CHAPTER 5: MANAGING EROSION IN VINEYARD BLOCKS AND AVENUES

Contents

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Understanding Soil Erosion in Irrigated Agriculture

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IMPACTS OF SOIL EROSION

Soil erosion is caused by the erosive forces of wind or water. In this publication, we focus our attention on concepts surrounding water-induced soil erosion. This type of erosion threatens our ability as humans to sustain our global population with food and fiber, and is closely linked to economic vitality, environmental quality, and human health concerns. Roughly 75 billion tons of fertile topsoil is lost worldwide from agricultural systems every year. In the United States, we lose an estimated 6.9 billion tons of soil each year (Pimentel, 2000). Losses at this scale are not sustainable and result in our increasing dependence on costly inputs such as fertilizers and soil amendments that we use in an attempt to make up for the beneficial qualities that were present in the lost topsoil (Pimentel, 2000).

Erosion results in the degradation of a soil's productivity in a number of ways: it reduces the efficiency of plant nutrient use, damages seedlings, decreases plants' rooting depth, reduces the soil's water-holding capacity, decreases its permeability, increases runoff, and reduces its infiltration rate. The loss of nutrients alone resulting from soil erosion has an estimated cost to the United States of up to $20 billion a year (Troeh, Hobbs, and Donahue, 1991). The sediment deposited by erosive water as it slows can bury seedlings and cause the formation of surface crusts that impede seedling emergence, which will decrease the year's crop yields. The combined effects of soil degradation and poor plant growth often result in even greater erosion later on.

All of these effects occur at or near the erosion site. Off-site impacts relate to the transport of sediment, nutrients, and agricultural chemicals and can be even more costly than on-site impacts. Severe economic and environmental costs are associated with the removal of sediment deposits from roads and from lakes and other surface water bodies. In the United States, more than 60 percent of water-eroded soils (about 2.4 billion tons of soil a year) end up in watercourses (Pimentel, 2000). This leads to the sedimentation of dams, disruption of aquatic ecosystems, and contamination of drinking water supplies.

The information in this publication is intended to help you maintain the productivity of agricultural land and reduce the enormous costs associated with erosion by promoting a better understanding of the soil erosion process, providing tools to help you recognize soil erosion, and introducing management practices that you can use to help reduce this kind of erosion.

TYPES OF WATER EROSION

In general, soil erosion is a three-step process. It begins with the detachment of soil particles, continues with the transport of those particles, and ends with the deposition of soil particles in a new location. Bare soils (soils that lack a cover of living or dead plant biomass) are highly susceptible to erosion, even on flat land. There are three main types of water- induced soil erosion: *sheet*, *rill*, and *gully*.

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The most common yet most overlooked form of soil loss is *sheet erosion*. Sheet erosion is the uniform removal of a thin film of soil from the land surface without the development of any recognizable water channels (Figure 1). This type of erosion is barely perceptible, but the loss of a single millimeter of soil depth from an acre of land, which can be easily lost during a single irrigation or rain event, works out to a total loss of up to 6.1 tons of soil (Pimentel, 2000).

Rill erosion is easier to recognize. It is the removal of soil through the cutting of multiple small water channels (Figure 1). Rills are small enough to be smoothed by normal tillage operations and will not form again in the same location. Together, sheet and rill erosion account for most soil erosion in agricultural land (Brady and Weil, 1999).

Gully erosion occurs in areas where water runoff is concentrated, and as a result cuts deep channels into the land surface. Gullies are incised channels that are larger than rills (Figure 2). You can remove small, ephemeral gullies by tilling, but they will form again in the same location on the landscape. Gullies actually represent less soil loss than sheet or rill erosion, but they pose added management concerns such as damage to machinery, barriers to livestock and equipment, and increased labor costs to repair eroded areas.

Figure 1. Examples of sheet and rill erosion. (A) Sheet and rill erosion in California's Central Valley (Photo by Toby O'Geen). (B) Note the exposed rock fragments from sheet erosion and the network of rills running across the hill slope (Photo courtesy of Kerry Arroues, USDA–NRCS).

INDICATORS OF SOIL EROSION

It is important for you to be able to recognize evidence of soil erosion in the field. Here are some visual indicators that you can watch for (USDA–NRCS, 2001):

- bare soil
- plants or rocks on pedestals
- exposed roots
- small benches of soil behind obstacles
- surface soil crusts
- increased tendency of runoff water to flow together into a network of connected channels
- deposits of soil where the field's slope changes
- decreased thickness of topsoil
- exposed subsoil at the soil surface
- visible rills or gullies
- silt-clouded water or sediment deposits in surface water bodies and irrigation canals
- poor plant growth

Figure 2. Example of gully erosion. Photo courtesy of Vic Claassen, UD Davis.

Table 1. Definitions of LCCS classes

LCCS class	LCCS class definition
I	Few limitations
II	Moderate limitations that require limited conservation practices
III	Severe limitations that require special conservation practices
IV	Very severe limitations that require careful management
V	Soils are not likely to erode, but have other limitations, impractical to remove
VI	Severe limitations that make soils generally unsuitable for cultivation
VII	Very severe limitations that make soils unsuitable for cultivation
VIII	Soils with limitations that nearly preclude their use for commercial crop production

Table 2. Definitions of LCCS units

LCCS units	Cause of limitation
1	Limitation caused by slope or by actual or potential erosion hazard
2	Limitation of wetness caused by poor drainage or flooding
3	Slow or very slow permeability of the subsoil
4	Sandy or gravelly soils with very low or low available water-holding capacity
5	Fine-textured or very fine-textured surface layer
6	Sodicity or salinity
7	High rock, stone, or cobble content
8	Shallow depth to bedrock (less than 40 inches [about 1 meter])
9	Poor fertility that cannot be corrected
10	High rock, stone, cobble, or gravel content in subsoil

Sources: Soil Survey Division Staff, 1993.

SOIL SURVEY INTERPRETATIONS

An additional tool to understanding the erosion potential of your land is a USDA–NRCS Soil Survey Report. You can get a hard copy of the relevant soil survey at a local NRCS office. New and future soil surveys will only be published online as PDF (Adobe Acrobat) documents at this URL: http://www.ca.nrcs.usda.gov/mlra02/.

You can find information about erosion at the field scale in a number of sections of a soil survey report. After you have used the soil survey report to identify the soil map unit(s) of interest, use the report's table of contents and summary of tables to guide you to the relevant pages. The *erosion hazard rating* describes the potential for erosion damage in terms of severity, ranging from slight to severe. This rating appears in the *Detailed Soil Map Units* section of your soil survey. Similar information for forested lands can be found in the *Woodland Management and Productivity* table.

Erosion is also listed as a land use limitation in the *Water Management* table. Soil erodibility and soil loss tolerance estimates for each map unit are found in the *Physical and Chemical Properties of the Soils* table. The *Land Capability Classification System* is used to evaluate soils for land use in soil surveys. It also contains information about the erodibility of a landscape.

LAND CAPABILITY CLASSIFICATION SYSTEM

The *land capability classification system* (LCCS) can be used to understand the production potential and erodibility of your land. In the LCCS, soils are generally grouped at three levels: capability class, subclass, and units. Not all soil survey reports list all three classification levels, however. Some reports only use the capability class and subclass levels. The soil's LCCS rating appears in the text of the *Detailed Soil Map Units* section. Some soil surveys also display it as a separate table. See your soil survey report's summary of tables or table of contents for clarification on this point.

Capability classes are the broadest groupings of land and are designated by Roman numerals I through VIII. Limitations on land use increase with higher numbers. The classes are explained in Table 1.

Capability subclass e (for example, *subclass 2e*) is added to the capability class number when there is risk associated with soil erosion. Classes I and V rarely have the letter *e* because they are subject to little or no erosion.

Capability units are soil groups within a subclass. The capability unit code provides information on the cause of the limitation. Capability units are generally designated by adding an Arabic numeral to the subclass code. For example, *IIe-3* and *IIIe-6* indicates that the erodibility of these sites is caused by slow permeability and salt-affected soil, respectively (Table 2).

SOIL EROSION FACTORS (K AND T)

Soil erosion factors (K and T), are found in soil survey reports in the *Physical and Chemical Properties of Soils* table. The soil loss tolerance factor *(T)* is an estimate of the maximum average annual rate of soil loss (in tons per acre) that can occur without significantly affecting crop productivity. T values are established based on the following factors:

- maintaining adequate soil depth
- value of nutrients lost
- maintaining water-control structures and control of floodplain sedimentation
- prevention of gullies
- yield reduction per inch of topsoil lost
- water losses
- seedling losses

T factors are important in the evaluation and development of conservation practices that reduce soil erosion (Schertz and Nearing, 2002).

The soil erodibility factor (*K*) describes erodibility based solely on the physical properties of the soil. You can find a detailed discussion of the K factor in the companion publication Erodibility of Agricultural Soils, with Examples in Lake and Mendocino Counties (UC ANR Publication 8194).

NEW SOIL SURVEY RESOURCES

The UC Davis Soil Resource Laboratory has developed an online soil survey browser that allows users to navigate across the state of California using point-and-click operations to access soil survey data. You can find this user-friendly soil survey tool at this URL: http://casoilresource.lawr.ucdavis.edu/.

The USDA–NRCS has also developed a nationwide Web soil survey interface that will allow users to create maps of specific soil properties for any region that has a published soil survey. This product is available at this URL: http://websoilsurvey.nrcs.usda.gov/app/.

SUMMARY

In all instances, we must consider soil to be a non-renewable resource. The rate of soil formation is very slow: it takes from 300 to 1000 years for nature to replace the soil that a field can lose to erosion in 25 years at a loss rate of 1 mm per year (Pimentel et al., 1976). In order to manage soils in a sustainable manner, we must take steps to reduce soil erosion.

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FOR MORE INFORMATION

You'll find related information in these titles and in other publications, slide sets, CD-ROMs, and videos from UC ANR:

Erodibility of Agricultural Soils, with Examples in Lake and Mendocino Counties, Publication 8194

Sediment Delivery Inventory and Monitoring: A Method for Water Quality Management in Rangeland Watersheds, Publication 8014

Vegetative Filter Strips for Nonpoint Source Pollution Control in Agriculture, Publication 8195

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Farm Water Quality Planning
A Water Quality and Technical Assistance Program for California Agriculture
http://waterquality.ucanr.org

This reference sheet is part of the **Farm Water Quality Planning (FWQP)** series, developed for a short course that provides training for growers of irrigated crops who are interested in implementing water quality protection practices. The short course teaches the basic concepts of watersheds, nonpoint source pollution (NPS), self-assessment techniques, and evaluation techniques. Management goals and practices are presented for a variety of cropping systems.

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Sediment Management Goals and Recommended Practices for Orchards and Vineyards

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This fact sheet includes *Management Goals* (MG) and *Recommended Practices* (RP) for reducing soil erosion at the source and capturing sediment before it enters waterways and causes water quality problems downstream.

The development of a comprehensive farm plan for sediment management in orchards and vineyards involves a sequence of eight Management Goals:

MG 1. Assess the existing soil conditions and rainfall runoff patterns.

MG 2. Develop an orchard or vineyard layout that minimizes erosion.

MG 3. Manage the orchard or vineyard floor to maintain protective vegetative cover during the rainy season.

MG 4. Coordinate efforts to control sources of runoff, sediment, and erosion with neighboring landowners.

MG 5. Manage roads and non-cropped areas of the orchard or vineyard to reduce runoff and prevent soil erosion.

MG 6. Retain eroded sediment and runoff before it leaves the orchard or vineyard.

MG 7. Prevent erosion that results from irrigation practices.

MG 8. Evaluate and maintain Management Goals and Recommended Practices.

Each Management Goal can be accomplished through a customized set of Recommended Practices, listed under each Management Goal below. The choice of which practices you implement will depend to a great deal on your individual situation.

The best strategy for preventing sediment loss, water pollution, and damage to the orchard or vineyard is to develop an integrated system of practices. Sole reliance on a single strategy is not sufficient for most orchards and vineyards grown where the topography is variable. As you evaluate the economics of practices that could be used in your operation, keep in mind that prevention of the conditions that lead to runoff and erosion is always cheaper than fixing the physical problems caused by runoff and erosion after the fact.

Many of the specific Recommended Practices require some hydrologic or engineering calculations to reduce the likelihood of damage from large storms. Natural Resources Conservation Service (NRCS) practice names and numbers are provided for those practices that have NRCS construction standards and specifications. Please consult your local NRCS office for free assistance with developing these practices.

MG 1. Assess the existing soil conditions and rainfall runoff patterns.

RP 1.1. Identify the areas of the orchard or vineyard with the most erodible soils and the locations where erosion and soil deposition have occurred in the past.

RP 1.2. Identify sources of runoff water and sediments that are upslope of your operation. For example, this could include an undeveloped hillside, an adjacent roadway or ditch, a neighboring farm, a construction site, recently graded land, or a burned area.

RP 1.3. Evaluate the slopes and surface water flow patterns in the fields and in adjacent areas that are hydrologically connected. Ask the question, "Where would the runoff flow if an extremely large rainstorm occurred?"

RP 1.4. Evaluate the current cultural practices to identify which have been the most effective in controlling runoff and erosion.

MG 2. Develop an orchard or vineyard layout that minimizes erosion.

RP 2.1. Avoid cultivation of steep slopes.

RP 2.2. Avoid orchard or vineyard development operations during the winter rainy season.

RP 2.3. Leave an adequate uncultivated setback from any riparian areas.

RP 2.4. Evaluate, through numerous soil pits, the permeability characteristics of the soil. Look for any compacted horizons or notable stratifications that may impede infiltration.

RP 2.5. Consider deep ripping to break up any restrictive soil layers and mix together stratified horizons (NRCS Deep Tillage #324).

RP 2.6. Smooth and level the surface to remove any pockets where water could accumulate (NRCS Irrigation Land Leveling #464).

RP 2.7. Consider installing drainage tile if historical or current evaluations indicate that excessive water accumulates in the soil profile.

RP 2.8. Arrange the orchard or vineyard blocks to best encompass uniform soil and slope factors within each block.

RP 2.9. Locate and construct access roads so that they will not be sources of runoff and erosion or conveyances of runoff from other areas (NRCS Access Road #560).

RP 2.10. Install terraces or other structures to alter the orchard or vineyard slope and water flow characteristics. Proper planning, layout, and maintenance of terrace structures is mandatory if they are to function as conservation measures. Consult qualified personnel when designing and constructing them.

RP 2.11. Orient orchard or vineyard rows to facilitate management without creating an erosion hazard (NRCS Row Arrangement #557):

RP 2.11.1. Rows oriented with the slope may be suitable for heavily mechanized operations, but care must be taken that wheel tracks do not become channels for runoff.

RP 2.11.2. Rows oriented across the slope may reduce the erosion hazard, but with steeper slopes problems may arise with machinery access.

RP 2.11.3. Curving rows along the slope contour are suitable for the steepest areas. In vineyards, this will require a more elaborate trellis system than for straight rows, and that can hinder mechanization. The typical cropping density for curved rows is lower than for straight rows (NRCS Contour Orchard and Other Fruit Area #331).

RP 2.12. When considering planting in an area that is highly susceptible to erosion, decide whether the projected value of the crop from that area will justify the extra costs necessary to properly plant and maintain the orchard or vineyard there.

MG 3. Manage the orchard or vineyard floor to maintain protective vegetative cover during the rainy season.

RP 3.1. A cover crop should be included in the Recommended Practices (NRCS Cover Crop #340).

RP 3.1.1. Annual cover crops combined with cultivation or mowing (e.g., barley) may be appropriate if summer and fall soil cover is not required.

RP 3.1.2. Reseeding winter annuals with minimal or no floor tillage may be more appropriate if it is important to have protection from erosion as early as possible in the fall.

RP 3.1.3. Consult sources such as *Cover Cropping in Vineyards* (UC ANR Publication 3338) and observe local orchards and vineyards to help determine which cover crop management scheme is best for your situation.

RP 3.2. Floor management can maintain some surface residues from a cover crop. The use of no-till implements allows you to maintain weed control while retaining the benefits of surface residue (NRCS Residue Management #329).

RP 3.3. Areas under development need to have the protection of a winter cover crop (NRCS Cover Crop #340).

RP 3.4. Use mechanical equipment that helps maintain the soil in a non-erodible condition.

RP 3.4.1. Consider the use of tracked vehicles for difficult terrain.

RP 3.4.2. Wide tires on wheeled vehicles can reduce rut formation.

RP 3.4.3. Use lightweight vehicles when possible.

MG 4. Coordinate efforts to control sources of runoff, sediment, and erosion with neighboring landowners.

RP 4.1. Work with neighboring landowners, when possible, to reduce runoff sources and impacts of soil erosion and sedimentation downstream or on adjacent lands. Erosion problems can often be solved without expensive measures if neighboring landowners are involved.

MG 5. Manage roads and non-cropped areas of the orchard or vineyard to reduce runoff and prevent soil erosion.

RP 5.1. Protect roads and other non-cropped areas from incoming, concentrated runoff. Diversion structures or drainage systems may be necessary to divert concentrated runoff from an upslope source. Common sources include adjacent surfaced roadways, culverts, and natural drainages from uncultivated areas (NRCS Diversion #362).

RP 5.2. Non-cropped areas such as row headlands should he managed with winter cover crops (NRCS Cover Crop #340).

RP 5.3. Low-lying areas within the orchard or vineyard that tend to become channels for surface runoff may best be left unplanted and instead used as grassed filter strips to trap any sediments carried by runoff. Consult qualified guidance for the design and construction of grassed filter strips (NRCS Filter Strip #393).

RP 5.4. Stream setback areas need to have year-round cover. If these areas have been disturbed or previously cultivated, they should be planted to a compatible native species that will not require maintenance in the future (NRCS Critical Area Planting #342, Riparian Forest Buffer #391, Stream Bank Protection #580).

RP 5.5. Roads need to be situated such that they are not sources or conveyances for runoff (NRCS Access Road #560). To accomplish this,

RP 5.5.1. Avoid locating roads on steep slopes, if possible.

RP 5.5.2. Grade the road surface to encourage water to drain off of the road surface.

RP 5.5.3. Incorporate rolling swales to prevent the movement of runoff over large distances on the road surface.

RP 5.5.4. Incorporate drainage structures to remove accumulated water from the road surface or from the road ditch.

RP 5.5.5. For specific information, consult manuals such as the *Handbook for Forest and Ranch Roads* available from the Mendocino County Resource Conservation District (RCD).

RP 5.6. Non-surfaced roads in the orchard or vineyard can also be planted with a cover crop. This is particularly suitable for those roads that are not generally accessed in the winter due to muddy conditions. A cover crop will also reduce the length of time that these roads are inaccessible (Critical Area Planting #342).

RP 5.7. Avoid driving on muddy roads; this creates channels for runoff.

RP 5.8. Cut banks and exposed fill areas should be protected with straw, jute netting, and a cover crop until the native vegetation has become reestablished (NRCS Cut Bank Stabilization #742).

