Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

CONSERVATION COVER

CODE 327

(ac)

DEFINITION

Establishing and maintaining permanent vegetative cover.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Reduce sheet, rill, and wind erosion and sedimentation
- Reduce ground and surface water quality degradation by nutrients and surface water quality degradation by sediment
- Reduce emissions of particulate matter (PM), PM precursors, and greenhouse gases
- Enhance wildlife, pollinator and beneficial organism habitat

CONDITIONS WHERE PRACTICE APPLIES

This practice applies on all lands needing permanent herbaceous vegetative cover. This practice does not apply to plantings for forage production or to critical area plantings. This practice can be applied on a portion of the field.

CRITERIA

General Criteria Applicable to All Purposes

Select species that are adapted to the soil, ecological sites, and climatic conditions that are suitable for the planned purpose and site conditions. Periodic removal of some products such as high value trees, medicinal herbs, nuts, and fruits is permitted provided the conservation purpose is not compromised by the loss of vegetation or harvesting disturbance.

Inoculate legumes at planting time.

Choose seeding rates and planting methods that will be adequate to accomplish the planned purpose. Planting dates, planting methods and care in handling and planting of the seed or planting stock shall ensure that planted materials have an acceptable rate of survival.

Prepare the site by establishing a consistent seeding depth. Eliminate weeds that would impede the establishment and growth of selected species. Use Herbaceous Weed Treatment (315) to control weeds and competing herbaceous vegetation. Use Brush Management (314) to remove non-target brush that will impede the establishment and growth of selected species. Use Cover Crop (340) to suppress weeds, control soil erosion or improve soil organic matter during site preparation.

Base the timing and equipment selection on the site and soil conditions.

Apply nutrients as needed to ensure vegetation establishment and planned growth based on soil test. Pollinator, beneficial organism and native grass plantings generally do not require lime or fertilizer. Do not apply lime or fertilizer to pollinator, beneficial organism or native grass plantings unless a soil test indicates pH is too low for establishment and productive growth, and the appropriate NRCS specialist has been consulted.

For slow growing plant species, including native grasses and forbs, control competing vegetation during the establishment period.

Additional Criteria to Reduce Sheet, Rill, and Wind Erosion and Sedimentation

Determine and maintain the amount of plant biomass and cover needed to reduce wind and water erosion to the planned soil loss objective by using the current approved wind and/or water erosion prediction technology.

Additional Criteria to Reduce Emissions of Particulate Matter (PM), PM Precursors, and Greenhouse Gases

In perennial crop systems such as orchards, vineyards, berries and nursery stock, establish vegetation to provide full ground coverage in the alleyway during mowing and harvest operations to minimize generation of particulate matter.

Additional Criteria to Enhance Wildlife, Pollinator and Beneficial Organism Habitat

Plant a diverse mixture of grass and forb species to promote bio-diversity and meet the needs of the targeted species using approved habitat appraisal guides, evaluation tools, and appraisal worksheets for the respective state.

For pollinator and beneficial organism habitat plantings, ensure several species of flowering plants are established for each bloom period; spring, summer and fall.

For beneficial organism habitat optimal function, locate plantings where beneficial insects can access targeted crops.

Locate habitat plantings to avoid exposure from all types of pesticides and drift that could harm wildlife, pollinators, and other beneficial organisms. Use Integrated Pest Management (595) to prevent, avoid and/or mitigate potential exposure to habitat protect plantings from pesticides and drift.

Follow a NRCS NY approved reference when establishing pollinator habitat.

Additional Criteria to Improve Soil Health

To maintain or improve soil organic matter, select plants that will produce high volumes of organic material. The amount of biomass needed will be determined using the current soil conditioning index procedure.

CONSIDERATIONS

This practice may be used to promote the conservation of wildlife species in general, including threatened and endangered species.

Certified seed and planting stock that is adapted to the site should be used when it is available.

On sites where annual grasses are an expected weed problem, it may be necessary to postpone nitrogen fertilizer application until the planted species are well established.

Where applicable this practice may be used to conserve and stabilize archaeological and historic sites.

Consider rotating management and maintenance activities (e.g. mow only one-fourth or one-third of the area each year) throughout the managed area to maximize spatial and temporal diversity.

Use Early Successional Habitat Development/Management (647) or Prescribed Burning (338) to manage established conservation cover and associated habitat.

Where wildlife management is an objective, the food and cover value of the planting can be enhanced by using a habitat evaluation procedure to aid in selecting plant species and by providing or managing for other habitat requirements necessary to achieve the objective. Encouraging plant species diversity and establishing plantings that result in multiple structural levels of vegetation within the conservation cover will maximize wildlife use.

To provide habitat for natural enemies of crop pests, select a mix of plant species that provide year-round habitat and food (accessible pollen or nectar) for the desired beneficial species. Consider habitat requirements of predatory and parasitic insects, spiders, insectivorous birds and bats, raptors, and terrestrial rodent predators. Consult Land Grant University Integrated Pest Management recommendations for beneficial habitat plantings to manage the target pest species.

Where practical, use native species that are appropriate for the identified resource concern and management objective. Consider trying to re-establish the native plant community for the site.

If a native cover (other than what was planted) establishes, and this cover meets the intended purpose and the landowner's objectives, the cover should be considered adequate.

During vegetation establishment, natural mulches, such as wood products or hay, can be used to conserve soil moisture, support beneficial soil life, and suppress competing vegetation. Use Mulch (484).

PLANS AND SPECIFICATIONS

Prepare plans and specifications for the site to include, but are not limited to:

- recommended species,
- seeding rates and dates,
- establishment procedures,
- management actions needed to insure and adequate stand

Specifications and operation and maintenance shall be recorded using approved Implementation Requirement document.

