application of gravel and cleaning of paved access road surfaces to accomplish track-out control.

Tree, Shrub, or Windbreak Planting

Rule Definition

"Tree, shrub, or windbreak planting" means providing a woody vegetative barrier to the wind.

Purpose

Barriers placed perpendicular to the wind direction can reduce wind speeds by changing the pattern of airflow over the land surface, which helps reduce wind erosion and PM_{10}.

Suggestions for Implementation

- The distance of 10 times the barrier height is considered the protected area downwind of the barrier.
- Single row plantings are most popular in field windbreaks because they use less water and occupy the least amount of land area for the amount of protection derived.
- Recommended species for planting can be obtained at all NRCD offices.
- The planting should be done at a time and manner to ensure survival and growth of selected species.
- Moisture conservation or supplemental watering should be provided for plant establishment and growth, as well as the use of drought tolerant species.
- Windbreaks should be aligned across the prevailing wind direction. While 90 degrees or perpendicular is preferred, benefits can still be realized when windbreaks are aligned as close to perpendicular as possible.
- The interval between windbreaks should be determined using current approved wind erosion technology, available at all NRCD offices.

Watering

Rule Definition

"Watering" means applying water to non-cropland.

Purpose

Applying water from a truck, tractor or other portable spray system to bare soil surfaces, such as unpaved roadways and equipment yards where high traffic areas exist, can help reduce PM_{10}. Watering the soil surface tends to compact the soil so that it is not dispersed into the air.

Suggestions for Implementation

Watering can be effective during peak usage times, such as silage harvest time.

- Apply water so that the surface is visibly moist.

Cropland

Land on a commercial farm that:

- ***is within the timeframe of final harvest to plant emergence,***
- ***has been tilled in a prior year and is suitable for crop production, but is currently fallow, or***
- ***is a turn-row.***

Best management practices for use on cropland

Artificial Wind Barrier
Cover Crop
Cross-Wind Ridges
Cross-Wind Strip-Cropping
Cross-Wind Vegetative Strips
Manure Application
Mulching
Multi-Year Crop
Permanent Cover
Planting Based on Soil Moisture
Residue Management
Sequential Cropping
Surface Roughening
Tree, Shrub, or Windbreak Planting

Artificial Wind Barrier

Rule Definition

"Artificial wind barrier" means a physical barrier to the wind.

Purpose

Artificial wind barriers disrupt the erosive flow of wind over unprotected cropland fields thus helping to reduce PM_{10}.

Suggestions for Implementation

- Continuous board fences, burlap fences, crate walls, bales of hay and similar material can be used to control air currents and blowing soil.
- Barriers should be aligned across the prevailing wind direction. While 90 degrees or perpendicular is preferred, benefits can still be realized when barriers are aligned as close to perpendicular as possible.
- The distance of 10 times the barrier height is considered the protected area downwind of the barrier.

Cover Crop

Rule Definition

"Cover crop" means plants or a green manure crop grown for seasonal soil protection or soil improvement.

Purpose

Cover crops help control soil movement and protect the soil surface between crops. Cover crop reduces wind erosion by shielding the soil

with vegetation and anchoring the soil with roots.

Suggestions for Implementation

It is recommended that:

- Cover crops consist of any vegetative cover that maintains more than 60 percent ground cover.
- Short-term cover be grown between major crops. Plants are then tilled into the soil prior to or during major crop planting.
- Longer-term cover may be maintained by periodic mowing to maintain at least 60 percent cover.

- Specific information on cover crops can be obtained from the Cooperative Extension Service or the NRCD office.

Cross-Wind Ridges

Rule Definition

"Cross-wind ridges" means soil ridges formed by a tillage operation.

Purpose

Ridges formed by tillage operations create protective windbreaks that disrupt the erosive forces of high winds.

Suggestions for Implementation

It is recommended that:

- Ridges formed by tillage or planting should be aligned across the prevailing wind direction. While 90 degrees or perpendicular is preferred, benefits can still be realized with ridges as close to perpendicular as possible.
- If ridges deteriorate and become ineffective due to weathering or erosion, they should be reestablished, unless doing so would damage a growing crop.
- This practice is best adapted on soils, which are stable enough to sustain effective ridges, such as clayey, silty and sandy loam soils. It is not well adapted on unstable soils, such as sands, loamy sands and certain organic soils.

Cross-Wind Strip-Cropping

Rule Definition

"Cross-wind strip-cropping" means planting strips of alternating crops within the same field.

Purpose

Growing crops or managing residue as a protective cover in strips across the prevailing wind direction can break the effects of high wind events.

Suggestions for Implementation

It is recommended that:

- A cross-wind strip-cropping system consist of at least two crop or residue cover alternating strips.
- Strip widths be at least 25 feet but no more than 330 feet.
- Strips should be aligned across the prevailing wind direction. While 90 degrees or perpendicular is preferred, benefits can still be realized when the strips are oriented as close to perpendicular as possible.
- Protective cover includes, but is not limited to a growing crop, grasses, legumes, grass-legume mixtures, standing stubble or tilled residue with enough surface cover to provide protection.