RP 5.9. Plant bare soil and disturbed areas of the farm such as cut banks, field margins, and abandoned slopes with a dense cover of vegetation to control erosion and suppress weed growth. A mix of species should be selected to accomplish quick establishment but also provide long-term coverage, attract beneficial insects, and compete against weed species (NRCS Critical Area Planting #342).

RP 5.10. A hedge of shrubs can be established along field margins or between field blocks to reduce wind effects, protect slopes from erosion, and attract beneficial insects. A mix of species should be selected to extend the shrubs' flowering season (NRCS Hedgerow Planting #422).

RP 5.11. A row of trees or large shrubs can be established as a wind break to reduce spray drift and intercept insect and weed seed disbursement. This planting can also help protect steep slopes, stabilize stream or ditch banks, and reduce soil saturation in low-lying areas (NRCS Tree/Shrub Establisbment #612).

RP 5.12. Manage existing gullies on the farm by controlling concentrated runoff with a combination of management, vegetative, and structural measures to prevent the advance of the gully. Prevent head cutting by installing a grade stabilization structure (NRCS Grade Stabilization Structure #410, Diversion #362, Critical Area Planting #342, Underground Outlet #620, Row Arrangement #557).

MG 6. Retain eroded sediment and runoff before it leaves the orchard or vineyard.

RP 6.1. Permanent sediment-trapping structures can be built to capture and filter runoff that is generated in the orchard or vineyard, preventing it from moving downstream. These structures will require annual maintenance and cleaning as well as installation costs. They should be seen as a safety measure; the majority of effort should be focused on reducing the formation of runoff and erosion at it source.

MG 7. Prevent erosion that results from irrigation practices.

RP 7.1. Design irrigation systems to suit the intake rate of the soil, thus preventing runoff.

RP 7.2. Maintain irrigation systems to prevent breaks and leaks.

MG 8. Evaluate and maintain Management Goals and Recommended Practices.

RP 8.1. Evaluate the Management Goals and Recommended Practices implemented for sediment management during future runoff periods to ensure their proper operation and function. Correct any deficiencies as needed. Remove accumulated sediment from basins annually or as needed, and spread it back onto field areas.

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Adapted from *Sediment management goals and management practices for strawberries,* UC ANR Publication 8071 (Daniel Mountjoy, 2002).

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FOR MORE INFORMATION

You will find related information in these titles and in other publications, slide sets, CD-ROMs, and videos from UC ANR:

Evaluating Water Quality, Publication 8118

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The Farm Water Quality Plan, Publication 9002

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SOIL QUALITY

INTRODUCTION

What is soil?

Soil is a living, dynamic resource that supports plant life. It is made up of different size mineral particles (sand, silt, and clay), organic matter, and numerous species of living organisms. Soil has biological, chemical, and physical properties that are always changing.

What does soil do for us?

Soil provides a physical matrix, chemical environment, and biological setting for water, nutrient, air, and heat exchange for living organisms.

Soil controls the distribution of rainfall or irrigation water to runoff, infiltration, storage, or deep drainage. Its regulation of water flow affects the movement of soluble materials, such as nitrate nitrogen or pesticides.

Soil regulates biological activity and molecular exchanges among solid, liquid, and gaseous phases. This affects nutrient cycling, plant growth, and decomposition of organic materials.

Soil acts as a filter to protect the quality of water, air, and other resources.

Soil provides mechanical support for living organisms and their structures. People and wildlife depend on the this function.

What is Soil Quality?

Soil quality is the fitness of a specific kind of soil to function within its surroundings, support plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

How is soil quality important to landowners?

Soil quality enhancement is important to support crop, range, and woodland production and sustain water supplies. Enhanced soil quality can help to reduce the onsite and offsite costs of soil erosion, improve nutrient use efficiencies, and ensure that the resource is sustained for future use. It is also essential to maintain other resources that depend on the soil, such as water quality, air quality, and wildlife habitat.

How can soil quality be evaluated?

Soil quality and soil health can be evaluated by monitoring several indicators. The type of indicator chosen depends on the soil function and scale (i.e. field, farm, watershed, or region) in which the evaluation is made. For example, an indicator of soil loss by erosion may be the thinning of the surface layer or visual and physical evidence of gullies, small rills, adjacent sediment, etc. Indicators for physical, chemical, and biological conditions can be simple field tests or sophisticated laboratory analyses.

Soil quality indicators may be considered diagnostic tools to assess the health of the soil or else as a cause for concern to the farmer, producer, rancher, woodland manager, or gardener, to stimulate a change in management. Trends in soil health can help in planning and evaluating current land use practices. The information gathered from monitoring soil health can be used to improve conservation recommendations.

How can my awareness of soil quality be applied?

Soil quality can be applied through several natural resource approaches:

- Data from soil surveys, fertility labs, and field tests can help identify areas where natural soil properties (texture, drainage, etc.) or management related problems currently exist. Once these conditions are identified, corrections can be planned.
- Areas with potential resource problems can be identified and shown on soil interpretive maps. These fragile areas that can be easily be damaged my need more intensive management to prevent damage or be converted to a less demanding land use.
- After installing conservation practices, trends in soil quality can be tracked to show the success of the practice or the need for other management changes.

What concerns are addressed by soil quality?

- Loss of soil material by erosion
- Deposition of sediment by wind or floodwaters
- Compaction of layers near the surface
- Soil aggregation at the surface
- Infiltration reduction
- Crusting of the soil surface
- Nutrient loss or imbalance
- Pesticide carryover
- Buildup of salts
- Change in pH to an unfavorable range
- Loss of organic matter
- Reduced biological activity and poor residue breakdown
- Infestation by weeds or pathogens

- Excessive wetness

SOIL COMPACTION

What is compaction?

Soil compaction occurs when soil particles are pressed together, reducing the pore space between them. This increases the weight of solids per unit volume of soil (bulk density). Soil compaction occurs in response to pressure (weight per unit area) exerted by field machinery or animals. The risk for compaction is greatest when soils are wet.

Why is compaction a problem?

Compaction restricts rooting depth, which reduces the uptake of water and nutrients by plants. It decreases pore size, increases the proportion of water-filled pore space at field moisture, and decreases soil temperature. This affects the activity of soil organisms by decreasing the rate of decomposition of soil organic matter and subsequent release of nutrients.

Compaction decreases infiltration and thus increases runoff and the hazard of water erosion.

How can compacted soils be identified?

- Platy or weak structure, or a massive condition,
- Greater penetration resistance,
- Higher bulk density,
- Restricted plant rooting,
- Flattened, turned, or stubby plant roots.

The significance of bulk density depends on the soil texture. Rough guidelines for the minimum bulk density at which a root restricting condition will occur for various soil textures are (g/cc stands for grams per cubic centimeter):

Texture	Bulk Density (g/cc)
Coarse, medium, and fine sand and loamy sands other than loamy very fine sand	1.80
Very fine sand, loamy very fine sand	1.77
Sandy loams	1.75
Loam, sandy clay loam	1.70
Clay loam	1.65
Sandy clay	1.60
Silt, silt loam	1.55
Silty clay loam	1.50
Silty clay	1.45
Clay	1.40

What causes soil compaction?

Soil compaction is caused by tilling, harvesting, or grazing when the soils are wet.

Soil water content influences compaction. A dry soil is much more resistant to compaction than a moist or wet soil.

Other factors affecting compaction include the texture, pressure exerted, composition (texture, organic matter, plus clay content and type), and the number of passes by vehicle traffic and machinery. Sandy loam, loam, and sandy clay loam soils compact more easily than silt, silt loam, silty clay loam, silty clay, or clay soils.

Compaction may extend to 20 inches. Deep compaction affects smaller areas than shallow compaction, but it persists because shrinking and swelling and freezing and thawing affect it less. Machinery that has axle loads of more than 10 tons may cause compaction below 12 inches. Grazing by large animals can cause compaction because their hooves have a relatively small area and therefore exert a high pressure.

How long will compaction last?

The persistence of soil compaction is determined by the depth at which it occurs, the shrink-swell potential of the soil, and the climate. As the depth increases, the more persistent the condition. The type and percentage of clay determine the shrink-swell potential. The greater the shrink-swell potential and number of wet/dry cycles, the lower is the duration of compaction at a particular depth. Freeze/thaw cycles also help decrease near-surface compaction.

How do organic matter and compaction interact?

Soil organic matter promotes aggregation of soil particles. This increases porosity and reduces bulk density (i.e., compaction). It also increases permeability and may increase plant available water.

Addition of manure, compost, or other organic materials including newspaper, woodchips, and municipal sludge can improve soil structure, helping to resist compaction.

Thick layers of forest litter reduce the impact of machinery, thus reducing compaction.

How can compaction be reduced?

- Reduce the number of trips across the area.

- Till or harvest when the soils are not wet.
- Reduce the pressure of equipment.
- Maintain or increase organic matter in the soil.
- Harvest timber on frozen soil or snow.

SOIL ORGANIC MATTER

What is soil organic matter?

Soil organic matter is that fraction of the soil composed of anything that once lived. It includes plant and animal remains in various stages of decomposition, cells and tissues of soil organisms, and substances from plant root and soil microbes. Well-decomposed organic matter forms humus, a dark brown, porous, spongy material that has a pleasant, earthy smell. In most soils, the organic matter accounts for less than about 5% of the volume.

What does organic matter do?

Organic matter is an essential component of soils because it:

- Provides a carbon and energy source for soil microbes;
- Stabilizes and holds soil particles together, thus reducing the hazard of erosion;
- Aids the growth of crops by improving the soil's ability to store and transmit air and water;
- Stores and supplies such nutrients as nitrogen, phosphorus, and sulfur, which are needed for the growth of plants and soil organisms;
- Retains nutrients by providing cation-exchange and anion-exchange capacities;
- Maintains soil in an uncompacted condtion with lower bulk density;
- Makes soil more friable, less sticky, and easier to work;
- Retains carbon from the atmosphere and other sources;
- Reduces the negative environmental effects of pesticides, heavy metals, and many other pollutants.

Soil organic matter also improves tilth in the surface horizons, reduces crusting, increases the rate of water infiltration, reduces runoff, and facilitates penetration of plant roots.

Where does it come from?

Plants produce organic compounds by using the energy of sunlight to combine carbon dioxide from the atmosphere with water from the soil. Soil organic matter is created by the cycling of these organic compounds in plants, animals, and microorganisms into the soil.

What happens to soil organic matter?

Soil organic matter can be lost through erosion. This process selectively detaches and transports particles on the soil surface that have the highest content of organic matter.

Soil organic matter is also utilized by soil microorganisms as energy and nutrients to support their own life processes. Some of the material is incorporated into the microbes, but most is released as carbon dioxide and water. Some nitrogen is released in gaseous form, but some is retained, along with most of the phosphorus and sulfur.

When soils are tilled, organic matter is decomposed faster because of changes in water, aeration, and temperature conditions. The amount of organic matter lost after clearing a wooded area or tilling native grassland varies according to the kind of soil, but most organic matter is lost within the first 10 years.

Rates of decomposition are very low at temperatures below 38^{o} F (4^{o} C) but rise steadily with increasing temperature to at least 102^{o} F (40^{o} C) and with water content until air becomes limiting. Losses are higher with aerobic decomposition (with oxygen) than with anaerobic decomposition (in excessively wet soils). Available nitrogen also promotes organic matter decomposition.

What controls the amount?

The amount of soil organic matter is controlled by a balance between additions of plant and animal materials and losses by decomposition. Both additions and losses are very strongly controlled by management activities.

The amount of water available for plant growth is the primary factor controlling the production of plant materials. Other major controls are air temperature and soil fertility. Salinity and chemical toxicities can also limit the production of plant biomass. Other controls are the intensity of sunlight, the content of carbon dioxide in the atmosphere, and relative humidity.

The proportion of the total plant biomass that reaches the soil as a source of organic matter depends largely on the amounts consumed by mammals and insects, destroyed by fire, or produced and harvested for human use.

Practices decreasing soil organic matter include those that:

1. Decrease the production of plant material by
    a. Replacing perennial vegetation with short-season vegetation,
    b. Replacing mixed vegetation with monoculture crops,
    c. Introducing more aggressive but less productive species,
    d. Using cultivars with high harvest indices,
    e. Increasing the use of bare fallow.

2. Decrease the supply of organic materials by
    a. Burning forest, range, or crop residue,
    b. Grazing,
    c. Removing plant products.
3. Increase decomposition by
    a. Tillage,
    b. Drainage,
    c. Fertilization (especially with nitrogen).

Practices increasing soil organic matter include those that:

1. Increase the production of plant materials by
    a. Irrigation,
    b. Fertilization to increase plant biomass production,
    c. Use of cover crops
    d. Improved vegetative stands,
    e. Introduction of plants that produce more biomass,
    f. Reforestation
    g. Restoration of grasslands.
2. Increase supply of organic materials by
    a. Protecting from fire,
    b. Using forage by grazing rather than by harvesting,
    c. Controlling insects and rodents,
    d. Applying animal manure or other carbon-rich wastes,
    e. Applying plant materials from other areas.
3. Decrease decomposition by
    a. Reducing or eliminating tillage,
    b. Keeping the soil saturated with water (although this may cause other problems),
    c. Keeping the soil cool with vegetative cover.

AGGREGATE STABILITY

What are soil aggregates?

Soil aggregates are groups of soil particles that bind to each other more strongly than to adjacent particles. The space between the aggregates provide pore space for retention and exchange of air and water.

What is aggregate stability?

Aggregate stability refers to the ability of soil aggregates to resist disruption when outside forces (usually associated with water) are applied. Aggregate stability is not the same as *dry aggregate stability*, which is used for wind erosion prediction. The latter term is a size evaluation.

Why is aggregate stability important?

Aggregation affects erosion, movement of water, and plant root growth. Desirable aggregates are stable against rainfall and water movement. Aggregates that break down in water or fall apart when struck by raindrops release individual soil particles that can seal the soil surface and clog pores. This breakdown creates crusts that close pores and other pathways for water and air entry into a soil and also restrict emergence of seedlings from a soil.

Optimum conditions have a large range in pore size distribution. This includes large pores between the aggregates and smaller pores within the aggregates. The pore space between aggregates is essential for water and air entry and exchange. This pore space provides zones of weakness through which plant roots can grow. If the soil mass has a low bulk density or large pore spaces, aggregation is less important. For example, sandy soils have low aggregation, but roots and water can move readily.

How is aggregate stability measured?

Numerous methods measure aggregate stability. The standard method of the NRCS Soil Survey Laboratory can be used in a field office or in a simple laboratory. This procedure involves repeated agitation of the aggregates in distilled water.

An alternative procedure described here does not require weighing. The measurements are made on air-dry soil that has passed through a sieve with 2-millimeter mesh and retained by a sieve with a 1-millimeter mesh. A quantity of these 2-1 millimeter aggregates is placed in a small open container with a fine screen at the bottom. This container is placed in distilled water. After a period of time, the container is removed from the water and its contents are allowed to dry. The content is then removed and visually examined for the breakdown from the original aggregate size. Those materials that have the least change from the original aggregates have the greatest aggregate stability.

Soils that have a high percentage of silt often show lower aggregate stability if measured air-dry than the field behavior would suggest, because water entry destroys the aggregate structure.

What influences aggregate stability?

The stability of aggregates is affected by soil texture, the predominant type of clay, extractable iron, and extractable cations, the amount and type of organic matter present, and the type and size of the microbial population.

Some clays expand like an accordion as they absorb water. Expansion and contraction of clay particles can shift and crack the soil mass and create or break apart aggregates.

Calcium ions associated with clay generally promote aggregation, whereas sodium ions promote dispersion.

Soils with over about five percent iron oxides, expressed as elemental iron, tend to have greater aggregate stability.

Soils that have a high content of organic matter have greater aggregate stability. Additions of organic matter increase aggregate stability, primarily after decomposition begins and microorganisms have produced chemical breakdown products or mycelia have formed.

Soil microorganisms produce many different kinds of organic compounds, some of which help to hold the aggregates together. The type and species of microorganisms are important. Fungal mycelial growth binds soil particles together more effectively than smaller organisms, such as bacteria.

Aggregate stability declines rapidly in soil planted to a clean-tilled crop. It increases while the soil is in sod and crops, such as alfalfa.

SOIL EVALUATION

Gathering information on a site's soil is the first step in determining vineyard potential. The physical and chemical components of a soil will directly affect how easy it is to first establish a vineyard on the site and then to maintain vine growth that can support yield and fruit quality goals. Throughout the world grapes are commercially grown in soil types ranging from gravelly sand to dense clays. Although vineyard design and farming practices can mitigate the effect of poor soil structure on vine growth, it is usually far less costly in terms of inputs to grow vines in soil types that fall between these two extremes.

Likewise there are acceptable ranges of specific chemical components of a soil that affect vine growth and production. Soil amendments and fertilizer applications may not completely overcome chemical limitations of a soil. Commonly, the degree of success is proportional to vine performance. As a result, it is imperative to characterize a vineyard site's soil in terms of its physical and chemical components in order to estimate return on investment.

What are indicators?

Soil quality indicators are physical, chemical, and biological properties, processes, and characteristics that can be measured to monitor changes in the soil.

The types of indicators that are the most useful depend on the function of soil for which soil quality is being evaluated. These functions include:

- Providing a physical, chemical, and biological setting for living organisms;
- Regulating and partitioning water flow, storing and cycling nutrients and other elements;
- Supporting biological activity and diversity for plant and animal productivity;
- Filtering, buffering, degrading, immobilizing, and detoxifying organic and inorganic materials;
- Providing mechanical support for living organisms and their structures.

What are some indicators?

Indicators of soil quality can be categorized into four general groups: visual, physical, chemical, and biological.

Visual indicators may be obtained from observation or photographic interpretation. Exposure of subsoil, change in soil color, ephemeral gullies, ponding, runoff, plant response, weed species, blowing soil, and deposition are only a few examples of potential locally determined indicators. Visual evidence can be a clear indication that soil quality is threatened or changing.

Backhoe observation pits dug on the site will allow you to gather extremely useful information that will affect vineyard layout, rootstock choice, irrigation requirements and drainage needs. Ideally, a knowledgeable soils engineer, viticulturist, consultant, etc. will provide a description of each pit utilizing text or graphics that include some of the following components by depth. The source of this information may be from visual observation and laboratory analyses of soil samples taken from the holes.

Physical indicators are related to the arrangement of solid particles and pores. Examples include topsoil depth, bulk density, porosity, aggregate stability, texture, crusting, and compaction. Physical indicators primarily reflect limitations to root growth, seedling emergence, infiltration, or movement of water within the soil profile.

<u>Soil Texture</u>

This component of a soil will affect rootstock selection, irrigation requirement and fertilization needs. Soil texture impacts water holding capacity and nutrient availability and thus is an important site characteristic to be considered when estimating potential vine growth. Additionally, soil textures impact types and population levels of soil-borne pests and pathogens.