OPERATION AND MAINTENANCE

Mowing and harvest operations in a perennial crop system such as orchards, vineyards, berries, and nursery stock shall be done in a manner which minimizes the generation of particulate matter.

If wildlife habitat enhancement is a purpose, maintenance practices and activities shall not disturb cover during the reproductive period for the desired species. Exceptions should be considered for periodic burning or mowing when necessary to maintain the health of the plant community.

Control noxious weeds and other invasive species.

To benefit insect food sources for grassland nesting birds, spraying or other control of noxious weeds shall be done on a "spot" basis to protect forbs and legumes that benefit native pollinators and other wildlife.

Re-vegetate bare spots.

REFERENCES

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool and D.C. Yoder. 1997. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE), Agricultural Handbook Number 703.

Revised Universal Soil Loss Equation Version 2 (RUSLE2) website:
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/

The Xerces Society for Invertebrate Conservation and USDA, NRCS. 2018. Planting for Pollinators and Beneficial Insects Wildflower Habitat Establishment Guide: New York. 21pp.

USDA, NRCS and The Xerces Society for Invertebrate Conservation. 2014. Preventing or mitigating potential negative impacts of pesticides on pollinators using IPM and other conservation practices. Nat. Agron. Tech Note 9. Washington, DC. http://directives.sc.egov.usda.gov/

USDA, NRCS. 2012. A guide to conservation plantings on critical areas in the northeast. USDA, NRCS, Big Flats Plant Materials Center, Corning NY (http://plant-materials.nrcs.usda.gov/nypmc/)

Wind Erosion Prediction System (WEPS) website:
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/

United States Department of Agriculture

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

CRITICAL AREA PLANTING

CODE 342

(ac)

DEFINITION

Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal seeding/planting methods.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Stabilize areas with existing or expected high rates of soil erosion by wind or water
- Stabilize stream and channel banks, pond and other shorelines, earthen features of structural conservation practices
- Stabilize areas such as sand dunes and riparian areas

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to highly disturbed areas such as—

- Active or abandoned mined lands.
- Urban restoration sites.
- Construction areas.
- Conservation practice construction sites.
- Areas needing stabilization before or after natural disasters such as floods, hurricanes, tornados, and wildfires.
- Eroded banks of natural channels, banks of newly constructed channels, and lake shorelines.
- Other areas degraded by human activities or natural events.

CRITERIA

General Criteria Applicable to All Purposes

Site preparation

Conduct a site investigation to identify any physical, chemical, or biological conditions that could affect the successful establishment of vegetation.

Clear treatment areas of unwanted materials and smooth or shape, if needed, to meet planting purpose(s).

Prepare a suitable seedbed for all seeded species. Rip compacted layers and re-firm the soil prior to seedbed preparation, as needed.

As site conditions dictate, when grading slopes, stockpile topsoil for even redistribution over treatment areas prior to planting.

Species selection
Select species for seeding or planting that are suited to local site conditions and intended uses, and common to the site or location. Match species with site characteristics and purpose of planting as specified in a New York NRCS approved technical reference.

Selected species will have the capacity to achieve adequate density and vigor to stabilize the site within an appropriate time period.

Establishment of vegetation
Plant seeds using the method or methods best suited to site and soil conditions.

Limit sod placement to areas that can naturally supply needed moisture or are suitable for irrigation during the establishment period. Place and anchor sod using techniques to ensure that it remains in place until established.

Specify species, rates of seeding or planting, legume inoculation, minimum quality of planting stock (e.g., pure live seed (PLS) or stem caliper), method of seedbed preparation, and method of establishment before application. Use only viable, high-quality seed or planting stock.

Seed or plant at a time and in a manner that best ensures establishment and growth of the selected species.

Plant during approved times for the species to be used.

Apply soil amendments (e.g., lime, fertilizer, compost) according to current soil test results. Mulch or otherwise stabilize plantings as necessary to ensure successful establishment.

Specify species selection, planting or seeding rates, site preparation, and establishment methods using New York NRCS approved technical references.

Additional Criteria to Stabilize Stream and Channel Banks, Pond and Other Shorelines, Earthen Features of Structural Conservation Practices

Bank and channel slopes
Shape channel side slopes so that they are stable and allow establishment and maintenance of desired vegetation.

A combination of vegetative and structural measures may be necessary on slopes steeper than 3:1 to ensure adequate stability.

Species selection
Plant material used for this purpose must—

- Be adapted to the hydrologic zone into which they will be planted.
- Be adapted and proven in the regions in which they will be used.
- Be compatible with existing vegetation in the area.
- Protect the channel banks but not restrict channel capacity.

Establishment of vegetation
Plant seeds and/or planting stock using the method or methods best suited to site and soil conditions**.** Specify species, planting rates, spacing, methods and dates of planting based on local planting guides or technical notes.

Identify and protect desirable existing vegetation during practice installation.

Use a combination of vegetative and structural practices with living and inert material when flow velocities, soils, and bank stability preclude stabilization by vegetative establishment alone. Use Conservation Practice Standard (CPS) Streambank Stabilization (Code 580) for the structural measures.

Control existing vegetation on a site that will compete with species to be established vegetatively (e.g.. bare-root, containerized, ball-and-burlap, potted) to ensure successful establishment of the planted species.

Plant streambank stabilization vegetation in accordance with the NRCS Engineering Field Handbook Part 650, Chapter 16, “Streambank and Shoreline Protection,” and Chapter 18, “Soil Bioengineering for Upland Slope Protection & Erosion Reduction.”

Site protection and access control
Restrict access to planted areas until fully established.