Cross-Wind Vegetative Strips

Rule Definition

"Cross-wind vegetative strips" means herbaceous cover established in 1 or more strips within the same field.

Purpose

Herbaceous cover creates a protective windbreak that disrupts the erosive forces of high winds, especially during critical wind erosion periods.

Suggestions for Implementation

It is recommended that:

- Herbaceous cover be composed of perennial or annual vegetation, growing or dead.
- Strips consist of at least one row of plants, providing the porosity can be achieved with a single row that contains no gaps.
- When two or more rows are required to achieve the required porosity and to avoid gaps, the rows should be spaced no more than 36 inches apart.
- Annual vegetation strips be composed of more than one row.
- Strips designed for this purpose have a minimum expected height of two feet.
- Strips designed for this purpose achieve a minimum porosity of 40 to 50 percent.
- Spacing between strips (not within row) not exceed 12 times the expected height of the herbaceous cover.
- Spacing between strips be adjusted to accommodate widths of farm equipment to minimize partial or incomplete passes.

Manure Application

Rule Definition

"Manure application" means applying animal waste or biosolids to a soil surface.

Purpose

Applying manure to maintain or improve chemical and biological condition of the soil can help reduce wind erosion and PM_{10}.

Suggestions for Implementation

- If the application or storage of manure is near a water source, precautions should be taken to prevent accidental leakage, spillage or runoff that will result in undesirable effects on soil, water and plants.
- Caution should be used when applying manure to ensure that state and local regulations are not violated.
- Caution should be used when certain manures are applied as they can volatilize and contribute to odor and ammonia emissions.
- Manures should be incorporated as quickly as possible to reduce odor and ammonia emissions, and to preserve nutrient value if the area is to be cropped in the future.

Mulching

Rule Definition

"Mulching" means applying plant residue or other material that is not produced on site to a soil surface.

Purpose

Adding a protective layer to the soil surface reduces soil movement in high wind events. This practice also conserves soil moisture, which can reduce surface movement of soil.

Suggestions for Implementation

It is recommended that:

- This practice can be used after low residue producing crops, like cotton, are harvested.
- Materials for mulching be acquired as waste products from other enterprises. These include, but are not limited to, wood bark, chips, shavings, and saw dust; food processing wastes; and small grain straw/chaff.
- Mulches be applied by blowers, hydro applicators, disk type straw punchers and spreaders.
- When small grain straw is used, spread at least 4,000 pounds straw per acre, distribute evenly and partially incorporate into the soil.
- When wood fibers are used, spread at least 2,000 pounds per acre or achieve 80 percent cover.

Multi-Year Crop

Rule Definition

"Multi-year crop" means a crop, pasture, or orchard that is grown, or will be grown, on a continuous basis for more than one year.

Purpose

Surface covers, such as crops, pasture and orchards, that are grown and maintained for a long duration, protect the soil surface from erosive winds. The longer a crop or cover is protecting the soil surface, the less time the surface is susceptible to wind erosion.

Examples of multi-year crops are:

- Alfalfa
- Citrus
- Roses
- Livestock pastures
- Nuts (Pecans)
- Sod

Permanent Cover

Rule Definition
"Permanent cover" means a perennial vegetative cover on cropland.

Purpose
Maintaining a long-term (perennial) vegetative cover on cropland that is temporarily not producing a major crop protects the soil surface from erosive winds.

Suggestions for Implementation
It is recommended that:

- Perennial species of grasses and/or legumes be used to establish at least 60 percent cover.
- When perennial species are used, maintenance by periodic mowing or swathing/baling is encouraged.
- Specific information on permanent cover types can be obtained from the Cooperative Extension Service or all NRCD offices.

Planting Based on Soil Moisture

Rule Definition
"Planting based on soil moisture" means applying water to soil before performing planting operations.

Purpose
Planting based on soil moisture reduces PM_{10} during the planting operation and is effective from the time of planting until crop establishment. Planting based on soil moisture is one of the most efficient practices to reduce PM_{10} between planting and crop emergence. Moisture causes soil to crust and therefore PM_{10} is not easily transported into the air.

Suggestions for Implementation

- Care should be taken to avoid over compaction of the soil, which could result in additional tillage operations.
- Irrigation should be applied as soon after soil preparation for planting as possible. After watering, a thin crust develops on the soil surface, which stabilizes the soil until planting
- The time between bed lifting, irrigation and planting should be minimized as much as possible.
- Use the soil moisture "feel method" to determine adequate soil moisture. See the Natural Resource Conservation Service publication #1619 "Estimating Soil Moisture by Feel and Appearance." This publication is available at all NRCD offices.