A soil's texture is determined by the size of particles which make it up. From largest to smallest, the three categories of particle size are sand, silt, and clay. "Loam" is an equal mix of sand and silt. A "clay loam" is a mix of sand, silt and clay that has more clay than sand or silt.

In general, gravel and sand are more permeable, that is they allow for greater downward movement of water, than are loams, silts or clays. Soil structure will affect relative permeability of the latter three textures. Also, the consolidation present at the site will determine the overall permeability of these tighter soils textures.

Soil Structure

Soil particles are usually arranged in aggregates, or groups and the type of group defines the soil structure. This also impact a soil's water holding capacity as well as aeration and the potential for compaction. A soil with a "strong" structure has cracks and large pores through which water and air move freely. The other extreme is a very "weak" structure, often called "massive", which means there are no cracks or pores and therefore has low permeability.

Soil Consolidation

Soils that are "dense" have less pore space between soil aggregates and are less permeable than "loose" soils.

Mottling

Color is an indication of a soil's parent material. It can provide some clues regarding the soil's chemical components. Mottling specifically is an indication of past or current saturated conditions. If this condition occurs at a shallow or intermediate depth, subsurface drainage will be required.

Root Density

The presence, absence or density of roots in the soil profile is an indicator of restrictive layers.

Chemical indicators include measurements of pH, salinity, organic matter, phosphorus concentrations, cation-exchange capacity, nutrient cycling, and concentrations of elements that may be potential contaminants (heavy metals, radioactive compounds, etc.) or those that are needed for plant growth and development. The soil's chemical condition affects soil-plant relations, water quality, buffering capacities, availability of nutrients and water to plants and other organisms, mobility of contaminants, and some physical conditions, such as the tendency for crust to form.

Knowledge of the chemical composition of your soil within the potential rooting zone will provide insight into the limiting factors that may affect initial vine growth as well as indicate the types of fertilizers required for sustained vine health. Some of the soil limitations can be addressed by incorporating pre-plant amendments and others must be dealt with scheduled post-plant fertilizer additions.

pH Determination

The pH of a soil is a measure of hydrogen ion concentration in the saturation extract. It is usually determined by measuring the acidity of a saturated paste or a dilute aqueous suspension of a 1 to 2. 1 to 5 or 1 to 10 soil-to-water ratio. The lower the pH value, the more acidic the soil and the higher the pH value, the more alkaline the soil sample. pH affects nutrient solubility and therefore availability to the plant as well as diversity and population of soil microbes.

Grapevines are commonly grown in soil pH ranging from 5.5 – 8.5. Optimal values lie within this range. Nutrient availability and microbial activity is enhanced at about pH 6.0 – 6.5.

Lime Requirement [LiR] (tons/Acre)

On a soil sample with a pH of less than 6.5, a lab will determine the amount of lime needed to raise the pH of a 6" to 7" layer of soil to a specific lesser degree of acidity, usually to 6.0 or 6.5. The factors that affect the LiR include pH, exchangeable acidity, buffering capacity and soil texture. Generally, LiR increases as soil texture becomes tighter.

Cation Exchange Capactiy [CEC] (milliequivalents/100 gms soil)

This is a measure of the soil's ability to adsorb cations (positively charged atoms). It is largely determined by the soil's clay content, organic matter and salt level. A high CEC means that the soil's nutrient capacity is high.

Calcium/Magnesium [Ca/Mg] (ppm)

Each of these elements are essential to plant growth and they are reported separately as well as in a unites ratio (Ca:Mg). They are indicators of clay type and soil structure.

Phosphorus [P] (ppm)

Low levels of soil P, or low P availability occur in the North Coast and is not common in other California viticulture areas. The presence of organic matter and particularly humus, will increase available P.

Salinity [Ece] (mmhos/cm or dS/meter)

Sodium, calcium and magnesium are the principle salts that may collectively cause a saline soil condition. Excessive soluble salts can result in poor plant growth because vines have difficulty in extracting water and nutrients from the soil. In an area that has not been farmed, this can be caused by evaporation from soil overlaying a perched water table, or from poorly drained areas. Salinity can also occur when slats are added in the form of fertilizers or poor quality irrigation water to shallow or poorly drained areas.

<u>Permeability determined by estimating the Exchangeable Sodium Level [ESP] (%)</u>

Water movement through a soil profile can be affected by soil chemistry as well as gross physical constraints such as a tight clay or sharp textural change. An excessive sodium level, relative to calcium and magnesium may result in a dispersion of soil colloids reducing the number of larger pores thus permeability. A dispersive soil can have water penetration problems within the profile as well as a run off problems due to surface crusting. (Surface crusting is more likely caused by irrigating with very pure, low salt water.)

<u>Boron [B] (PPM)</u>

Essential plant micronutrient, but a little bit goes a long way. High soil levels are usually associated with high-boron water. Deficiency is as common as toxicity in some areas.

<u>Organic Matter [OM] (%)</u>

Organic matter may be of interest to determine the overall fertility of the site. It consists of plant and animal residues in various stages of decomposition, plus living soil organisms and substances produced by these organisms. The residue is decomposed by soil microorganisms (fungi, nematodes, bacteria, protozoa), therefore the diversity and population of soil microbes is a function of the OM level. The decomposition process of OM results in the formation of soil aggregates, thus improving soil structure, aeration, permeability and water holding capacity. Decomposition also results in the mineralization of OM, thus nutrients such as N, P, and K become more available for plant uptake.

<u>Other analyses</u>

Soil analysis reports may include a host of other parameters than the ones described in here. These include nitrate-nitrogen (NO3-N), potassium (K), zinc (Zn), manganese (Mn), copper (Cu), iron (Fe) and molybdenum (Mo). Given what is currently understood about grapevine nutrition however, it is more informative to make these determinations on plant tissue samples.

Biological indicators include measurements of micro and macro-organisms, their activity, or byproducts. Earthworm, nematode, or termite populations have been suggested for use in the some parts of the country. Respiration rate can be used to detect microbial activity, specifically microbial decomposition of organic matter in the soil. Ergosterol, a fungal byproduct, has been used to measure the activity of organisms that play an important role in the formation and stability of soil aggregates. Measurement of decomposition rates of plant residue in bags or measurements of weed seed numbers, or pathogen populations can also serve as biological indicators of soil quality.

How are indicators selected?

Soil quality is estimated by observing or measuring several different properties or processes. No single property can be used as an index of soil quality.

The selection of indicators should be based on:

- The land use;
- The relationship between an indicator and the soil function being assessed;
- The ease and reliability of the measurement;
- Variation between sampling times and variation across the sampling area;
- The sensitivity of the measurement to changes in soil management;
- Compatibility with routine sampling and monitoring;
- The skills required for use and interpretation.

When and where to measure?

The optimum time and location for observing or sampling soil quality indicators depends on the function for which the assessment is being made. The frequency of measurement also varies according to climate and land use.

Soil variation across a field, pasture, forest, or rangeland can greatly affect the choice of indicators. Depending on the function, such factors as the landscape unit, soil map unit, or crop growth stage may be critical. Wheel tracks can dramatically affect many properties measured for plant productivity. Management history and current inputs should also be recorded to ensure a valid interpretation of the information.

Monitoring soil quality should be directed primarily toward the detection of trend changes that are measureable over a 1- to 10-year period. The detected changes must be real, but at the same time they must change rapidly enough so that land managers can correct problems before undesired and perhaps irreversible loss of soil quality occurs.

<u>Soil Sampling Guidelines</u>

Inadequate field sampling may result in a misinterpretation of a site's soil analysis, yet there is no single correct method to collect soil samples from an unplanted site. The number of samples collected, the consolidation of samples from different areas of the site and the depth of the profile from which samples are taken may vary between two sites of similar size. The size and variability of the site being evaluated will affect the number of backhoe holes dug and samples collected. In 360 acres, one backhoe pit every 5 to 10 acres will result in 72 to 36 holes and at least twice that many soil samples. While could add up to substantial sampling costs, the investment is justified in extremely variable areas. Likewise, a 5 acre site being assessed for vineyard potential ought to have more than one backhoe hole dug in order to accurately characterize the area.

When siting pits, the objective is to capture an area's variability. Look for differences in terrain, surface drainage patterns and resident vegetation. These are indicators of changes in soil texture, depth, and fertility. On hillsides that are under consideration for development, look for any evidence of old slips that indicate the presence of a slip plane and dig enough pits, preferably in a grid, to characterize the eroded area and the area immediately adjacent to it.

Number of backhoe observation pits

When soil changes are common or expected over small areas or by depth, no less than one pit every 5 acres should be considered. In areas that are more homogeneous, 1 in every 20 acres is common. Identify each pit location in notes that describe why you chose to site it as you did. Site pits so that they are in areas representative of the land's previous use activities. For example, when following livestock or dairy operations, pits should be located in the areas of different animal use intensities. If vines are to replace a tree crop, make sure pits are sited in selected rows and row centers. Also, consider the irrigation system that was in use for the previous crop. Sample at the head and tail ends of furrow and flood surface systems. If possible, look for different patterns in an existing crop's vigor and site pits so that they may explain restrictions on plant size. A greater density of holes may be required on smaller parcels than larger ones.

Number of soil samples per pit

Optimally, one every 12 inches of depth. Practically, enough samples to characterize the soil conditions found in the hole. Keep samples taken at different depths separate if distinct changes in soil texture or structure are obvious. It is important to sample the entire effective rooting depth. If excessive salts or minerals such as boron are suspected, ideally, samples should be taken at 6 to 12 inch intervals in the profile.

Things to Avoid When Taking Soil Samples

- Do not combine soils that were farmed utilizing different fertilizer or irrigation practices.
- Do not combine soils of different cropping or animal use histories
- Do not use contaminated collection containers.

What does the value mean?

Interpreting indicator measurements to separate soil quality trends from periodic or random changes is currently providing a major challenge for researchers and soil managers. Soils and their indicator values vary because of differences in parent material, climatic condition, topographic or landscape position, soil organisms, and types of vegetation. For example, cation exchange capacity may relate to organic matter, but it may also relate to the kind and amount of clay.

Establishing acceptable ranges, examining trends and rates of change over time, and including estimates of the variance associated with the measurements are important in interpreting indicators. Changes need to be evaluated as a group, with a change in any one indicator being evaluated only in relation to changes in others. Evaluations before and after, or with an without intervention, are also needed to develop appropriate and meaningful relationships for various kinds of soils and the functions that are expected of them.

The overall goal should be to maintain or improve soil quality without adversely affecting other resources.

Best Management Farming Practices for Water Quality Protection

Conservation Cover (327) Fact Sheet

BMP: Bare soil is covered with vegetation. Ditches and banks are protected from concentrated flow, gullies and ditches are stabilized, and erosion is reduced on cropped and non-cropped areas. Crop and air quality are protected from dust.

NRCS Practice Standard: Conservation Cover (327)

Planting, establishing and maintaining vegetation on land needing permanent vegetative cover and protection.

Conservation Cover (NRCS Conservation Practice Code 327)

Definition: Establishing and maintaining permanent vegetative cover.

Purposes:

- Reduce soil erosion and sedimentation
- Improve water quality
- Enhance wildlife habitat
- Improve soil quality
- Manage plant pests
- Provide beneficial insect habitat

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

CONSIDER THIS:

This practice involves establishing and maintaining a protective cover of perennial vegetation.

In perennial crop systems such as vineyards, vegetation established needs to provide full year- round coverage in vineyard middles.

Permanent plant mixes may consist of grasses, legumes and/or other forbs adapted to soils and micro-climates of Napa County.

Select species for planting that are suited to current site conditions and intended uses.

Avoid invasive plant species.

Prepare a seedbed sufficient to suppress weeds and provide for germination and growth of selected species.

Establish vegetation by October 15.

When applying straw mulch, apply certified weed free mulch at 1500 lbs/acre at planting, distribute uniformly over seeded area within 48 hours after seeding. Anchor straw using hand tools, rollers, crimpers, disks or similar equipment.

Use hydro-mulch planting on steep, inaccessible sites not suitable for straw mulch planting and on other sites when rain is expected 60 days following planting.

Do not use fertilizer when using this practice for water quality purposes.

Best Management Farming Practices for Water Quality Protection

Cover Crop (327) Fact Sheet

BMP: Soil is covered with vegetation

NRCS Practice Standard: Cover Crop (340)

Planting cover crops is the most cost effective method to reduce erosion and sediment deposition from your property. Cover crops prevent sheet and rill erosion and provide many other benefits on your farm. Benefits include improved water infiltration, nitrogen fixation in the soil, and habitat for beneficial insects. Crop and air quality are protected from dust.

Cover Crops (NRCS Conservation Practice Code 340)

Definition: Grasses, legumes, forbs or other herbaceous plants established in vineyards and orchards to provide seasonal or year round ground cover for conservation purposes.

Purposes:

- Reduce soil erosion from storm runoff
- Increase soil organic matter
- Cycle excess nutrients before reaching waterways
- Increase bio-diversity
- Suppress unwanted weeds
- Manage soil moisture
- Reduce dust
- Manage crop vigor
- Provide habitat for beneficial insects
- Improve water infiltration

CONSIDER THIS:

Establish cover crops by October 15 and maintain throughout rainy season.

Drill or broadcast seed and incorporate into soil.

Choose species compatible with crop.

Avoid using species that are on local weed lists or are hosts to Pierce's Disease.

Use certified weed free straw mulch at 1500 lbs/acre where cover crops are planted late or if rain is likely before cover crop is established.

Avoid tilling early in the spring or late in the fall.

Minimize tillage practices if slopes are greater than 5%.

Use filter strips to filter sediment before it reaches a water body.

Keep on-site erosion control materials such as straw bales or wattles, gravel or geotextile fabrics. Protect stockpiles from rain. train crews in proper installation techniques.

Check site after each rainfall.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

VINEYARD COVER CROPS

Cover crops have been used in California for over seventy-five years. They are non-economic crops that are grown to improve or maintain soil fertility, improve soil structure and texture, and reduce or eliminate soil erosion.

Cover crops can be divided into 3 categories: (1) Temporary annual grasses, (2) permanent reseeding annual (die when mature) grasses and legumes, and (3) perennial (long-lived) grasses and legumes.

Temporary cover crops are short lived annual grasses intended to provide quick protection cover for one year or less, after the land is cleared and shaped. Barley and Annual ryegrass are examples of a temporary cover crop.

Permanent reseeding annual grassed and legumes are seeded between the vine rows after the vines are planted. These annuals do not need to be planted each year. If allowed to mature in the spring, seed will be available in the fall to produce a new stand. Blando brome, Zorro annual fescue, and Rose clover are examples.

Perennial grasses can be planted for specific problem areas of excessive moisture or high fertility. These year-round grasses have deep roots and produce a wear resistant sod. Berber orchardgrass, Fawn tall fescue, Luna pubescent wheatgrass, and Covar sheep fescue are examples of perennial grass cover crops.

Seeding date: The optimal time to plant is before the winter rains, usually before mid-October. After mid-October, the temperature drops and rainfall increases. Temperature and rainfall have a great effect on cover crop growth. The growth of cover crops planted late, can lag well behind those planted earlier.

Irrigated plantings: When plantings are to be irrigated, maintain adequate moisture in the upper 6 inches of soil during the first 4 weeks, and the upper 12 inches thereafter until the rainy season (during the establishment period).

Seedbed preparation: The are to be planted should be weed free and have a firm seedbed which has previously been roughened by scarifying, disking, harrowing, chiseling, or otherwise worked to a depth of 2 to 4 inches. No implement should be used that will create an excessive amount of downward movement of soil on sloping areas.

Seeding: Seed can be drilled or broadcast by hand, mechanical hand seeder, or power operated seeder. Seed should be incorporated into the soil, but not more than 1 inch deep.

Seeding recommendations depend on site conditions and personal preference. Mature growth heights are approximate and seeding rates are given in pounds per acre using a broadcast method.

TEMPORARY COVER CROPS	LBS/AC
Annual ryegrass (24 to 36")	27
Barley (16 to 30")	135

PERMANENT RESEEDING ANNUALS & LEGUMES		LBS/AC
	Blando brome (12 to 24")	18
	Zorro annual fescue (8 to 18")	12
Mixture #1	Blando brome	12
	Rose clover (6 to 10")	9
Mixture #2	Blando brome	12
	Zorro annual fescue	4
Mixture #3	Zorro annual fescue	8
	Rose clover	9
Mixture #4	Zorro annual fescue	12
	Blando brome	6
	Rose clover	6

PERENNIAL GRASSES	LBS/AC
Berber orchardgrass (12 to 24")	24
Covar sheep fescue (6 to 12")	20
Fawn tall fescue (18 to 24")	36
Luna pubescent wheatgrass (8 to 18")	36

Fertilizing is recommended to help the cover crop grow more quickly during the fall and winter months on nutrient deficient soils. Incorporate fertilizer into the soil at the time of seeding. Ammonium phosphate sulfate (16-20-0) should be applied at a rate of 300 lbs/ac. If soil acidity is a problem, Calcium Nitrate (16-0-0), may be used at a rate of 300 lbs/ac.

Management of the permanent cover crop is essential to maintain the life of the stand. Properly timed mowing and weed control are important factors to perpetuate the cover crop, reduce competition from undesirable weeds, reduce frost hazard, and permit essential cultural operations. Mow timing and frequency depend on species of cover crop, mowing height, weed growth, and the accessibility to the vineyard. Broadleaf weeds can be controlled by timed mowings, spot spraying, or spraying.

<u>Fertilizer Recommendations:</u> 16-20-0 (ammonium phosphate sulfate) @ 300 lbs/ac

Straw Mulch Recommendations: 1.5 to 2 tons/ac (crimped or tucked in).

Example of cover crop in a vineyard.