Additional Criteria to Stabilize Areas Such As Sand Dunes and Riparian Areas

Plants for sand dunes and coastal sites must be able to survive being buried by blowing sand, sand blasting, salt spray, salt water flooding, drought, heat, and low nutrient supply.

Include sand trapping devices such as sand fences or brush matting in the revegetation/stabilization plans where applicable.

CONSIDERATIONS

Use species or diverse mixes that are adapted to the site and have multiple benefits. Use native species when appropriate for the site.

Use flowering shrubs and wildflowers with resilient root systems and good soil-holding capacity for incorporation as a small percentage of a larger grass-dominated planting to benefit pollinators and other wildlife. Where appropriate consider a diverse mixture of forbs to support pollinator habitat.

Avoid species that may harbor pests and adversely affect nearby crops, plant communities, or species in the planting. Diversify species to avoid loss of function due to species-specific pests.

Planning and installation of other CPSs such as Access Control (472) Diversion (362), Obstruction Removal (500), Subsurface Drain (606), or Underground Outlet (620), may be necessary to prepare the area or ensure vegetative establishment.

Areas of vegetation established with this practice can create habitat for various type of wildlife. Maintenance activities, such as mowing or spraying, can have detrimental effects on certain species. Perform management activities at the times and in a manner that causes the least disruption to wildlife.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for each field or management unit according to the criteria and operation and maintenance sections of this standard. Record practice specifications using approved Implementation Requirements document.

Address the following elements in the plan, as applicable, to meet the intended purpose(s):

- Practice purpose(s)
- Site preparation
- Topsoil requirements
- Fertilizer application
- Seedbed/planting area preparation
- Timing and method of seeding/planting
- Selection of species
- Seed/plant source
- Seed analysis/pure live seed (PLS)
- Seeding rate/plant spacing
- Mulching, PAM, or other stabilizing materials
- Supplemental water needed for establishment
- Protection of plantings
- Describe successful establishment (e.g., minimum percent ground/canopy cover, percent survival, stand density)

OPERATION AND MAINTENANCE

- Control access to the area to ensure the site remains stable.
- Protect plantings shall be protected from pests (e.g., weeds, insects, diseases, livestock, or wildlife) as necessary to ensure long-term survival.
- Inspect, reseed or replant, and fertilize as needed to ensure that this practice functions as intended throughout its expected life.
- Observe establishment progress and success at regular intervals until the practice has met the criteria for successful establishment and implementation.
- Maintain minimum successful establishment thresholds (e.g., minimum percent ground/canopy cover, percent survival, stand density).

REFERENCES

Federal Interagency Stream Restoration Working Group. 1998. Stream corridor restoration: principles, processes, and practices. USDA NRCS National Engineering Handbook, Part 653.

USDA NRCS. 2007. National Engineering Handbook, Part 654. Stream restoration guide.

USDA NRCS. 2015. The PLANTS Database (http://plants.usda.gov, 8 December 2015). National Plant Data Team, Greensboro, NC.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

OBSTRUCTION REMOVAL

CODE 500

(ac)

DEFINITION

Removal and disposal of buildings, structures, other works of improvement, vegetation, debris or other materials.

PURPOSE

This practice is used to accomplish the following purpose:

- To safely remove and dispose of unwanted obstructions in order to apply conservation practices or facilitate the planned land use

CONDITIONS WHERE PRACTICE APPLIES

On any land where existing obstructions interfere with planned land use development, public safety or infrastructure. This standard is not intended for the removal of obstructions from aquatic environments.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design and implement obstruction removal to comply with all federal, state and local laws and regulations.

Remove obstructions by demolition, excavation or other means required for removal. Dispose of all debris from the obstruction removal so that it does not impede subsequent work or cause onsite or offsite damage.

Dispose of inorganic materials such as rock piles, boulders, stones, concrete or masonry structures and metal or concrete fence posts by reusing, removal or burial at approved locations.

Dispose of organic materials such as wooden fence posts, woody vegetation, and woody building materials by removal to an approved landfill or recycling center, burial at an approved location or burning. Where burning is permitted, implement appropriate fire and smoke management precautions to protect public health and safety.

Dispose of trash and non-woody building materials in an approved landfill or recycling center.

Prior to any work, contact utility companies or the state one call system to identify the location of utility lines in the construction area and to arrange the shut off of utilities if necessary.

Before beginning demolition of buildings, ensure that all utilities, such as gas and electric have been shut off and disconnected from the structure.

The removal of obstructions can expose toxic or polluted materials. If toxic or polluted materials are expected to be found during the obstruction removal, specify appropriate handling and disposal criteria in the plans and specifications

When removing obstructions that contain chromated copper arsenate (CCA) treated wood, do not burn the wood. Burning of CCA treated wood can release toxic amounts of arsenic into the air and ash that are harmful to human and animal health. CCA treated wood should be buried in an approved landfill.

Reshape and regrade all areas disturbed by the obstruction removal so that they blend with the surrounding land features and conditions. Any foundations or below ground portions of the obstruction that remain in place shall have sufficient soil cover to meet the requirements of the planned land use. Compact fill areas according to site specific requirements.

Refer to NRCS Conservation Practice Standard 342, Critical Area Planting for seedbed preparation, seeding, fertilizing, and mulching requirements.

Erosion and Sediment Control
An erosion and sediment control plan shall be developed for all disturbed areas. For disturbed areas greater than one acre, the erosion and sediment control plan shall meet the planning, installation, and maintenance requirements of NYSDEC State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges. All erosion and sediment structures and measures shall be installed prior to earth disturbing activities unless otherwise directed in the construction drawings.