Residue Management

Rule Definition
"Residue management" means managing the amount and distribution of crop and other plant residues on a soil surface.

Purpose
Leaving crop and other plant residues on the soil surface can protect the soil between the time of harvest of one crop and emergence of a new crop, thus helping reduce wind erosion and the generation of PM_{10}.

Suggestions for Implementation
Many different residue management systems

have been developed. Some examples include:

- Reduced tillage systems, such as mulch-till, which partially incorporate surface residues and involve no plowing.
- No-till, which involves planting directly into the soil without any alteration to the seedbed. One example is planting a new crop directly into the grain stubble.
- Soil protection by crop residues can be increased by leaving residues on the soil surface as long as possible (e.g. by delaying tillage operations until just before planting).

It is recommended that:

- Stubble be left standing at six inches or more.
- Tillage be limited during this period to undercutting tools, such as blades, sweeps or deep tillage implements, such as a ripper or subsoiler.

- Loose residue be uniformly distributed on the soil surface.
- Residues from previous crops be left to maintain 60 percent ground cover.
- Specific information on determining small grain residue equivalents can be obtained from the Cooperative Extension Service or all NRCD offices.

- Consult NRCS Standard and Specification for Residue Management, # 329 and 344. This document is available at all NRCD offices.

Sequential Cropping

Rule Definition

"Sequential Cropping" means growing crops in a sequence that minimizes the amount of time bare soil is exposed on a field.

Purpose

By reducing the amount of time bare soil is exposed, sequential cropping helps reduce the window of time that the cropland is susceptible to PM_{10} erosion.

Some examples of sequential cropping include:

- Planting a winter grain crop between final harvest of a cotton crop and the planting of the next cotton crop.
- Close rotations of vegetable crops.

Suggestions for Implementation

It is recommended that:

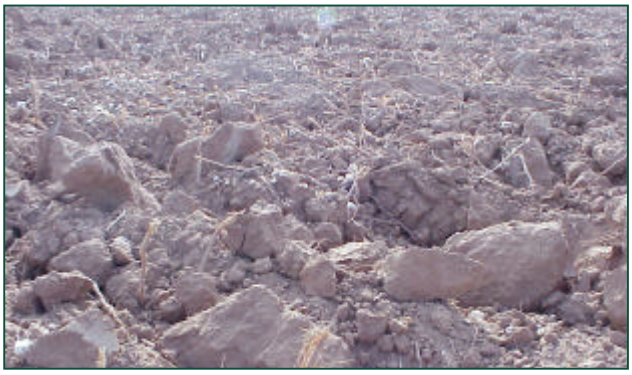
- The amount of time bare soil is exposed be limited to 30 days or less.
- Rotations be provided for acceptable substitute crops in case of crop failure or shift in planting intentions for weather related or economic reasons.

Surface Roughening

Rule Definition
"Surface roughening" means manipulating a soil surface to produce or maintain clods.

Purpose
The formation of clods helps disrupt the erosive force of the wind over an unprotected soil surface. Soil clods can be formed by tillage implements under appropriate soil moisture conditions.

Suggestions for Implementation
- Not all soils are able to form clods. Review the local soil survey or contact the NRCD office to help determine a specific field's soil type.
- Caution should be used to determine the most opportune time to roughen the soil surface while considering the tillage needed prior to planting, crop to be grown and irrigation water management needs (surface roughening can dry the upper soil profile more rapidly than not disturbing the soil).



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Suggestions for Implementation
- The distance of 10 times the barrier height is considered the protected area downwind of the barrier.
- Single row plantings are most popular in field windbreaks because they use less water and occupy the least amount of land area for the amount of protection derived.
- Recommended species for planting can be obtained at all NRCD offices.
- The planting should be done at a time and manner to insure survival and growth of selected species.
- Moisture conservation or supplemental watering should be provided for plant establishment and growth, as well as the use of drought tolerant species.
- Windbreaks should be aligned across the prevailing wind direction. While 90 degrees or perpendicular is preferred, benefits can still be realized when windbreaks are aligned as close to perpendicular as possible.
- The interval between windbreaks should be determined using current approved wind erosion technology available at all NRCD offices.

Stakeholders and Collaborating Partners

Agua Fria - New River Natural Resource Conservation District
Arizona Cotton Growers Association
Arizona Department of Agriculture
Arizona Department of Environmental Quality
Arizona Farm Bureau Federation
Arizona Nursery Association
East Maricopa Natural Resource Conservation District
Maricopa Association of Governments
Maricopa County Environmental Services Department
Maricopa County Farm Bureau
USDA Agricultural Research Service
USDA Natural Resources Conservation Service
US Environmental Protection Agency Region IX
University of Arizona - College of Agriculture and Life Sciences
University of Arizona - Cooperative Extension, Maricopa County
Western Growers Association