Selected Cover Crop Seed Mixes
For Napa County Vineyards*

Phillip Blake, Napa County NRCS District Conservationist

Hillside- Shallow Soils
"Erosion Control"

"Zorro" annual fescue	40%
"Blando" brome	27%
"Hykon" rose clover	23%

(seeding rate: 25lbs. per acre)

Hillside Quick Erosion Control
"Soil Builder"

Red Oats	65%
Crimson clover	13%
Austrian winter pea	22%

(seeding rate: 90 lbs. per acre)

Vineyard Terrace
"Slope Stabilizer"

'Blando" brome	45%
"Molate" red fescue	55%

(seeding rate: 25 lbs. per acre)

Hillside Soils
-Frequent Mowing-

"Zorro" annual fescue	40%
Subterranean clover	35%
"Hykon" rose clover	25%

(seeding rate: 30 lbs. per acre)

Quick Erosion Conrol
-Cold Soils-

Cereal rye	83%
Crimson clover	17%

(seeding rate: 90 lbs. per acre)

Native, No-till Blend
(Mature vineyards)

California meadow barley	36%
"Molate" red fescue	38%
California brome	26%

(seeding rate: 39 lbs. per acre)

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Napa Field Office

Native, No till Blend
"Low growing"

Idaho fescue	50%
"Molate" red fescue	50%

(seeding rate: 30 lbs. per acre)

High Altitude
"Mountain Turf"

Perennial ryegrass	35%
Creeping red fescue	35%
"Covar" sheep fescue	30%

(seeding rate: 32 lbs. per acre)

Grassed Waterways**

Meadow Barley	41%
California brome	33%
"Blando" brome	26%

(seeding rate: 39 lbs. per acre)

*** straw mulch the seedbed and irrigate to germinate plants before fall rains.*

Emergency Winter Mix
"Quick Cover"

Common barley	85%
Annual ryegrass	15%

(seeding rate: 100 lbs. per acre)

Heavy Use Areas
-Vineyard Headlands-

Bluebunch wildrye	40%
Cal.meadow barley	27%
California brome	33%

(seeding rate: 45 lbs. per acre)

"Showboat"

Crimson clover	44%
"Hykon rose clover	44%
Wildflower blend-	12%
Yarrow	
Calif. Poppy	
Paper poppy	
Tidy tips	

(seeding rate: 27 lbs. per acre)

- Seed selection and use of fertilizers will vary depending on site conditions, including soil type.
- Seeding rates are based on the broadcast seeding method. If seed is drilled, rates may be lower.
- Check pure-live seed, (PLS) % on seed bag tags- rates listed above are based on 100% PLS.
- Seed variety selection may vary with site conditions. Check with NRCS or your agronomy consultant for site specific recommendations.
- Seed mixes listed, except "quick erosion" and "Emergency Winter Ground Cover" are for no-till management programs.

United States Department of Agriculture
NRCS Natural Resources Conservation Service
Napa Field Office

Best Management Farming Practices for Water Quality Protection
Mulching (484) Fact Sheet

BMP: Bare soil is covered with vegetation, reduction of erosion from non-cropped areas, protect newly planted areas.

NRCS Practice Standard: Mulching (484)

Applying plant residues or other suitable materials produced off site to the land surface. Mulching is used on bare, exposed soil surfaces that are deemed to be potential critical erosion areas. In most cases, mulch will consist of grain straw residue, but may include wood chips, leaves, composted yard waste, etc.

Mulching (NRCS Conservation Practice Code 484)

Definition: Applying plant residues or other suitable materials produced off site to the land surface.

Purposes:

- Conserve soil moisture
- Moderate soil temperature
- Provide erosion control
- Suppress weed growth
- Facilitate the establishment of vegetative cover
- Improve soil condition
- Reduce airborne particulates

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

CONSIDER THIS:

Straw mulches will generally be applied at a rate of at least 2,000 lbs per acre (approximately one straw bale per 20 ft x 40 ft plot)

Anchor straw using hand tools, rollers, crimpers, disks or similar equipment (see page 2 of this document).

Use certified weed-free straw.

Key areas for mulch application will be field perimeters, vineyard avenues, and steep slopes requiring quick erosion control cover.

Mulches, including wood fiber materials and manufactured erosion control blankets may also be used.

Where feasible, use late summer irrigation to help bind mulch and establish vegetative cover before fall rains commence.

Straw bales, straw wattles, and other similar materials may also be installed in critical locations to provide sediment retention and storm runoff control.

Maintain mulched surfaces throughout the rainy season.

Stockpile and tarp erosion control materials such as straw bales or wattles, gravel or geotextile fabrics in locations with wet-weather access. Train crews in proper installation techniques.

Check site after each rainfall.

Best Management Farming Practices for Water Quality Protection
Mulching (484) Fact Sheet

Methods for Anchoring Straw Mulch – *From NRCS Fact Sheet 55*

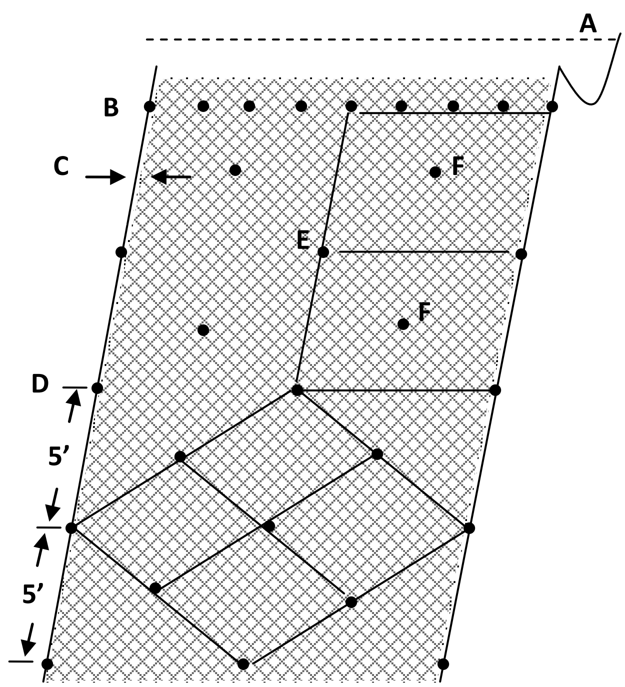
Hand Punching: A spade or shovel is used to punch straw into the slope until all areas have straw standing perpendicularly to the slope and embedded at least 4 inches into the slope. It should be punched about 12 inches apart.

Roller Punching: A roller equipped with straight studs not less than 6 inches long, from 4 - 6 inches wide and approximately one inch thick is rolled over the slope.

Crimper Punching: Like roller punching, the crimper has serrated disk blades about 4 - 8 inches apart which force straw mulch into the soil.

Crimping should be done in two directions with the final pass across the slope.

Matting: Matting is used on large, steep areas which cannot be punched with a roller or by hand. Jute, wood excelsior or plastic netting is applied over unpunched straw

Matting Instructions	***Matting Diagram***
A. Lay jute netting or similar material in strips down the slope over straw. Bury upper end in 6-8 inch deep and wide trench. Most netting comes in 14 to 17 ft wide rolls. B. Secure upper end with stakes every 2 ft. C. Overlap seams on each side by 4-5 inches. D. Secure seams with stakes every 5 ft. E. Stake down the center every 5 ft. F. Stake middles to create diamond pattern that provides stakes spaced 4-5 ft apart. G. Use pointed 1x2 inch stakes 8-9 inches long. Leave 1-2 inch top above netting, or use U-shaped metal pins at least 9 inches long. NOTE: when joining two strips, overlap upper strip 3 ft. over lower strip.	

Best Management Farming Practices for Water Quality Protection
Straw Mulching (Fact Sheet-55)

BMP: Bare soil is covered with vegetation, reduction of erosion from non-cropped areas, protect newly planted areas.

Straw Mulching – NRCS Fact Sheet (55)

Straw mulching can be used on bare or seeded slopes to reduce potential for erosion. To prevent being blown or washed away, straw requires anchoring by matting, crimping or other methods. The mulch should cover the entire seeded or bare area. The mulch should extend into existing vegetation or be stabilized on all sides to prevent wind or water damage which may start at the edges.

Straw Mulching (Fact Sheet-55)

Definition: The application of straw as a protective cover over seeded areas to reduce erosion and aid in revegetation or over bare soils that will be landscaped later to reduce erosion.

Purposes:

- To budget, supply, and conserve nutrients for plant production.
- To minimize agricultural nonpoint source pollution of surface and groundwater resources.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen), and the formation of atmospheric particulates.
- To maintain or improve the physical, chemical, and biological condition of soil.

Consider this:

Use no-till/strip-till with cover crops to sequester nutrients, increase soil organic matter, increase aggregate stability, reduce compaction, improve infiltration, and enhance soil biological activity to improve nutrient use efficiency.

Develop site-specific yield maps to diagnose low- and high- yield areas, or zones, and make the necessary management changes.

Use soil tests, plant tissue analyses, and field observations to check for secondary plant nutrient deficiencies or toxicity that may impact plant growth or nutrient availability.

Use conservation practices that slow runoff, reduce erosion, and increase infiltration, e.g., filter strip, contour farming, or contour buffer strips.

Use application methods and timing strategies that reduce the risk of nutrient transport by ground and surface waters.

Use high-efficiency irrigation technologies (e.g., reduced-pressure drop nozzles for center pivots) to reduce the potential for nutrient losses.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.asp

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Best Management Farming Practices for Water Quality Protection
Critical Area Planting (342) Fact Sheet

BMP: Bare soil is covered with vegetation, ditches and banks are protected from concentrated flow, gullies and ditches are stabilized, and erosion is reduced on non-cropped areas. Crop and air quality protected from dust.

NRCS Practice Standard: Critical Area Planting (342)

Use on areas with existing or expected high rates of erosion or degraded sites that usually cannot be stabilized by ordinary conservation treatment and/or management. If left untreated, these areas could be severely damaged by erosion or sedimentation, or could cause significant off-site damage.

Critical Area Planting (NRCS Conservation Practice Code 342)

Definition: Planting vegetation on critically eroding areas that require extraordinary treatment.

Purposes:

- Stabilize areas with existing or expected high rates of soil erosion by water or wind
- Restore degraded sites that cannot be stabilized through normal methods

CONSIDER THIS:

This practice may be used on cuts, fills and disturbed areas, and waterline stabilization for small streams and ponds.

Select species for planting that are suited to current site conditions and intended uses.

Select species that will have the capacity to achieve adequate density and vigor within an appropriate time frame to stabilize the site sufficiently.

When applying straw mulch apply at 1500 lbs/acre at planting, distribute uniformly over seeded area within 48 hours after seeding. Anchor straw using hand tools, rollers, crimpers, disks or similar equipment.

Use certified weed-free straw.

Straw may be anchored by jute, erosion control blankets, plastic or excelsior matting.

Use hydro-mulch planting on steep, inaccessible sites not suitable for straw mulch planting and on other sites when rain is expected 60 days following planting.

Do not use fertilizer when using this practice for water quality purposes.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

Best Management Farming Practices for Water Quality Protection
Critical Area Planting (342) Fact Sheet

Four Common Approaches to Critical Area Planting

Container Planting

Instructions

- Choose plants and planting plan with a professional and according to needs of site.
- When ready to plant, cultivate planting area and remove weeds and stones.
- Dig holes – create holes with vertical, lightly scarified sides. Loosen soill at bottom to depth of 6”
- Partially backfill planting hole with planting mixture consisting of at least 50 percent native soil. Up to 25% sand and manure can be used to amend soil.
- Remove plants from the containers taking care to not disturb the root ball.Set plants in center of pits and adjust so that after settling, the crown of the plant will stand 1-2” above grade.

- Backfill hole with planting mixture. Firmly press down soil to eliminating air pockets, but do not pack. Build a 4” high berm around edge of root ball to form a basin. The bottom of the basin shall be at surrounding finish grade.
- Fill basin with water immediately after planting, take care not to disturb soil or expose plant roots.
- Apply a 2” layer of mulch around each plant. And support 5-gallon and 15-gallon trees by 3 stakes.
- Planting shall not create downward movement of soil on sloping areas.
- For the first 2 growing seasons, plants should be properly irrigated and protected from weeds, pests, and pest free and shall be protected against animal grazing and other hazards.

Best Management Farming Practices for Water Quality Protection
Critical Area Planting (342) Fact Sheet

Four Common Approaches to Critical Area Planting

Seeding and Straw Mulch

Instructions:

- Roughen seedbed by scarifying, disking, harrowing, or chiseling to a depth of 2- 4 inches. On steep slopes, horizontal indentations left by tracked equipment are acceptable seed beds.
- Drill or broadcast seed (consult with professional for appropriate seed mix) and incorporate into soil up to 1 inch deep.
- Uniformly cover seeded area with new, pesticide-free straw (2 tons per acre) within 48 hours after seeding. If straw is applied by blower, it shall not be chopped in lengths less than 6 inches.
- Anchor the mulch in place by one of the following methods:
  - Use hand tools, mulching rollers, straight serrated disks to tuck straw in at a minimum of 3 " spacing, not to exceed 1' in both directions.
  - Use jute matting (minimum 1 lb/ 10 in^2 and a maximum opening o f 1" x 1") -- apply matting over mulched area and beyond by at least 1'. If vegetation or structures mark the boundaries, continue the matting into the stable vegetation or structure. Cut matting around objects so it lays flat on the surface. Bury upper end of matting in a trench at least 6 in deep. Overlap sides of rolls by at least 4 in, place uphill roll length over downhill roll length, with overlap of at least 3 ft. Install U-shaped staples perpendicular to the slope and space them ~ 5 ft apart down the sides in the overlap area and center of the roll. Install staples at most 1 ft apart across upper end of each roll and across the overlap area where an uphill and downhill roll meet.

Best Management Farming Practices for Water Quality Protection
Critical Area Planting (342) Fact Sheet

Four Common Approaches to Critical Area Planting

Hydro-seeding and Tackified Straw

Instructions:

- Roughen seedbed by scarifying, disking, harrowing, or chiseling to a depth of 2- 4 inches. On steep slopes, horizontal indentations left by tracked equipment are acceptable seed beds.
- Create wood mulch-water slurry in which to place seeds (consult with professional to determine appropriate mix). Use wood cellulose fiber that does not contain growth inhibiting factors. Material should have the property to be evenly dispersed and suspended when agitated in water. Material should be dyed with a nontoxic water-soluble green dye. The wood fiber mulch may be derived from recycled wood chips or a combination of recycled newsprint, cardboard, and wood fiber (with at most 50 percent newsprint).
- Continuously mix the slurry and mix for at least five minutes prior to first application. Seed should not remain in slurry longer than 30 minutes; wood fiber should not remain in slurry longer than 2 hours. Apply slurry with hydroseeder such that wood fiber is applied at the rate of 500 pounds per acre. Apply slurry at a continuous and uniform rate that is non-erosive.
- Uniformly cover hydro-seeded area with new, pest-free straw (2 tons per acre) within 48 hours after seeding. If straw is applied by blower, it shall not be chopped in lengths less than 6 inches.
- Anchor the mulch in place by one of the following methods:
    - Hand tools, mulching rollers, straight serrated disks -- the straw shall be tucked in a minimum of 3 in on a spacing not to exceed one foot in both directions.
    - Uniformly cover straw with hydro-mulch within 48 hours following straw applicaiton. Unless otherwise specified on the Practice Requirements sheet, the hydo-mulch shall be wood fiber mulch, a tackifier, and water in the following portions per acre:

Tackifier	Rate	Wood Fiber Mulch	Water
M-Binder	100 lbs	150 lbs	700 gal
Ecotak-SAT	100 lbs	150 lbs	700 gal
Sentinel	100 lbs	500 lbs	2,000 gal
Fish-STIK	60 lb	500 lbs	3,000 gal
Soil Master WR	100 lbs	250 lbs	1,000 gal

Four Common Approaches to Critical Area Planting

Hydro-seeding and Erosion Control Blankets

Instructions

- Roughen seedbed by scarifying, disking, harrowing, or chiseling to a depth of 2- 4 inches. On steep slopes, horizontal indentations left by tracked equipment are acceptable seed beds.
- Create wood mulch-water slurry in which to place seeds (consult with professional to determine appropriate mix). Use wood cellulose fiber that does not contain growth inhibiting factors. Material should have the property to be evenly dispersed and suspended when agitated in water. Material should be dyed with a nontoxic water-soluble green dye. The wood fiber mulch may be derived from recycled wood chips or a combination of recycled newsprint, cardboard, and wood fiber (with at most 50 percent newsprint).
- Continuously mix the slurry and mix for at least five minutes prior to first application. Seed should not remain in slurry longer than 30 minutes; wood fiber should not remain in slurry longer than 2 hours. Apply slurry with hydroseeder such that wood fiber is applied at the rate of 500 pounds per acre. Apply slurry at a continuous and uniform rate that is non-erosive.
- Distribute erosion control blankets uniformly over the surface of the seeded area within 48 hours of seeding. Start blankets on the backside 3' below the crest of the treated slope and install vertically down the treated slope. Apply so that the netting is on top and the fibers are in contact with the soil. Overlap adjoining blanket edges by at least 4".
- Drive staples vertically into ground with reference to the slope. Apply 4 staples across the start and end of each roll 4" from the starting edge at the slope crest and 2" from the end edge.
- Space staples at 6' intervals down both sides of each roll, 2" from blanket edge. Add staples down the center of each roll at 6' intervals, alternate spacing with side staples.

Best Management Farming Practices for Water Quality Protection

Filter Strip (393) Fact Sheet

BMP: Vegetation is established to filter sediment

NRCS Practice Standard: Filter Strip (393)

Use filter strips to filter suspended sediment before it reaches a water body. Planting a filter strip is an effective method to prevent sediment from leaving your property and preventing sediment delivery into sensitive areas such as streams and other water bodies. A filter strip will also prevent transport and delivery of nutrients, pesticides and adsorbed contaminants into water bodies. A filter strip should be installed only below areas where sheet and rill erosion have been reduced to an acceptable level and where other practices are in place that slow runoff and contaminant delivery.

Filter Strip (NRCS Conservation Practice Code 393)

Definition: An area of vegetation established for the purpose of removing sediment, organic materials, and other pollutants from runoff.

Purposes:

- To reduce sediment, particulate organics, and sediment adsorbed contaminant loadings in runoff
- To reduce dissolved contaminant loadings in runoff
- To serve as Zone 3 of a Riparian Forest Buffer, Practice Standard 391
- To restore, create or enhance herbaceous habitat for wildlife and beneficial insects
- To maintain or enhance watershed function and value

CONSIDER THIS:

Filter strips are typically positioned down-slope of a field or disturbed area and, to the extent possible, placed on the approximate contour.

Plant grass and legume seed uniformly over area.

Mulch newly seeded filter strips at 1500 lbs of straw/acre.

Use certified weed-free straw.

Consider sowing small grains or other annual grasses as a companion (nurse) crop until establishment.

After establishment, maintain dense vegetation, reseeding when necessary.

Mow filter strips as necessary to encourage dense vegetative growth.

Control undesirable weed species, mow after rainy season.

Inspect and repair after storm events, reseed disturbed areas.

Restore or replant the filter strip if it accumulates so much sediment that it no longer functions effectively.

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Vegetative Filter Strips for Nonpoint Source Pollution Control in Agriculture

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VEGETATIVE FILTER STRIPS: WHAT ARE THEY?

Orchards, vineyards, and row crops have the greatest erosion rates in irrigated agriculture, especially those that are managed with bare soil between tree or vine rows. The vegetative filter strip (VFS) offers one way to control erosion rates and keep soil in the field rather than letting it be carried off site in drainage water. A VFS is an area of vegetation that is planted intentionally to help remove sediment and other pollutants from runoff water (Dillaha et al., 1989).

Vegetative filter strips protect surface water bodies in a number of ways:

- They intercept surface water runoff and trap as much as 75 to 100 percent of the water's sediment.
- They capture nutrients in runoff, both through plant uptake and through adsorption to soil particles.
- They promote degradation and transformation of pollutants into less-toxic forms.
- They remove over 60 percent of certain pathogens from the runoff.