CONSIDERATIONS

The recycling or reuse of materials should be considered as the first option for disposal of materials from obstruction removal. Most woody debris can be recycled into mulch or other products. Recycling or other environmentally friendly options exist for the disposal of many other materials as well.

Demolition activities can generate large amounts of dust. Where necessary, use dust suppression techniques such as spraying water on the removal site to suppress dust.

Considerations should be given to wildlife and wetlands.

Considerations should be given to cultural resources.

Obstruction removal often involves heavy equipment working in environmentally sensitive areas. Ensure that servicing and refueling of equipment is done in a manner that minimizes spills and volatilization.

Demolition of structures and the removal of debris can be a hazardous undertaking. This is especially true for the removal of downed and tangled trees. This type of work should be done by qualified personnel with proper equipment following appropriate safety procedures.

Old buildings, structures and trees can provide habitat for wildlife. The potential for use by and presence of at-risk species should be considered and addressed prior to any obstruction removal activity. The presence of roosting birds, bats and rodents may also pose a health and safety hazard to workers that should be considered.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for obstruction removal that describe the requirements for applying the practice according to this standard. Plans and specifications for this practice can be included in the plans and specifications for the practice it supports. As a minimum the plans and specifications shall include:

- A plan view showing the location of obstruction removal site.
- Details and location for the disposal of materials from the obstruction removal.
- Details of how the site will be stabilized after construction.

- Construction specifications that describe in writing, site specific requirements for the obstruction removal.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance (O&M) plan for the operator. O&M for this practice may be addressed in the O&M plans for the practice it supports. The minimum requirements to be addressed in the operation and maintenance plan are:

- Periodic checking to ensure the site remains stable after the obstruction removal.
- When disposal of debris occurs on site, periodic checking to ensure that the disposal site remains stable.
- Repair any problems as soon as possible.

REFERENCES

U. S. Department of Labor. Occupational Safety and Health Administration. Safety and Health Regulations for Construction**,**29 CFR 1926. U. S. Washington, DC.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

ROOF RUNOFF STRUCTURE

CODE 558

(no)

DEFINITION

A structure that will collect, control, and convey precipitation runoff from a roof.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Protect surface water quality by excluding roof runoff from contaminated areas
- Protect a structure foundation from water damage or soil erosion from excess water runoff
- Increase infiltration of runoff water
- Capture water for other uses

CONDITIONS WHERE PRACTICE APPLIES

Where roof runoff from precipitation needs to be—

- Diverted away from a contaminated area or the foundation of a structure;
- Collected and conveyed to a stable outlet or infiltration area; or
- Collected and captured for other uses such as evaporative cooling systems, livestock water, and irrigation.

CRITERIA

General Criteria Applicable to All Purposes

Evaluate the condition of the existing roof structure prior to installation of a gutter. Install new fascia boards as needed to support gutters and downspouts for the practice life span. Mount gutters on plumb fascia boards.

Ensure that the gutter support system will withstand the anticipated loading, including loads from snow and ice, as applicable. If structural support is missing or insufficient, design the required support for the selected gutter. As an alternative to increasing the structural supports, use a ground gutter design to convey the roof runoff.

Where snow and ice damage will occur, install the roof gutter below the projection of the roof line.

Use a pipe guard or pipe casing where necessary to protect the downspout, lateral, or cross-pipe pipelines of the roof runoff structure from damage by livestock or equipment.

Gutter Design Capacity

When a roof runoff structure is used to protect roof runoff from contamination by manure, design the roof runoff structure to convey the flow rate generated from a 25-year, 5-minute rainfall event. (Refer to

National Engineering Handbook (NEH) (Title 210), Part 651, “Agricultural Waste Management Field Handbook,” Chapter 10, Appendix 10B).

For other applications, design the roof runoff structure to convey the flow rate generated from a 10-year, 5-minute rainfall event. D x 0.278 = discharge in cfs/1000sqft

Downspout
Use downspouts, collector pipes, lateral downspouts, or cross-pipes with a capacity equal or exceeding the roof gutter flow rate.

When a downspout outlets at the ground level, place an elbow and energy dissipation device at the outlet to provide erosion protection and direct water away from the foundation of the structure.

Ground Gutter
Where runoff from the roof eave drops onto the ground surface, provide a ground gutter with adequate provision to convey runoff away from the foundation of the structure.

Ground gutter designs can use a rock pad, a rock-filled trench with a subsurface drain, a concrete channel, or a precast channel to convey the roof runoff water to a stable discharge location or infiltration area.

Outlet
Roof runoff can empty into a subsurface drain, underground outlet, a ground gutter, a storage tank, or onto stabilized soil.

Size the outlet to ensure adequate design capacity. Provide for a clean-out of the outlet as appropriate.

Use NRCS Conservation Practice Standard (CPS) Subsurface Drain (Code 606) to design a subsurface drain used to dewater a ground gutter or infiltration ditch.

Use NRCS CPS Underground Outlet (Code 620) to design an underground outlet used to convey roof runoff to a stable outlet.

Materials
Roof gutters and downspouts may be made of aluminum, galvanized steel, wood, or plastic. Aluminum gutters and downspouts require a minimum nominal thickness of 0.027 inches and 0.020 inches, respectively. Galvanized steel gutters and downspouts require a minimum 28 gauge. Wood may be redwood, cedar, cypress, or other species that has the desired longevity and will be free of knots. Plastics must contain ultraviolet stabilizers.

To prevent corrosion, avoid contact between components of dissimilar metals.

To enable infiltration with rock-filled trenches and rock pads use ‘poorly graded rock’ (rock fragments approximately all the same size) that is free of appreciable amounts of sand or soil particles. Do not use crushed limestone for backfill material unless it has been washed.