KEY DESIGN ELEMENTS FOR VEGETATIVE FILTER STRIPS

The United States Environmental Protection Agency (EPA) encourages growers to use engineered vegetative treatment systems such as VFSs at sites where these systems are likely to bring about a significant reduction in nonpoint source (NPS) pollution (US EPA, 2002). You can establish VFSs downslope from crop fields or animal production sites to control NPS pollutants that would otherwise escape with runoff. In orchards, you can use multiple VFSs installed perpendicular to the direction of surface water runoff to reduce soil erosion and even avoid expenses associated with herbicide application. The strips also have the potential to reduce the level of some pesticides in runoff by enhancing water infiltration and retention in the field. For example, contaminants such as phosphorus and certain pesticides such as pyrethroids that bind strongly to soil particles get trapped and retained in VFSs.

Key elements to consider when designing VFSs are discussed at the US EPA's Web site (http://www.epa.gov/OWOW/NPS/MMGI/Chapter7/index.html) under section II.C., "Management Measure for Vegetated Treatment Systems." These elements include

- Slope. Vegetative filter strips work best on slopes of less than 5 percent and are not recommended for slopes greater than 15 percent. They are ineffective on hilly plots or in terrain that allows concentrated water flow. If you see evidence of concentrated flow in the form of channels or rills you should use other erosion control strategies instead, such as establishing terraces, dykes, berms, or vegetative barriers.

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- Site preparation. The land where filter strips are to be planted should be roughened by disking and harrowing or by raking to prepare a good seedbed. After that you can seed the strips with a mixture of grasses and legumes to establish a stand.
- Soil conditioning. Before planting, apply any soil amendments that would ordinarily be used for crops grown on your land including fertilizer, lime, compost, or gypsum.
- Width. Strip width is an important variable influencing the effectiveness of VFSs because the period of contact between runoff water and vegetation in the filter strip increases as the strip's width increases (Tables 1 and 2). Generally speaking, the wider the filter strip, the better it will perform. One effective approach in sloping terrain is to plant grasses in bands about 6 feet (1.8 m) wide along hillside contours every 10 to 100 feet (3–30 m), depending on slope. The bands run crosswise on the hillside, perpendicular to the line of the slope. A single, dense VFS about 30 feet (9 m) wide is appropriate when you are protecting riparian areas, especially when an in-field system of strips is not possible. On flat terrain, 10- to 15-foot (3–4.5 m) wide filter strips at field boundaries and along irrigation ditches and roads are effective (Figure 1). One suggested design criterion is that the combined width of VFSs for a field should be at least as great as the width of the runoff-contributing area, though this may in fact be an impractical standard.
- Vegetation. Sturdy, tall perennial grasses do the best job of trapping sediment. Generally, hardy perennial native grass species that are capable of withstanding summer drought conditions are preferred, though it is important to consider local conditions and cultural practices. Short, flexible grasses are much less effective. Legumes are less effective than grasses at trapping sediment, but they work well when mixed with grasses because they boost nitrogen levels in the soil. Filter strips can also include other vegetation planted parallel to the grass strips, such as poplar, walnut, or shrubs. Note that soils that are subject to prolonged saturated conditions may require special wetland plant species. The USDA–NRCS "VegSpec" Web site (http://ironwood.itc.nrcs.usda.gov/Netdynamics/Vegspec/pages/HomeVegspec.htm) is an excellent Web-based support system that can help you select appropriate plant species for filter strips and other vegetative establishment practices.

Table 1. Minimum width for vegetative filter strips

Slope	Minimum width of buffer strip
1–3%	25 ft
4–7%	35 ft
8–10%	50 ft

Source: Standards and Specifications No. 393, USDA–NRCS Field Office Technical Guide, 2004.

Table 2. Examples of pollutant removal efficiency for vegetative filter strips

Filter type	Nutrient source	Plot length	Pollutant	Removal efficiency %	Reference
Bermudagrass buffer strip	cropland runoff	16 ft (4.8 m)	chlorpyrifos dicamba 2,4-D mecroprop	62–99 90–100 89–98 89–95	Cole et al., 1997
Bermudagrass-crabgrass mixture	cropland runoff	14–17 ft (4.3–5.3 m)	P (total) N (total)	26 50	Parsons et al., 1991
Bluegrass and fescue sod (9% slope)	cropland runoff	15 ft (4.6 m) 30 ft (9.1 m) 45 ft (13.7 m)	NH_4-N atrazine NH_4-N atrazine NH_4-N atrazine	92 93 100 100 97 98	Barfield et al., 1992
Corn-oat or orchardgrass mixture (4% slope)	feedlot	45 ft (13.7 m)	P (total) N (total)	88 87	Young et al., 1980
Fescue (10% slope)	dairy waste on silt loam soil	5 ft (1.5 m) 13 ft (4.0 m)	P dissolved NO_3 P dissolved NO_3	8 57 62 68	Doyle et al., 1977
Orchardgrass (5–16% slope)	simulated feedlot	15 ft (4.6 m) 30 ft (9.1 m)	P (total) N (total) P (total) N (total)	39 43 52 52	Dillaha et al., 1988
Orchardgrass (5–16% slope)	cropland runoff	15 ft (4.6 m) 30 ft (9.1 m)	P (total) N (total) P (total) N (total)	75 61 87 61	Dillaha et al., 1989
Ryegrass	cropland runoff	20, 40, & 60 ft (6, 12, & 18 m)	suspended solids atrazine isoproturon diflufenican NO_3 P (soluble)	87–100 44–100 99 97 47–100 22–89	Patty et al., 1997
Sorghum-Sudan-grass mix (4% slope)	feedlot	45 ft (13.7 m)	P (total) N (total)	81 84	Young et al., 1980
Vegetated drainage ditch	simulated runoff	13 ft (4 m)	atrazine pyrethroid	98 100	Moore et al., 2001

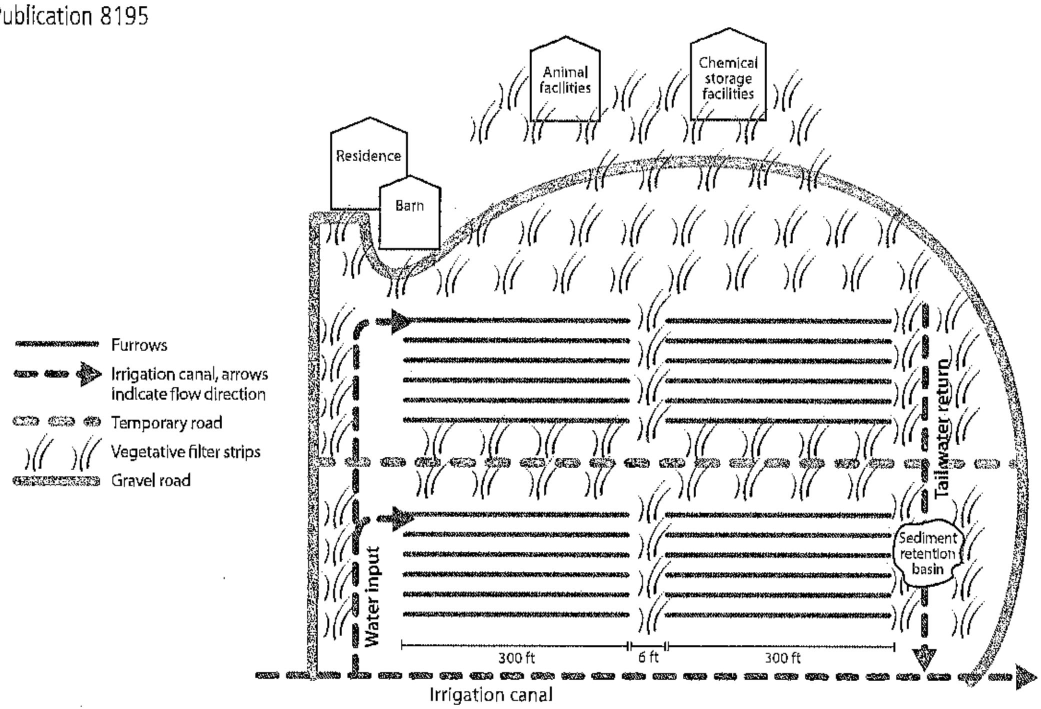

Figure 1. Farm plan indicating potential locations for vegetative filter strips.

- **Placement.** It is best to place the filter strips strategically so as to maximize the efficiency of contaminant removal. As a land manager, you have to identify where water flows on the property in order to identify the locations where VFSs will have the best chance of intercepting runoff. For instance, filter strips along stream banks are helpful since these areas can be subject to concentrated surface runoff from the surrounding landscape, but if you move the filter strips further up-slope within fields or orchards they can do their work before concentrated runoff occurs and that will yield better results. In irrigated row crop systems, wide filter strips along field boundaries would be most practical. A sample layout for VFS placement is illustrated in Figure 1. There are several critical placement areas: along roads, ditches, and animal confinement facilities, interspaced with the crop within the field, and at the field boundaries. Vegetated irrigation ditches can also be an effective strategy to trap pollutants.
- **Maintenance.** Vegetative filter strips require minimal maintenance, but you should consider the following operations:
  - Inspect the strips regularly for bare spots and other signs of erosion, especially after intense rain or runoff events.
  - Shallow, sheetlike flow of water must be maintained. If you find any evidence of channels and rills, repair it and reseed those areas.
  - Remove excess sediment buildup to keep water from diverting to a new, easier drainage route. If sediment accumulation is high (more than 6 inches deep), you will need to cultivate and reseed the affected areas.
  - Irrigate occasionally in summer if the vegetation that you plant requires it.
  - Mow the strips occasionally to a height of 4 to 10 inches to deter noxious weeds.
  - If pathogens such as bacteria are present in runoff water, mow the strips short to introduce sunlight and air that will desiccate the bacteria.
  - Noxious weeds must be controlled in and around the filter strips. You

may have to apply spot treatments of herbicide to control perennial noxious weeds.
  - Limit traffic within filter strips.
  - Occasionally harvest the filter strip vegetation and remove the cut biomass to prevent nutrient buildup.
- Monitoring. Some thought and effort should be given to monitoring the performance of the filter strips after installation. That way it will be possible for you to gauge your success and make later adaptations (such as redesign or replanting) to ensure regulatory compliance.

OBSERVED NONPOINT SOURCE POLLUTION CONTROL USING VEGETATIVE FILTER STRIPS

The effectiveness of VFSs for control of several NPS pollutants from cropland and feedlot runoff has been the subject of study, as has their effectiveness on sediment removal from surface mining and urban runoff (see Table 2). Based on empirical studies, trapping or removal efficiency frequently exceeded 90 percent of sediments, 50 to 80 percent of nutrients, and 44 to 100 percent of the herbicide atrazine. The ability of VFSs to trap pesticides varies depending on the nature of the compound and the design and maintenance of the filter strip. Vegetative filter strips are better at removing pesticides such as pyrethroids that bind to soil particles.

POLLUTANT-FILTERING MECHANISMS OF VEGETATIVE FILTER STRIPS

A vegetative filter strip functionally consists of three distinct layers—surface vegetation, root zone, and subsoil horizon—and as a result, the flow of water and pollutants through the filter strip can be a complex process. Once surface flow enters a VFS, infiltration is followed by saturation of the shallow subsurface. When the inflow rate exceeds the strip's infiltration capacity, overland flow occurs. In the root zone, some water infiltrates deeper into the subsoil while the remainder becomes lateral subsurface flow or *interflow* (Figure 2).

Runoff is less from hill slopes that have VFSs than from those that have none, a result of increased infiltration rates in the vegetated area. The vegetative strip's root zone allows high infiltration rates via macropores that arise with the generally

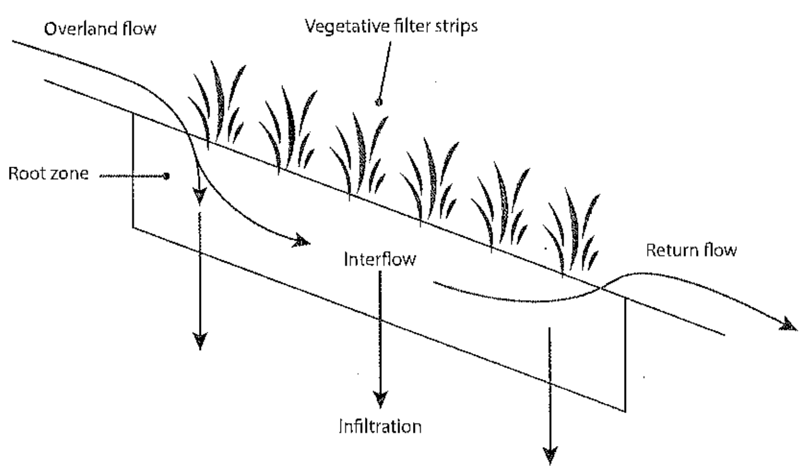

Figure 2. Cross-section of the patterns of water flow through hillside vegetative filter strips.

improved soil structure created by plant roots and other biological activities. The most important pollutant-trapping mechanism of VFSs is infiltration, followed by storage in the surface layer.

The soil constituent with the greatest influence on pesticide transport or pollutant retention and degradation is organic matter in the root zone and overlying surface litter layer. Greater biological activity in a soil improves its ability to effectively deal with pesticides and pollutants, and that kind of activity is more prevalent in a soil rich in plant roots, soil micro- and macro-fauna, and bacteria than in a soil without those organisms. Soil microorganisms play an essential role in the degradation of contaminants and soil organic matter is chemically reactive with the contaminants. For these reasons, you can expect degradation and adsorption of herbicides and pesticides to be greater in the filter strip's root zone than in adjacent fallow soils.

Vegetative filter strips on sloping land are subject to horizontal interflow within the root zone, in which case some pesticides may be filtered out, adsorbing onto soil organic matter. When the interflow water reappears on the surface as return flow it may have a lower pesticide concentration than the water that has flowed above ground. When infiltration is high in a VFS, the microbial- and plant-uptake processes cause denitrification, degradation of chemicals, and reduction of chemical concentrations in the surface layer between runoff events.

The effectiveness of VFSs depends on field conditions such as soil type, rainfall intensity, slope, micro-topography (surface soil roughness), the infiltration capacity of the vegetated area, the width of the strip, and the height of its plants. Slope and micro-topography affect overland flow velocity and uniformity and also appear to have an effect on the ability of VFSs to retain sediment and pollutants in runoff. Of course, the steeper the slope, the greater the sediment yield, all other factors being equal. Infiltration capacity and interflow within the VFSs influence the fate and path of dissolved nutrients and chemicals. The width of VFSs determines the strips' sediment-removing capacity and the amount of time the pollutant can be expected to remain in soil layers where adsorption and degradation processes are active.

You can find additional information at USDA–NRCS's "Buffer Strips Common Sense Conservation" Web site (http://www.nrcs.usda.gov/feature/buffers/). For more information on vegetative filter strips and incentive programs for land managers, contact your local UC Cooperative Extension office, Natural Resources Conservation Service office, Resource Conservation District, or Farm Service Agency office.

GLOSSARY

Absorption: the uptake of matter by a substance (such as a sponge) or living tissue (such as a plant).

Adsorption: a process whereby contaminants in water are drawn to and retained on the surfaces of soil solids by a chemical or physical binding mechanism.

Decomposition: a process whereby complex chemical compounds such as pesticides or organic materials are transformed into simpler compounds such as carbon dioxide gas.

Denitrification: the anaerobic conversion of nitrate-nitrogen into nitrogen gas by microbes.

Deposition: the retention of a transported material (such as waterborne chemicals) in a new, stationary position.

Infiltration: the entry of water into soil.

Interflow: water that moves through a filter strip as subsurface flow.

Volatilization: the transformation of a compound from liquid phase to gas phase.

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FOR MORE INFORMATION

You'll find related information in these titles and in other publications, slide sets, CD-ROMs, and videos from UC ANR:

The Farm Water Quality Plan, Publication 9002

Practices for Reducing Nonpoint Source Pollution from Irrigated Agriculture, Publication 8075

Developing a Nonpoint Source Pollution Evaluation Program, Publication 8087

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Best Management Farming Practices for Water Quality Protection

Diversion (362) Fact Sheet

BMP: Structures to divert sediment to settling areas are installed and maintained.

NRCS Practice Standard: Diversion (362)

Constructed erosion control diversions will collect runoff from vineyard facilities and discharge runoff to a safe and stable outlet.

Diversions (NRCS Conservation Practice Code 362)

Definition: A channel generally constructed across the slope with a supporting ridge on the lower side

Purposes:

- Break up concentrations of water on long slopes
- Collect or direct water
- Intercept surface flow
- Control erosion and protect water quality
- Minimize potential entry of sediment to surface waters
- Spread storm water runoff to multiple low-discharge locations
- Provide temporary or long-term erosion protection on newly-developed or redeveloped farmland

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

CONSIDER THIS:

Diversions that protect agricultural land shall have a minimum capacity for the peak discharge from a 10-year frequency, 24-hour duration storm.

The outlet conditions, topography, land use, cultural operations and soil type shall determine the location of the diversion.

A combination of practices may be needed to prevent damaging accumulations of sediment in the diversion channel.

Each diversion must have a safe and stable outlet with adequate capacity. The outlet could be a grassed waterway, a lined waterway, a vegetated or paved area, a grade stabilization structure, an underground outlet, a stable watercourse, a sediment basin, rock energy dissipator, level spreader or a combination of these practices.

The outlet must convey runoff to a point where outflow will not cause damage.

Seek assistance from a licensed engineer or other qualified professional.

Best Management Farming Practices for Water Quality Protection

Underground Outlet (620) Fact Sheet

BMP: Divert water to a stable outlet.

NRCS Practice Standard: Underground Outlet 620

Runoff waters will be collected from avenues, swales and constructed erosion control diversions to be piped to appropriate protected discharge locations or water spreading devices.

Underground Outlet (NRCS Conservation Practice Code 620)

Definition: A conduit or system of conduits installed beneath the surface of the ground to convey surface water to a suitable outlet.

Purposes:

- To prevent damage from erosion or flooding by conveying to protected discharge points concentrated runoff from diversions, terraces, detention or sediment basins, waterways, surface drains or other similar structures
- To collect excess surface runoff before it can concentrate and produce gullies
- To minimize potential entry of sediment and attached nutrients to surface waters
- To protect vineyard avenues, swales and other terrain where runoff may begin to concentrate
- To spread discharged waters to the maximum extent possible

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

CONSIDER THIS:

Minimize installation of conduits that may deliver high volumes of runoff to single-discharge locations.

Design underground outlets with adequate capacity to handle design storm peak flows.

Design runoff control structures to spread discharge to multiple locations in smaller increments to the extent feasible. Convey discharges to protected outlets.

Provide inlets with appropriate trash guards to ensure that trash or other debris entering the inlet passes through the conduit without plugging.

Design and locate basins following the guidelines of Napa County Conservation Regulations, as specified by NRCS and Napa County RCD.