Use NRCS National Engineering Manual (NEM) (Title 210), Part 536, Section 536.20, “Design Criteria for Reinforced Concrete,” for design and installation of reinforced concrete channels, pads, or slabs.

For non-reinforced concrete channels or pads use the 210-NEH, Part 642, Construction Specification 32, Structural Concrete.

Additional Criteria to Increase Infiltration

Increase runoff infiltration by directing flow to existing landscapes (e.g., lawns, mass planting areas, infiltration trenches, rain gardens, or natural areas). Ensure these areas have the capacity to infiltrate the runoff without adversely affecting the desired plant species and without creating a soil erosion problem.

Additional Criteria to Protect the Foundation of a Structure

For a design which outlets the roof runoff on the ground, slope the runoff discharge area away from the structure foundation. Use a minimum downspout extension of 5 feet to discharge runoff away from the foundation of a structure built on expansive soils or a building foundation placed on bedrock.

Additional Criteria to Capture Water for Other Uses

Design a water storage tank of adequate size, strength, and durability to hold water for the intended purpose. Install the tank on a firm, unyielding foundation. Anchor above-ground water storage tanks to prevent damage from wind loads.

Prohibit access to water storage tanks by children and animals to prevent drowning. Protect the area around the tank from erosion caused by overflow from the tank.

Construct or select water storage tanks of materials and in a manner that will not degrade the quality of the stored water. Design water supply attachments to meet system needs. Include a first flush diverter as necessary to reduce sediment, pathogens, and chemical pollutants in the collected water.

The water quality must be suitable for the intended use. The landowner is responsible for any water quality testing and treatment.

CONSIDERATIONS

Consider the use of multiple downspouts or an enlarged orifice leading to the downspout to reduce gutter size.

Consider installation of rain gardens at the outlets to clean, transpire and infiltrate runoff water.

Consider either a strainer at the head of the downspout, or a clean-out port on the riser pipe, when underground outlets are used.

Consider the use of wrap-around straps in lieu of rigid supports on steep roofs where the outer edge of the gutter cannot be placed below the projected roof line.

For cold climates, ensure the underground outlet is deep enough to avoid freezing or include a method to bypass the outlet without damage to the downspout.

PLANS AND SPECIFICATIONS

Provide plans and specifications for installing a roof runoff structure that describe the requirements for applying this practice to achieve its intended purpose. At a minimum, include the location, size, and any specific installation instructions of all gutters and spacing of downspouts, type of ground gutters, outlets, and the types and quality of material to be used.

Include plans and specifications for other practices essential for the proper functioning of the roof runoff structure.

Instruct landowner and contractor of responsibility to locate all buried utilities in the project area, including drainage tile and other structural measures.

OPERATION AND MAINTENANCE

Develop an operation and maintenance plan that is consistent with the purposes of the practice, site conditions, and safety requirements. The plan will contain, but not be limited to, the following provisions:

- Keep roof runoff structures clean and free of obstructions that reduce flow.
- Make regular inspections and perform cleaning and maintenance as needed.

REFERENCES

NRCS, 2009, National Engineering Handbook, Part 651, Agricultural Waste Management Field Handbook, Chapter 10, Agricultural Waste Management System Component Design

NRCS, 2009, National Engineering Handbook Part 651, Agricultural Waste Management Field Handbook, Chapter 10 Appendix 10B.

NRCS, National Engineering Handbook, Part 650, Engineering Field Handbook, Chapter 2, Estimating Runoff

NRCS National Engineering Manual, Part 536.20, Design Criteria for Reinforced Concrete

NRCS National Engineering Handbook, Part 642, Construction Specification 32, Structural Concrete

NRCS National Agricultural Engineering Technical Note 1, Roof Runoff Management – Gutter Selection size.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

ACCESS ROAD

CODE 560

(ft)

DEFINITION

An access road is an established route for equipment and vehicles.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- To provide a fixed route for vehicular travel for resource activities involving the management of conservation forestry operations, livestock, agriculture, wildlife habitat, and other conservation enterprises

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where access is needed from a private or public road or highway to a land use enterprise or conservation measure, or where access is needed in a planned land use area.

Access roads range from single-purpose, seasonal-use roads, designed for low speed and rough driving conditions, to all-purpose, all-weather roads. Single-purpose roads provide access to areas such as forest fire lines, forest management activities, remote recreation areas, or for maintenance of facilities.

This practice does not apply to temporary or infrequently used trails used for logging. Use NRCS Conservation Practice Standard (CPS) Forest Trails and Landings (Code 655) to meet this need. Trails and walkways used for animals, pedestrians, or off-road vehicles are addressed in NRCS CPS Trails and Walkways (Code 575).

CRITERIA

General Criteria Applicable to All Purposes

Design the access road to serve the enterprise or planned use with the expected vehicular or equipment traffic. Factors in the design include the type of vehicle or equipment and the speed, loads, soils, climate, turning radius, and other conditions under which vehicles and equipment are expected to operate.

Location

Locate the access road to serve the purpose intended, to facilitate the control and disposal of surface and subsurface water, to control or reduce erosion, and to make the best use of topographic features. Design the layout of the road to follow natural contours and slopes to minimize disturbance of drainage patterns. Locate the access road where it can be maintained and where water management problems are not created. To reduce potential pollution, position the road as far as possible from water bodies and watercourses. To the extent possible, do not impede overland flow.

Alignment
Adapt the gradient and horizontal alignment to the intensity of use, the mode of travel, the type of equipment and load weights, and the level of development.

Grades normally should not exceed 10 percent except for short lengths. A maximum grade of 15 percent should only be exceeded if necessary for special uses such as field access roads or fire protection roads.