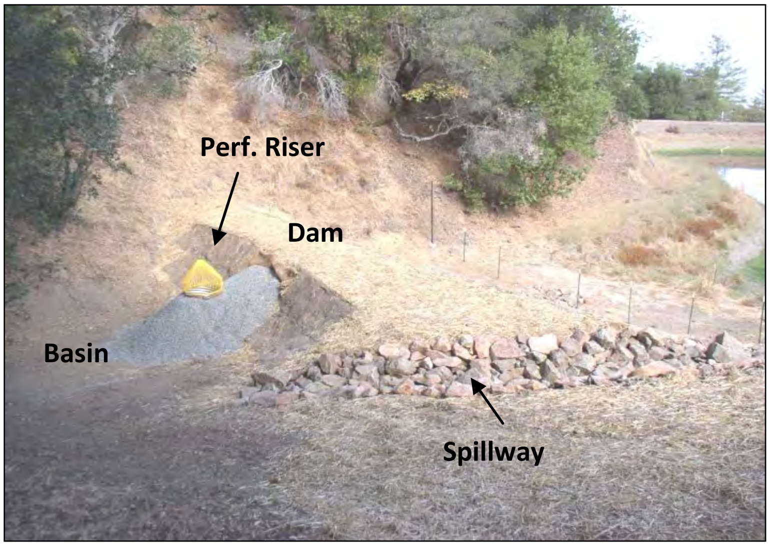
Seek assistance from a licensed engineer or other qualified professional.

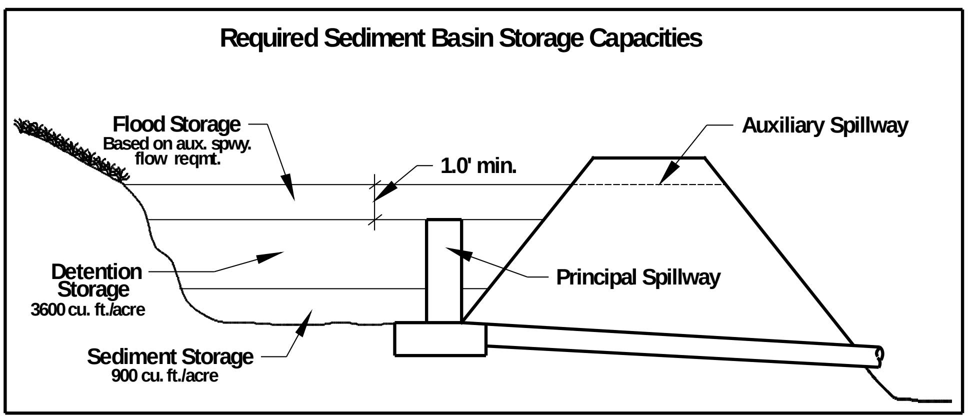
Best Management Farming Practices for Water Quality Protection

Sediment Basin (350) Fact Sheet

BMP: Structures to collect sediment appropriately sized, installed and maintained.

NRCS Practice Standard: Sediment Basin (350)





Sediment Basin (NRCS Conservation Practice Code 350)

A basin constructed with an engineered outlet, formed by an embankment or excavation or a combination of the two.

Purposes:

- Capture and detain sediment laden runoff, or other debris for a sufficient length of time to allow it to settle out in the basin
- Protect water quality

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

Consider this:

Sediment basin design and construction must comply with all applicable federal, state and local laws and regulations.

For maximum sediment retention, design basin so that detention storage remains full of water between storm events. To maximize peak flow attenuation, basin should de-water between storms.

Choose location so that it intercepts as much runoff as possible from disturbed area of watershed.

Choose location that minimizes the number of entry points for runoff into basin and interference with farming activities. Do not locate sediment basins in perennial streams.

Establish vegetation on embankment and side slopes of basin following construction.

Contact a licensed engineer or other qualified professional for design and construction assistance.

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FACT SHEET

United States
Department of
Agriculture

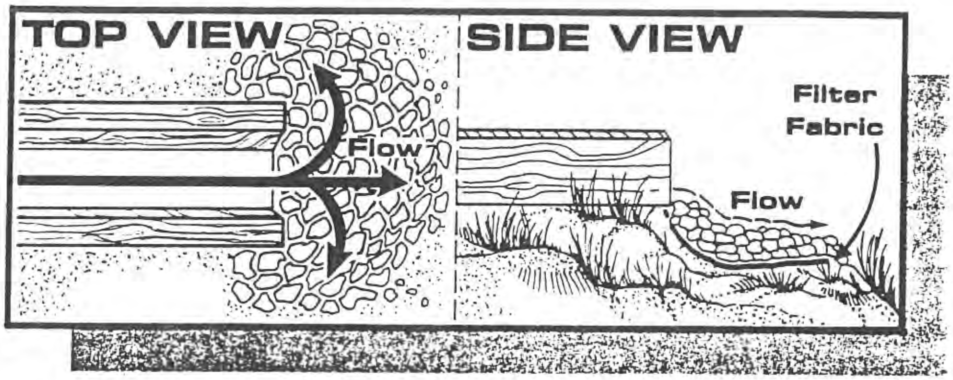
ENERGY DISSIPATERS
FOR EROSION CONTROL

Soil
Conservation
Service

An energy dissipater is a structure at the outlet of a culvert or drain which reduces the velocity of water after it leaves the drain (see illustrations below). This is very important for protecting the slope below the outlet from erosion. An energy dissipater should be a part of most drainage outlets.

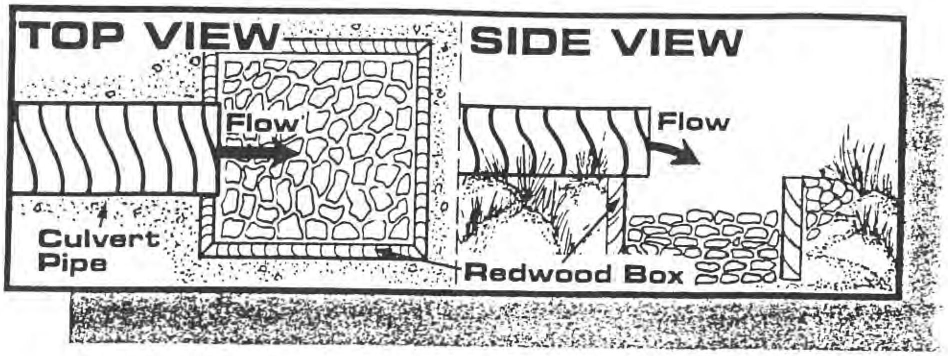
Rock "rip-rap" is usually the most effective energy dissipater for drainage outlets. Rock should be heavy and large enough (six inch minimum diameter) to stay in place. Rock should be carefully laid by hand, forming an evenly-lined depression or basin that will slow down the flow of the water. There should not be spaces between the rocks. If rocks are haphazardly piled below the drain outlet, they could cause greater erosion damage or undercutting of the culvert or drain. A piece of filter fabric placed between the ground and the rock will increase the stability of an energy dissipater.

ENERGY DISSIPATER (PLACED ROCK RIP-RAP)



If the rock is not heavy enough, water flow can dislodge it and decrease the effectiveness of the energy dissipater. If necessary, cement grouting, a redwood box, or a section of large culvert pipe can be used to hold rock in place.

ENERGY DISSIPATER (ROCK FILLED CONTAINER)



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Best Management Farming Practices for Water Quality Protection
Grade Stabilization (410) Fact Sheet

BMP: Stabilize grade and control erosion in natural and artificial channels. Prevent the formation or advancement of gullies. Maintain and improve habitat for fish and wildlife.

NRCS Practice Standard: Grade Stabilization (410)

This standard applies to all types of grade stabilization structures, including a combination of earth embankments and mechanical spillways and full-flow or detention-type structures. This standard also applies to channel side-inlet structures installed to lower the water from a field elevation, a surface drain, or a waterway to a deeper outlet channel. It does not apply to structures designed to control the rate of flow or to regulate the water level in channels.

Grade Stabilization (NRCS Conservation Practice Code 410)

Definition: A structure used to control the grade and head cutting in natural or artificial channels.

Purposes:

- Stabilize grade in channels where the concentration and flow velocity of water are resulting in head-cutting and bank erosion
- Prevent or control gully erosion

CONSIDER THIS:

Grade stabilization structures may affect volumes and rates of runoff, evaporation, deep percolation and ground water recharge.

Grade stabilization structures may affect soil water, plant growth and transpiration.

Structures may trap sediment and sediment attached substances carried by runoff.

Structures may influence the susceptibility of downstream stream banks and stream beds to erosion.

Structures may affect movement of dissolved substances to ground water.

Structure may affect the visual quality of water resources.

Structure may impact federal or state listed Rare, Threatened or Endangered species or their habitat.

Structures must be designed for stability after installation. The crest of the inlet must be set at an elevation that stabilized upstream head cutting.

For more information contact your local NRCS office or visit our website at http://efotg.sc.egov.usda.gov/treemenuFS.aspx

Best Management Farming Practices for Water Quality Protection
Grade Stabilization – Rock Drops (410a) Fact Sheet

BMP: Stabilize grade and control erosion in natural and artificial channels. Prevent the formation or advancement of gullies. Maintain and improve habitat for fish and wildlife.

NRCS Practice Standard: Grade Stabilization – Rock Drops (410a)

Rock drops are a type of grade stabilization structure. They should only be used in channels with grades less than five percent and width less than 50 feet, or with grades less than eight percent and width less than 25 feet. Flows shall not exceed 3 ft. over the drop for a
50-year frequency storm. These structures are limited to a maximum drop (FT) of 4 feet measured from weir to downstream toe; except structures in series, the structures are limited to a drop (FT) of 4 feet measured from weir to weir.

Grade Stabilization – Rock Drops (NRCS Conservation Practice Code 410a)

Definition: A structure composed of rocks in series used to control the grade and head cutting in natural or artificial channels.

Purposes:

- Stabilize grade in channels where the concentration and flow velocity of water are resulting in head-cutting and bank erosion

CONSIDER THIS:

All Considerations for Grades Stabilization Structures apply for Rock Drops.

Periodically, it will be necessary to replace and relocate rocks either by machine or by hand. It is necessary to maintain the rocks to the lines and grades of the original design.

Control livestock access to the structure because they may be injured, damage protective vegetation and earthfills or accelerate soil erosion.

Remove debris that may accumulate at the structure, and immediately upstream or downstream from the structure. Debris accumulation may reduce the hydraulic capacity and cause rocks to move or failure during a design storm.

Eradicate or otherwise remove all rodents or burrowing animals because their burrows may weaken earthen sections and develop flow paths for water and accelerate soil erosion or failure. Immediately repair any damage caused by their activity.

For more information contact your local NRCS office or visit our website at *http://efotg.sc.egov.usda.gov/treemenuFS.aspx*

EMERGENCY MEASURES AND TEMPORARY STRUCTURES

No one likes to acknowledge mistakes, but despite the most careful planning, errors do occur. Perhaps the rains came before your got your permanent erosion control measures fully in place, or you have torrential rains before your cover crop has grown sufficiently to hold the soil. These situations can be simple bad luck in the timing of fall rains. The error lies only in not being prepared. Saving the soil of your vineyard is the highest priority, even in the midst of pouring rain, particularly because heavy soil loss can have a negative impact to your watershed.

What to do? Well, first of all, be prepared with a supply of materials on hand which will assist you in building immediate, temporary structures. It is wise to add a supply of these materials to your vineyard storage area even before you begin an earth moving project.

As you read through the specifications and drawings included with this section, you will see some of the materials needed for emergencies. Bales of straw, steel reinforcing bar, steel fence 'tee" posts, heavy plastic sheeting, erosion blanket material, shovels, boots, heavy gloves, and spare rainsuits for vineyard workers-these are some of the things that will be useful. With these on hand you can construct temporary checkdams and dikes during the storm to slow or divert the problem water flows.

Immediate action is the important factor in an erosion emergency, so there's no waiting until the storm passes. A prudent vineyard manager goes out into the rain to survey the situation in the vineyard in any case. The most critical time to watch for problems is during storms, after the land has been cleared in preparation for vineyard planting. It is the mark of a good vineyard manager to be ready to meet an emergency.

LIST OF EMEFIGENCY MEASURES AND TEMPORARY STRUCTURES

Plastic-lined Ditch
Sandbag Flexible Pipe Drop
Straw Bale Checkdam
Straw Sale Sediment Barrier
Straw Sale Sediment Trap
Straw Sale Waterbar
Silt Fence

PRACTICES TO EXPEDITE PERMANENT INSTALLATIONS

PURPOSE

The purpose of this appendix is to provide some guidance in the use of common practices used during emergencies. Also included are cost estimates illustrating anticipated installation and average annual costs.

LIMITATIONS

These practices are considered emergency measures, have a very short life and may not work property. They should be used only when permanent practices have failed and immediate repairs are needed or during the period permanent practices &re being installed.

Emergency practices are to be replaced with permanent practices at the earliest opportunity.

Installation and maintenance are very critical to the relative success of emergency practices. Assistance should not be given if there are indications that installation and maintenance procedures may not be carried out.

Assistance provided by the Soil Conservation Service for emergency practices will be determined by the District Conservationist on a case-by-case basis.

PROBLEMS

Installation and maintenance are very critical to the relative success of emergency structures.

Emergency practices are usually constructed of materials that: have a short life (straw bales); are too light to withstand normal weather or operations (plastic sheeting); or control erosion and trap sediment without reducing erosion.

Poorly installed or maintained emergency structures frequently cause increased damages when they fail because of location and concentration of runoff flows.

TIPS

Waterbars and Sediment Traps

A waterbar can be constructed of straw bales to direct water flow or to increase water depth for a storm drainage inlet.

Sediment traps can be constructed of straw bales or filter fabric. These structures are to be used only for a limited time, until the unprotected areas can be permanently stabilized.

A. Tie-ins for waterbars and traps should be carefully designed to prevent flow around the protected area.

B. For structures in series, the toe of uphill structure should not be set higher than the top of the next downhill structure or protected level.

C. The allowable contributing drainage area and length of slope above emergency barrier structures should be: one acre and 100 feet of slope length for slopes up to 15 percent; and, one-half acre and 50 feet of slope length for slopes greater than 15 percent.

Installation Tips

Straw Bales: Bales should be clean straw, baled in the year of use, and shall be bound with wire or plastic twine. Kemp twine bound bales are less durable.

Bales should be placed in row with ends tightly abutting the adjacent bales. Some loose straw may be compressed between adjacent bales to close voids. The tops of the bales should all be level and set at the same elevation.

Each bale should be embedded in the soil a minimum of four inches. Drive 2 x 2 stakes or rebar through bales and into ground at least 1-1/2 to 2 feet for anchorage. The first stake in each bale should be driven toward a previously laid bale to force the bales together.

Silt Fence: Lay material in ditch bottom with upstream edge secured in a three inch to six inch deep trench backfilled with compacted soil. Attach downstream (top) edge to end posts with cable through a sewed tube or per fabric manufacturer's recommendations. Make certain that the center top edge of fabric is at least three to four inches below adjacent ground level at low end of fence.

The maximum drop should not exceed 1.5 feet unless supported with larger posts and wire fence as shown.

Sand and Gravel Filter Outlet (Strawbale sediment trap – single layer): Filter material is coarse (3/4 to 3 inches). well grade gravel or crushed rock. Fines should be less than 5 percent.

Operation and Maintenance Tips

Frequent inspection and maintenance is required. Inspect the structure on a daily basis when activity is nearby to locate areas damaged by personnel or equipment. Inspect the structure and provide necessary maintenance following each storm period. It is important to assure that loose straw is prevented from entering storm drainage facilities.

Trapped sediment should be removed and the filter material cleaned out or replaced after each storm.

Access Road (Plastic Line Ditch)

Plastic sheeting can be used as a temporary measure to line roadside ditches or swales until permanent measures can be installed.

Installation Tips

Maximum length of run for plastic sheeting should be the lessor of 400 feet or the distance required to accumulate 4 ft^3 /sec.

The plastic should have adequate anchorage to prevent undermining along the edges by water or uplifting caused by strong winds. Rocks should not be used to anchor plastic.

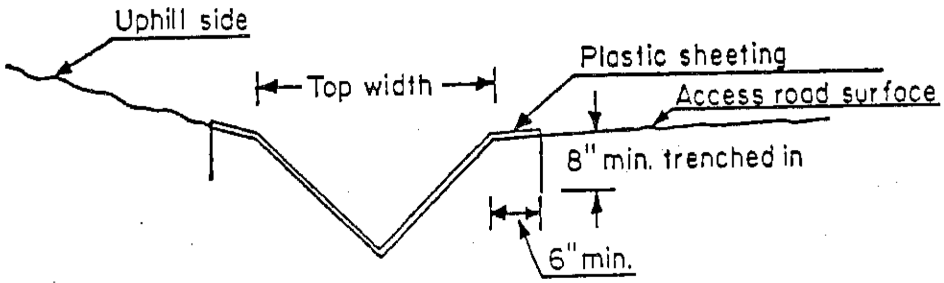
Plastic should be strong enough to prevent punctures from rocks and twigs and limited foot traffic. Clearing the area will help minimize the puncture problem.

The upstream sheet should overlap the downstream sheet a minimum of 12 inches. The upstream end of each sheet should be trenched into the ground a minimum of eight inches, including under laps.

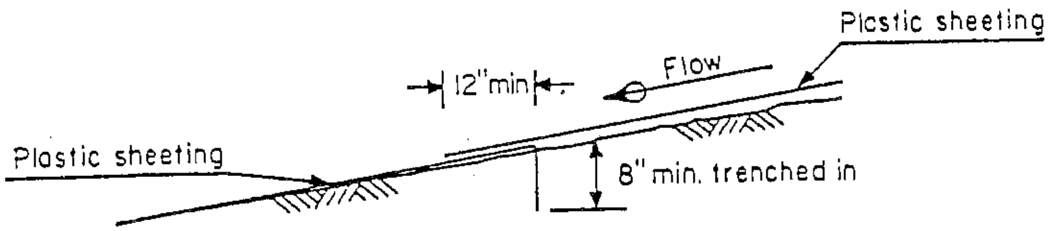
Operation and Maintenance Tips

Plastic sheeting should be inspected after each storm for damage, proper anchorage and lapping. Sections with holes should be repaired by cutting out the damaged sections across the width of the lining and inserting a new sheet with proper lapping and trenching at each end.

ACCESS ROAD – PLASTIC LINED DITCH (V-Shaped Ditch)



SECTION

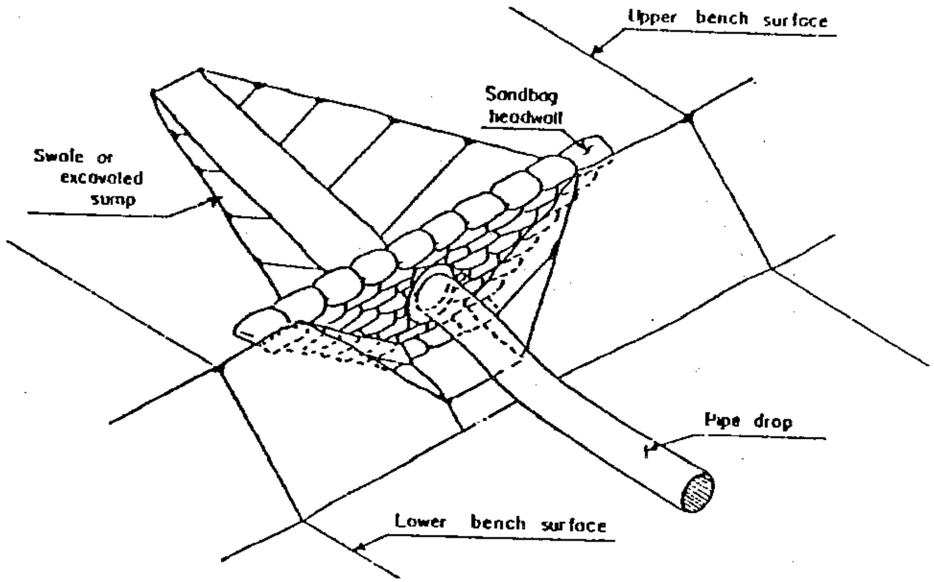


LAP DETAIL

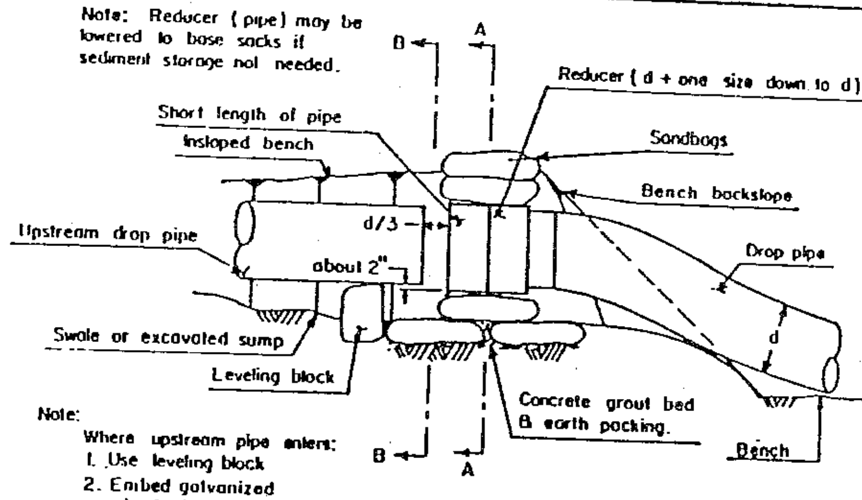
(NO SCALE)

Note: EMERGENCY PRACTICE to be used only when permanent practices fail or during the process of installing permanent practices.

TEMPORARY PRACTICES – PLASTIC LINED DITCH



ISOMETRIC VIEW

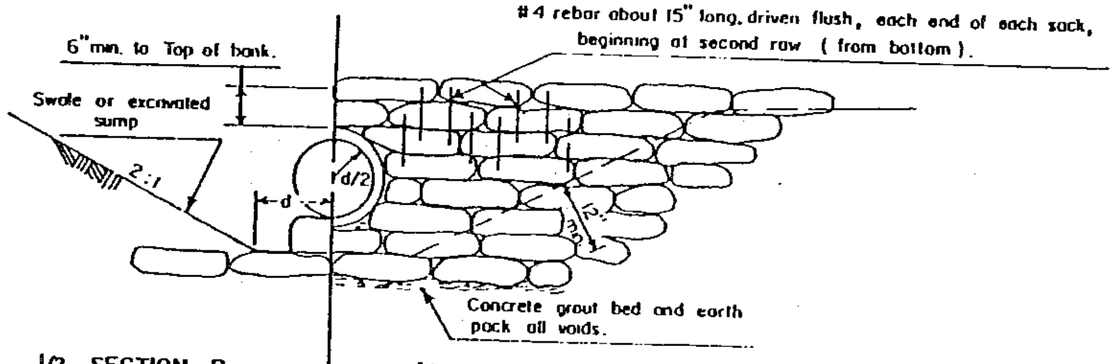


Note:
Where upstream pipe enters:
1. Use leveling block
2. Embed galvanized wire in leveling block to tie down end of upstream drop pipe.

PARTIAL SECTION

Detail at downstream structure in series.

Note: EMERGENCY PRACTICE to be used only when permanent practices fail or during the process of installing permanent practices.



1/2 SECTION B

1/2 SECTION A

VIEW

TEMPORARY SANDBAG
FLEXIBLE PIPE DROP

SCS ENG 383A REV 8-75

STRAW BALE DIKE

Definition: A straw bale dike is a temporary sediment barrier constructed of straw bales located downslope of a disturbed area or around a storm drainage inlet.

Purpose: The purpose of a straw bale dike is to prevent sediment transport from disturbed areas and also to prevent transported sediment from being discharged to a specific point, such as a storm drain inlet.

Applicability: A straw bale dike is installed in areas requiring protection from sedimentation caused by sheet and rill erosion during a limited time period (less than 3 months). There should be no stream channels or drainage ways above the barrier. The straw bale dike is used only until the unprotected areas can be stabilized.

Planning criteria: No design is required for contributing drainage areas within the limits which follow:

The allowable contributing drainage area and length of slope above the barrier are given in Table 1.

Table 1
Allowable Drainage Area for Straw Bale Dike

Slope	Maximum Drainage Area	Length of Slope
(Percent)	(Acres)	(Feet)
0-15	1	200
15+	½	100

Larger areas and longer slopes will require sediment removal by sediment basins or sediment traps.

Methods and Materials: The following criteria shall be used for straw bale dikes meeting the drainage area specifications in Table 1:

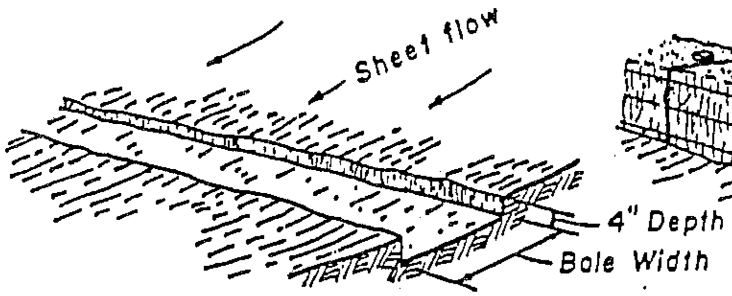
Straw Bales – Bales shall be bound with wire or nylon string. Twine bound bales are less durable.

Methods and Materials cont.:

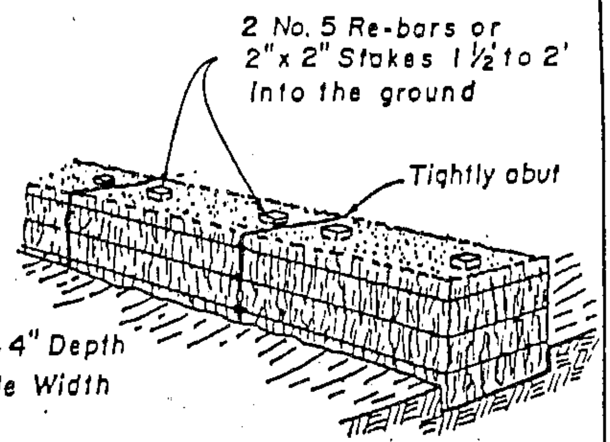
Bale Placement - Bales shall be placed in a row with ends tightly abutting the adjacent bales. Some loose straw may be compressed between adjacent bales to close voids. The tops of the bales shall all be level and set at the same elevation.

Anchorage -Each bale shall be embedded in the soil a minimum of 4 inches. Drive 2 x 2 stakes or rebar through bales and into ground 1 1/2 to 2 feet for anchorage. The first stake in each bale shall be driven toward a previously laid bale to force the bales together.

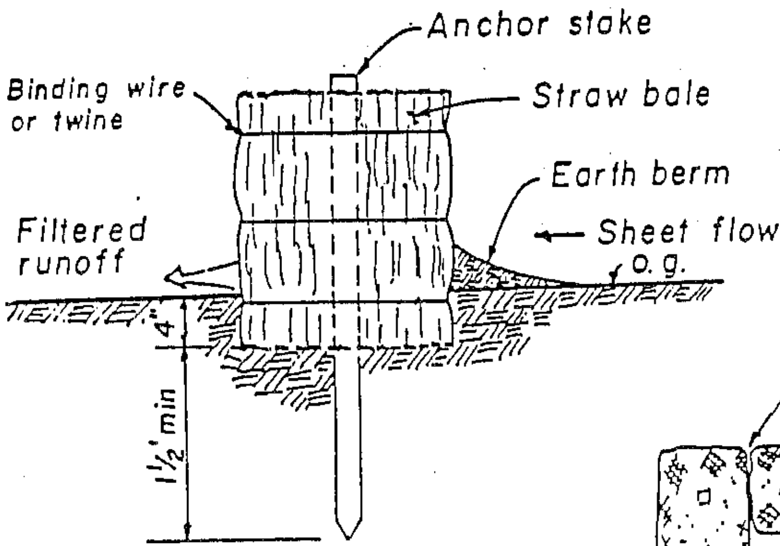
Operation and Maintenance: Periodic inspection and maintenance is required. Inspect the dike on a daily basis when construction activity is nearby to locate areas damaged by personnel or equipment. Inspect the dike and provide necessary maintenance following each storm period. The straw bales shall be removed once permanent drainage and stabilization practices are established. It is important to assure that loose straw is prevented from entering storm drainage facilities. Mixtures of straw and mud can severely clog pipeline and inlet structures. once removed from the dike, the used straw can be used as mulch in other areas.



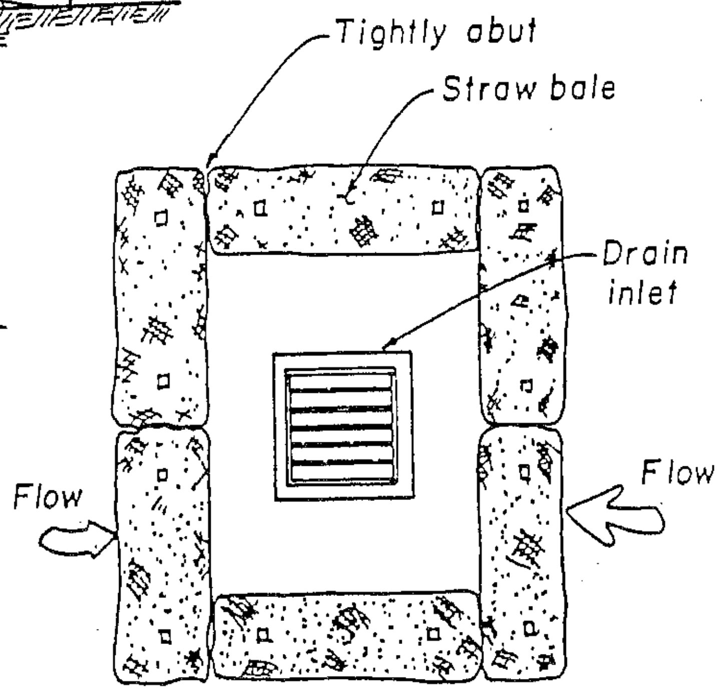
TRENCH DETAIL



BALE PLACEMENT

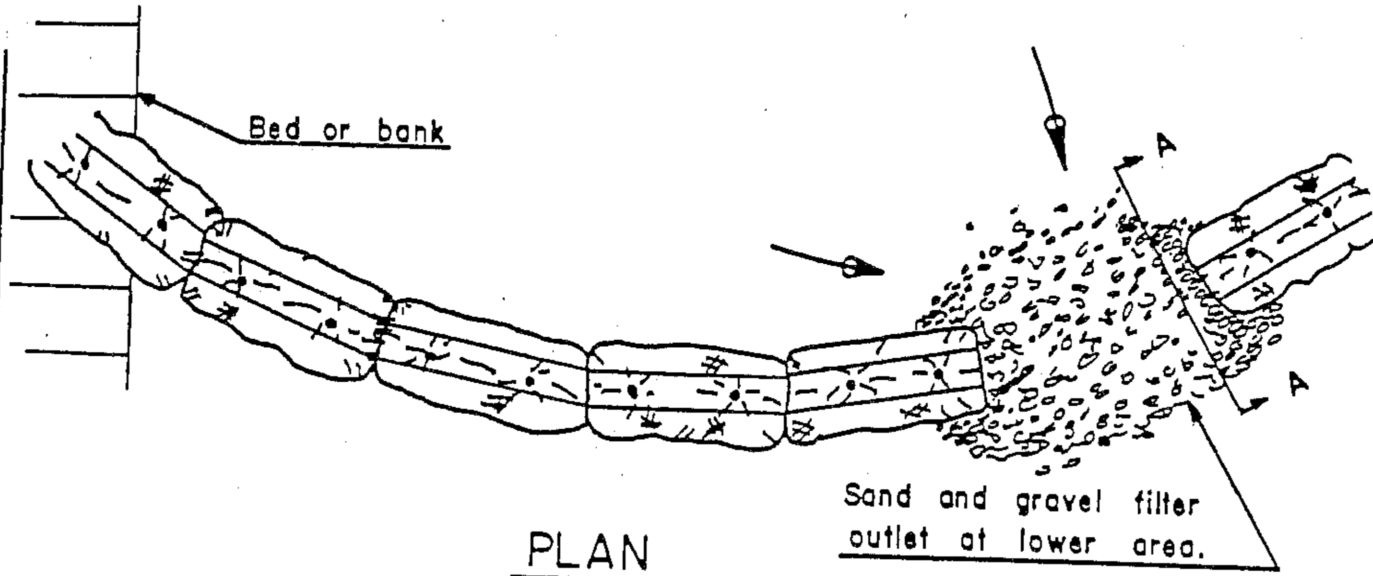


EMBEDDING DETAIL
no scale

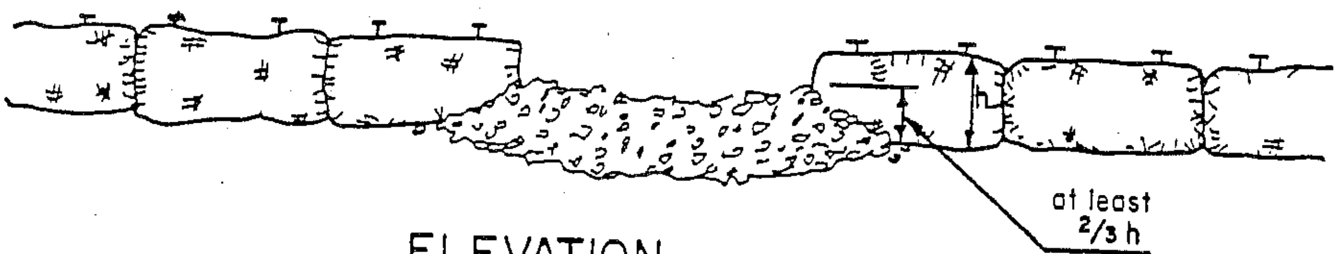


PLAN VIEW
STORM DRAIN PROTECTION
N. T. S.

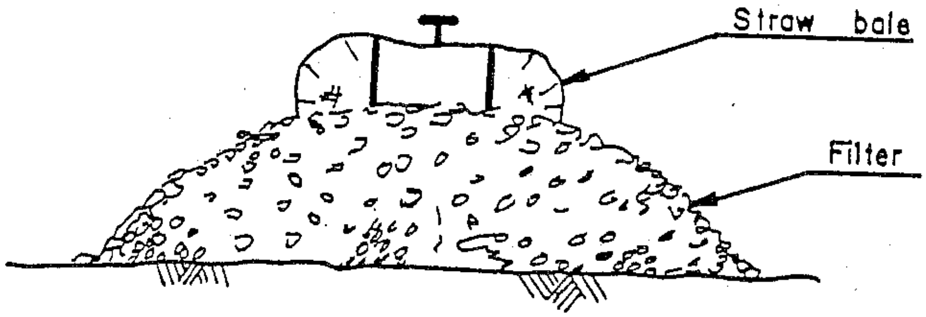
High Sierra R. C. & D. Erosion & Sediment Control Guide 3/90 LCS	STRAW BALE SEDIMENT BARRIER



PLAN



ELEVATION



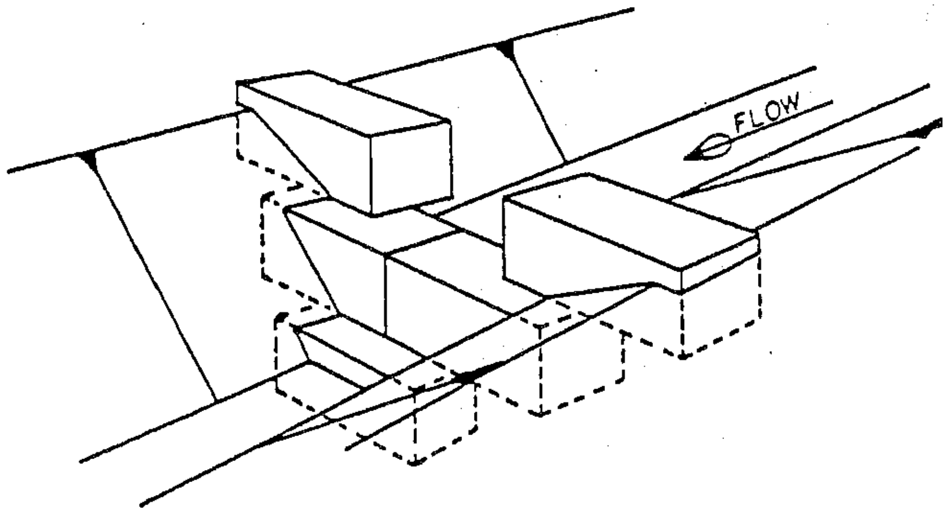
EMBEDDING DETAIL SECTION A—A

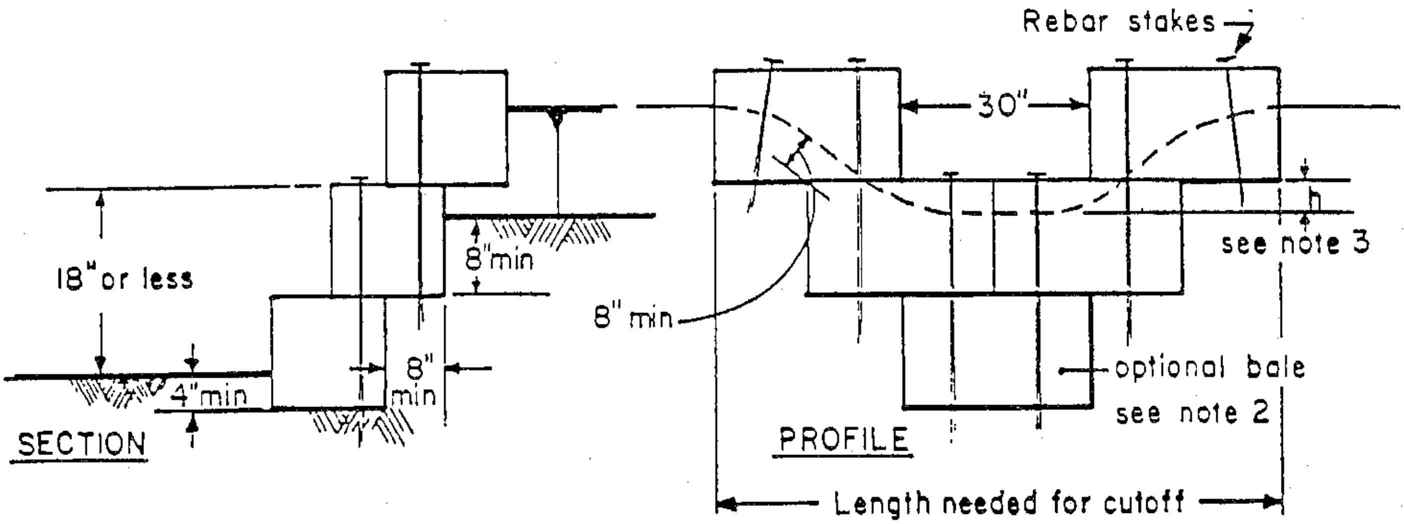
Note: $Q_{max.} = 0.5\ ft.^3/s$

EMERGENCY PRACTICE to be used only when permanent practices fail or during the process of installing permanent practices.