Width
The minimum width of the roadbed for an all-purpose road is 14 feet for one-way traffic and 20 feet for two-way traffic. The roadbed width includes a tread-width of 10 feet for one-way traffic or 16 feet for two-way traffic and 2 feet of shoulder width on each side. Increase the two-way traffic width by a minimum of 4 feet for trailer traffic. Single-purpose roads will have a minimum width of 10 feet with greater widths at curves and turnouts. Use vegetation or other measures to protect the shoulders from erosion.

Use turnouts on single lane roads where vehicles travel in both directions on a limited basis. Design the turnout to accommodate the anticipated vehicle use.

Provide a turnaround at the end of dead end roads. Size the turnaround for the anticipated vehicle type that will be using the road.

Provide parking space as needed to keep vehicles from parking on the shoulder or other undesirable locations.

Side slopes
Design all cuts and fills to have stable slopes that are a minimum of 2 horizontal to 1 vertical. For short lengths, rock areas, or very steep hillsides, steeper slopes may be permitted if soil conditions warrant and special stabilization measures are installed. Where possible, design slopes to a minimum of 4 horizontal to 1 vertical to improve establishment and maintenance of turf.

Where possible, avoid areas with geological conditions and soils that are subject to slides. When the area cannot be avoided, treat the area to prevent slides.

Drainage
The type of drainage structures used will depend on the intended use and runoff conditions. Provide a culvert, bridge, ford, or surface cross drain for water management at every natural drainageway. The capacity and design of the drainage feature must be consistent with sound engineering principles and must be adequate for the class of vehicle, road type, land use in the watershed, and intensity of use.

When a culvert or bridge is installed in a drainageway, it must have a minimum capacity that is sufficient to convey the design storm runoff without causing erosion or road overtopping. Table 1 lists minimum design storm frequencies for various road types.

Table 1: Minimum design storm frequencies

Road Intensity and Usage	Storm Frequency
Intermittent; single-purpose or farm use	2 year - 24 Hour
Frequent; farm headquarters, livestock access, isolated recreation areas	10 year - 24 Hour
High intensity; residential or public access	25 year - 24 Hour

For public access roads, design storm frequencies must also meet local standards.

Use NRCS CPSs Stream Crossing (Code 578), or Aquatic Organism Passage (Code 396) when aquatic species are present, to design stream crossings.

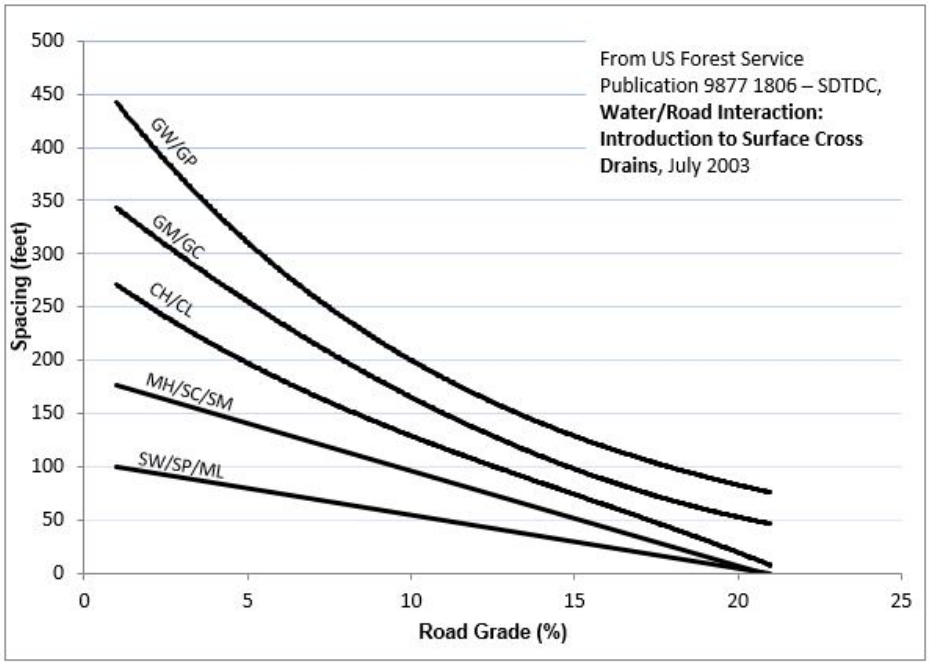
An erosion-resistant low point or overflow area may be constructed across the access road to supplement the culvert capacity on nonpublic-use roads.

Surface cross drains, such as broad-based or rolling dips, may be used to control and direct water flow off the road surface on low-intensity-use forest, ranch, or similar roads. Protect the outlets of drainage measures to limit erosion. On steep grades where water could run down the road, use a broad-based dip or other similar feature to divert runoff. The surface cross drain must be constructed of materials that are compatible with the use and maintenance of the road surface. The discharge area for a surface cross drain must be well-vegetated or have other erosion resistant materials (see fig. 1). Reduce separation distances as needed to account for local hydrologic conditions.

Design a minimum cross slope to direct precipitation off of the roadway. Cross slopes range from 1.5 to 2 percent for paved surfaces and 2 to 6 percent for unpaved surfaces.

Provide ditches, as needed, to move water away from the road. Maintain unobstructed flow into the ditches to prevent flows from causing roadside erosion. The capacity of a roadside ditch must be adequate to carry the drainage from the road surface. Design ditch channels to have stable grades and side slopes. Provide a stable outlet for the ditch. Protection may include riprap or other similar materials. Use NRCS CPSs Structure for Water Control (Code 587), Lined Waterway or Outlet (Code 468), or Grade Stabilization Structure (Code 410), if needed.