NO SCALE

STRAW BALE SEDIMENT TRAP





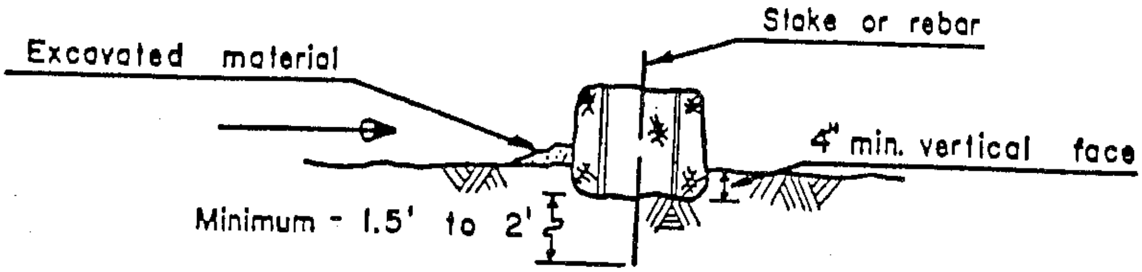
Note: 1.) EMERGENCY PRACTICE to be used only when permanent practices fail or during the process of installing permanent practices.

2.) Overlapping the bales at least 15" is necessary for adequate anchorage and less piping.

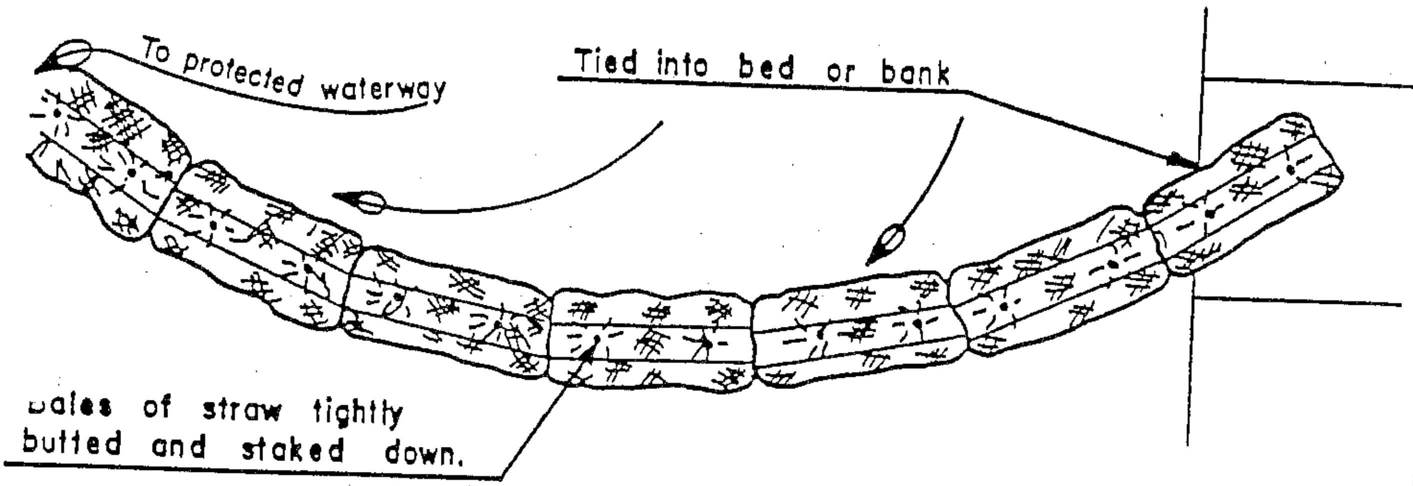
3.) The number of bales will depend on the cross section of drainage. "Optional" bale at bottom of section may not be necessary on low drops.

4.) Depth of trap, h; to allow for adequate embedment of bales used for traps, use h = 8" or less.

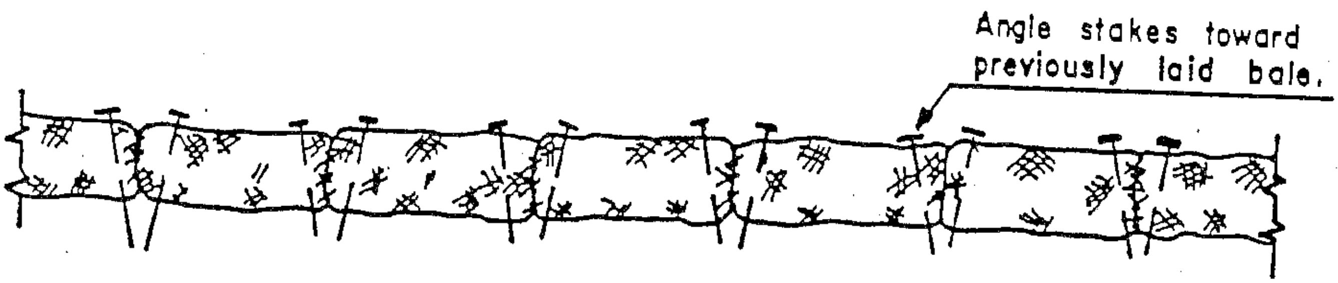
SEDIMENT TRAP (Strawbale) Q max. = 5 ft^3/s



EMBEDDING DETAIL



PLAN

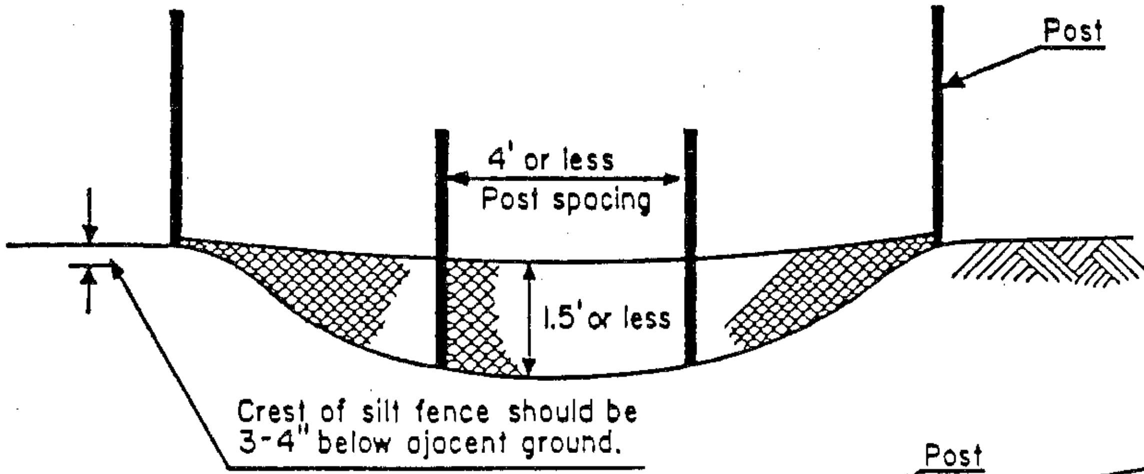


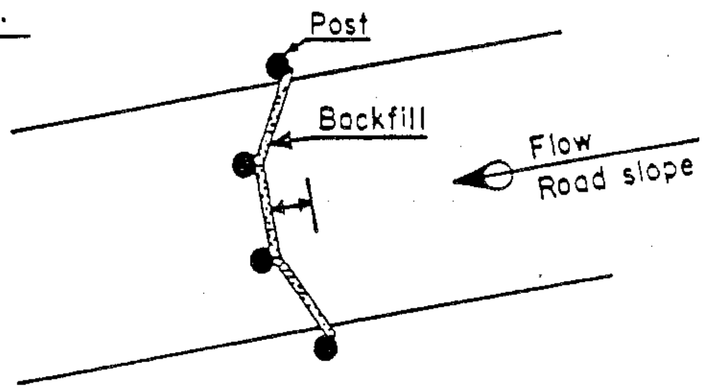
ELEVATION

NO SCALE

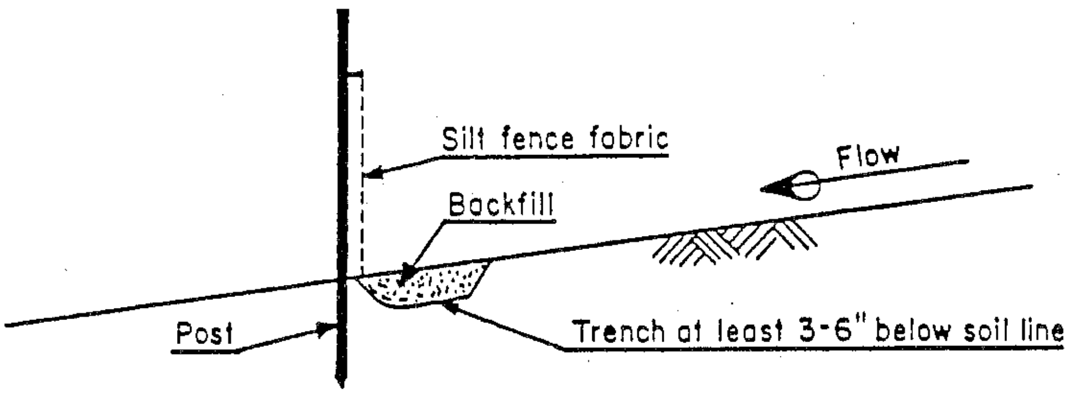
Note: EMERGENCY PRACTICE to be used only when permanent practices fail or during the process of installing permanent practices.

RAW BALE WATERBAR





PLAN

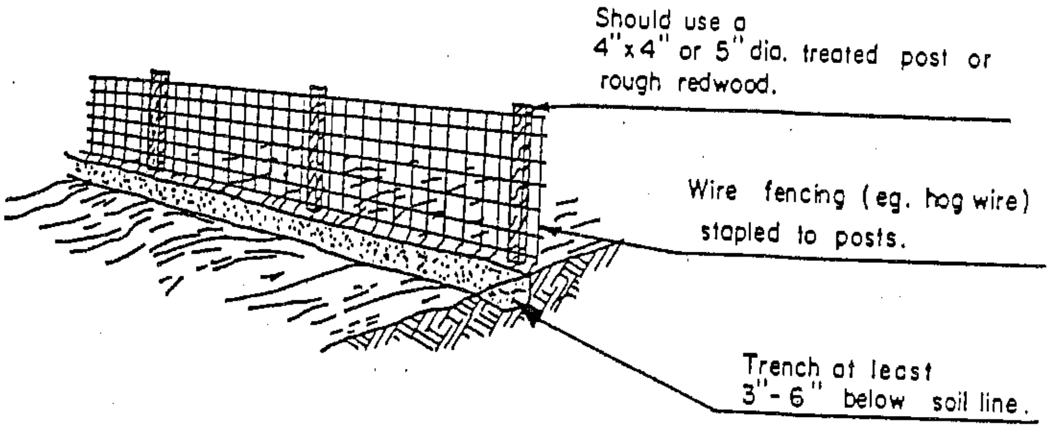


Attach fabric to fence per manufacturers recommendations.
Should use 1 1/4 lb. T-Posts, 4' long, driven at least 2' into ground.

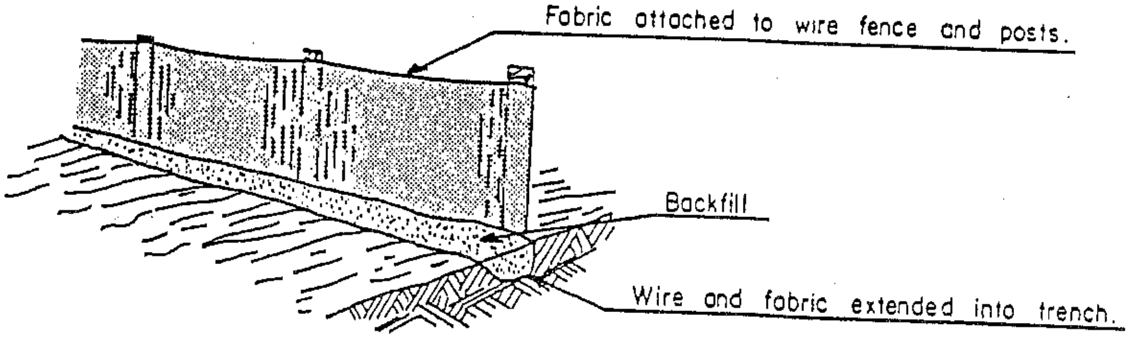
NO SCALE

Note: For roads or slopes only.
EMERGENCY PRACTICE to be used only when permonent practices fail or during the process of installing permonent practices.

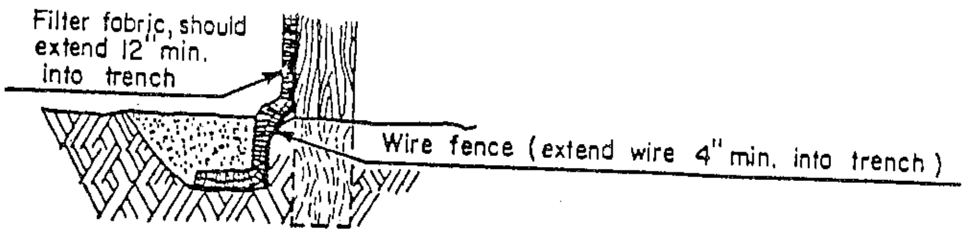
SILT FENCE (post supported)



CONSTRUCT SUPPORT STRUCTURE
(fence extends to adjacent ground)



ATTACH FILTER FABRIC

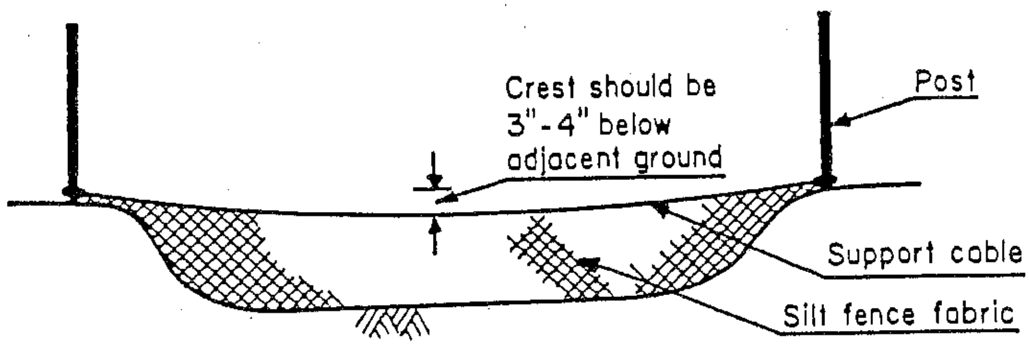


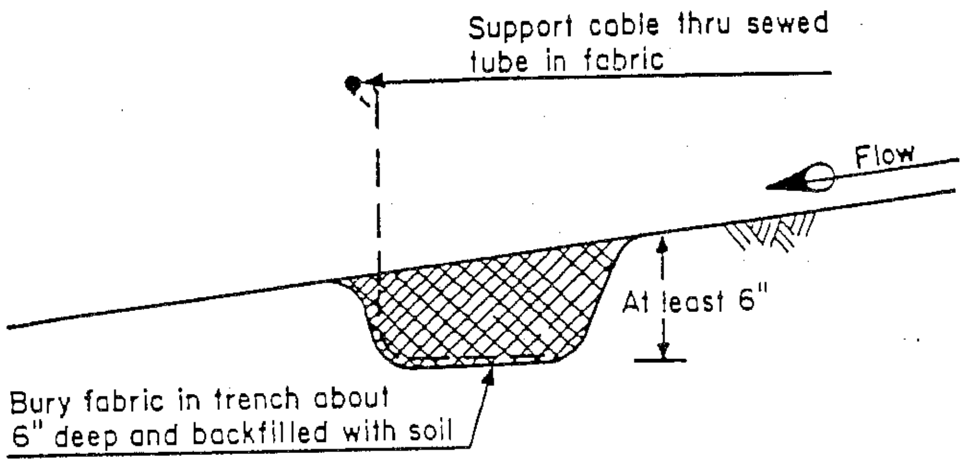
DETAIL

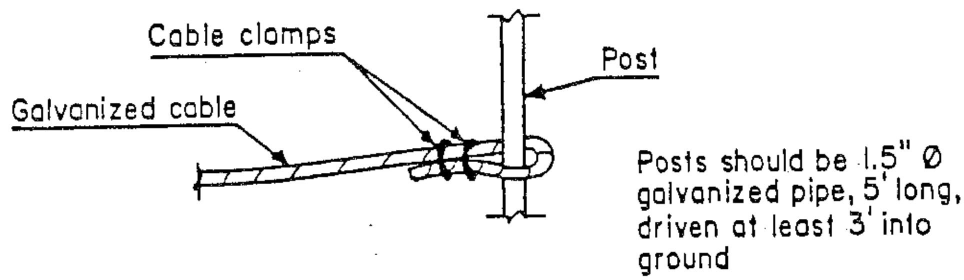
Note: 1. EMERGENCY PRACTICE to be used only when permanent practices fail or during the process of installing permanent practices.
2. Height is 4 feet or less.
3. Spacing of posts is 4 feet or less.
4. Posts should be set into ground at least 2 feet. Set in concrete if necessary.
5. Crest of silt fence should be 3"-4" below adjacent ground. Attach as per manufacturer's recommendations.

NO SCALE

SILT FENCE (Post Supported, h ≤ 4 feet)







Note: Height 1.5 feet or less.
EMERGENCY PRACTICE to be used only when permanent practices fail or during the process of installing permanent practices.

NO SCALE

SILT FENCE (cable supported)