Figure 1. Recommended spacing of surface cross drains based on soil types



Surfacing

Install a wearing course or surface treatment on the access road if required by traffic needs, soil, climate, erosion control, particulate matter emission control, or other site condition. If none of these factors apply, no special treatment of the surface is required.

When a treatment is used, the type of treatment will depend on local conditions, available materials, and the existing road base. On roads made of soils with weak bearing capacity, such as silts, organics, and clays, or where it is necessary to separate the surfacing material from the foundation material, place a geotextile material specifically designed for road stabilization applications under the surface treatment. Use the criteria in NRCS CPS Heavy Use Area Protection (Code 561) to design the surface treatment. Do not use toxic and acid-forming materials to build the road.

If dust control is needed, use NRCS CPS Dust Control on Unpaved Roads and Surfaces (Code 373).

Safety
Provide passing lanes, turnouts, guardrails, signs, and other facilities as needed for safe traffic flow. Design an intersection to a public highway to meet applicable Federal, State, and local criteria.

Erosion control
Use the criteria in NRCS CPS Critical Area Planting (Code 342) or the NRCS State-approved seeding specification to vegetate road banks and disturbed areas as soon as soil and climatic conditions are favorable. If permanent vegetation cannot be established in a timely manner, use appropriate temporary measures to control erosion. If the use of vegetation is precluded and protection against erosion is needed, use the criteria in NRCS CPS Mulching (Code 484) to provide surface protection.

During and after construction, use erosion and sediment control measures to minimize offsite damages.

CONSIDERATIONS

Consider visual resources and environmental values during planning and design of the road system.

Consider locating roads outside of the active floodplain to reduce bank erosion potential and the effects on stream hydrology.

Limiting the number of vehicles and vehicle speed will reduce the potential for generation of particulate matter and decrease safety and air quality concerns.

Consider using additional conservation practices, such as NRCS CPSs Dust Control on Unpaved Roads and Surfaces (Code 373) or Windbreak/Shelterbelt Establishment (Code 380), to reduce the potential for generation and transport of particulate matter emissions.

During adverse weather, some roads may become unsafe or may be damaged by use. Consider restricting access to the road at that time.

When revegetation is needed, consider revegetating using species or diverse mixes that are native or adapted to the site and have multiple benefits. In addition, where appropriate, consider a diverse mixture of forbs and wildflowers to support pollinator and other wildlife habitat.

Consideration should be given to—

- Effects on downstream flows, wetlands, or aquifers that would affect other water uses or users.
- Effects on wildlife habitats that would be associated with the practice.
- Utilizing buffers where possible to protect surface water.
- Short-term and construction-related effects of this practice.

PLANS AND SPECIFICATIONS

Provide plans and specifications that describe the requirements for applying the practice to achieve its intended purpose. As a minimum, include—

- A plan view of the proposed road that shows water features, known utilities, and other features that affect the design.
- Road width and length with profile and typical cross section(s) including turnouts, parking, and turnarounds.
- Design road grades or maximum grades when applicable.
- Soils investigation. Include location of soil borings and plot of the soil/geologic boring showing the Unified Soil Classification System, as needed.
- Type and thickness of surface treatment including any subbase preparation.
- Grading plan.

- Cut and fill slopes where applicable.
- Planned drainage features.
- Location, size, type, length, and invert elevations of all required water control structures.
- Vegetative requirements that include vegetation materials to be used, establishment rates, and season of planting.
- Erosion and sediment control measures, as needed.
- Safety features.
- Construction and material specifications.

OPERATION AND MAINTENANCE

Prepare a written operation and maintenance plan for the access road. As a minimum, include the following activities:

- Inspect culverts, roadside ditches, water bars, and outlets after each major runoff event and restore flow capacity as needed. Ensure proper cross section is available and outlets are stable.
- Maintain vegetated areas in adequate cover to meet the intended purpose(s).
- Fill low areas in travel treads and regrade, as needed, to maintain road cross section. Repair or replace surfacing materials as needed.
- Selection of chemical treatment(s) for surface treatment or snow/ice removal, as needed. Select the chemicals used for surface treatment or snow and ice removal to minimize adverse effects on stabilizing vegetation.
- Selection of dust control measures, as needed.

REFERENCES

American Association of State Highway and Transportation Officials. 2011. A Policy on Geometric Design of Highways and Streets, 6th Edition. Washington, D.C.

American Association of State Highway and Transportation Officials. 2001. Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT $\leq$ 400). Washington, D.C.

Swift, L.W., Jr. 1988. Forest Access Roads: Design, Maintenance, and Soil Loss. *In*: W.T. Swank and D.A. Crossley, Jr. (ed.) Ecological Studies, Vol. 66: Forest Hydrology and Ecology at Coweeta. New York: Springer-Verlag: 313-324.

USDA Forest Service. 2003. Water/Road Interaction: Introduction to Surface Cross Drains, Publication 9877 1806 – SDTDC. Washington, D.C.

Weaver, W.E., E.M. Weppner, and D.K. Hagans. 2015. Handbook for Forest, Ranch & Rural Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Upgrading, Maintaining and Closing Wildland Roads (Rev. 1st ed). Mendocino County Resource Conservation District. Ukiah, CA. https://www.pacificwatershed.com/sites/default/files/RoadsEnglishBOOKapril2015b.pdf

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

HEAVY USE AREA PROTECTION

CODE 561

(sf)

DEFINITION

Heavy use area protection is used to stabilize a ground surface that is frequently and intensively used by people, animals, or vehicles.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- To provide a stable, noneroding surface for areas frequently used by animals, people, or vehicles
- To protect or improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where a frequently or intensively used area requires treatment to address one or more resource concerns.

CRITERIA

General Criteria Applicable to All Purposes

Design Load

Base the design load on the type and frequency of traffic, (vehicular, animal, or human) anticipated on the heavy use area.

Foundation

Evaluate the site foundation to ensure that the presumptive bearing capacity of the soil meets the intended design load and frequency of use.

Where necessary, prepare the foundation by removal and disposal of materials that are not adequate to support the design loads.

Use a base course of gravel, crushed stone, other suitable material, geotextile, or a combination of materials on all sites that need increased load bearing strength, drainage, separation of material and soil reinforcement. Refer to Natural Resources Conservation Service (NRCS), National Engineering Handbook, Part 642; Design Note 24, Guide for Use of Geotextiles; or other State-approved reference for geotextile selection.

If there is the potential for ground water contamination from the heavy use area, select another site or provide an impervious barrier. Make provisions to treat contaminated surface runoff from the impervious area.

Surface Treatment
Select a surface treatment that is stable and appropriate to the purpose of the heavy use area. Surface treatments must meet the following requirements according to the material used.

Concrete
Design slabs-on-ground subject to distributed stationary loads, light vehicular traffic, or infrequent use by heavy trucks or agricultural equipment in accordance with American Concrete Institute (ACI) *Guide for the Design and Construction of Concrete Parking Lots (ACI 330R)*. Design slabs-on-ground subject to regular or frequent heavy truck or heavy agricultural equipment traffic in accordance with ACI *Guide to Design of Slabs-on-Ground (ACI 360R).* Design liquid-tight slabs in accordance with ACI *Code Requirements for Environmental Concrete Structures, Slabs-on-Soil (ACI 350, Appendix H).*

Design concrete structures in accordance with NRCS National Engineering Manual (NEM), Part 536, *Structural Engineering*.

Bituminous Concrete Pavement
Refer to AASHTO Guide for Design of Pavement Structures or the applicable State highway department's specification for design criteria for bituminous concrete paving.

In lieu of a site-specific design for areas that will be subject to light use, pave with a minimum of 4 inches of compacted bituminous concrete over a subgrade of at least 4 inches of well-compacted gravel. Use bituminous concrete mixtures commonly used for road paving in the area.

Other Cementitious Materials
Cementitious materials, such as soil cement, agricultural lime, roller- compacted concrete, and coal combustion by-products (flue gas desulphurization sludge and fly ash), can be used to provide a durable, stable surfacing material. Based on the properties of the surface material, develop a site-specific mix design with compressive strengths necessary for the expected use and loading on the heavy use area. Select materials that are non-toxic and that have chemical properties that are compatible with the intended use.

Aggregate
Design aggregate surfaces for expected wear and intended use. In lieu of a site-specific design for areas that will be subject to light non-vehicular use, install a minimum combined thickness for aggregate surfacing and base course of 6 inches for livestock and 4 inches for other applications.

For other applications, use NRCS Technical Note (Title 210), Agricultural Engineering Note 4, "Earth and Aggregate Surfacing Design Guide," or other appropriate methodology to design aggregate thickness.

Mulches
Use a minimum layer thickness of 6 inches for materials such as limestone screenings, cinders, tanbark, bark mulch, brick chips, or shredded rubber. Mulches are not recommended for livestock or vehicular applications.

Vegetation
Select vegetation that can withstand the intended use. Establish the vegetation in accordance with the criteria in NRCS Conservation Practice Standard (CPS) Critical Area Planting (Code 342) or the appropriate State reference.

Other
Other materials can be used if they will serve the intended purpose and design life.

Structures
When a roof is needed to address the resource concern, use NRCS CPS Roofs and Covers (Code 367). For nonwaste applications, design structures according to the accepted engineering practice.

Drainage and Erosion Control
Include provisions in the design for surface and subsurface drainage, as needed. Include provisions for disposal of runoff without causing erosion or water quality impairment. To the extent possible, prevent surface water from entering the heavy use area.

Stabilize all areas disturbed by construction as soon as possible after construction. Refer to the criteria in NRCS CPS *Critical Area Planting (Code 342)* for establishment of vegetation. If vegetation is not appropriate for the site, use the criteria in NRCS CPS *Mulching (Code 484)* to stabilize the disturbed area.

Additional Criteria for Livestock Heavy Use Areas
Include other practices to collect, store, utilize, or treat manure and contaminated runoff where contaminated runoff will cause a resource concern.

Additional Criteria for Recreation Areas
The Americans with Disabilities Act of 1990 (ADA) requires recreation areas that are used by the public to be accessible to people with disabilities. Address accessibility requirements for new construction and when existing facilities are being altered.

CONSIDERATIONS

Heavy use areas can have a significant impact on adjoining land uses. These impacts can be environmental, visual and cultural. Select a treatment that is compatible with adjoining areas. Consider such things as proximity to neighbors and the land use where the stabilization will take place.

Vegetated heavy use areas may need additional materials such as geogrids or other reinforcing techniques or planned periods of rest and recovery to ensure that vegetative stabilization will succeed.

Consider the safety of the users during the design. Avoid slippery surfaces, sharp corners, or surfaces and structures that might entrap users. For heavy use areas used by livestock avoid the use of sharp aggregates that might injure livestock.

Paving or otherwise reducing the permeability of the heavily used area can reduce infiltration and increase surface runoff. Depending on the size of the heavy use area, this can have an impact on the water budget of the surrounding area. Consider the effects to ground and surface water.

Installation of heavy use area protection on muddy sites can improve animal health. Mud transmits bacterial and fungal diseases and provides a breeding ground for flies. Hoof suction makes it difficult for cattle to move around in muddy areas. In addition, mud negates the insulation value of hair coat and the animals must use more energy to keep warm. As temperatures fall, animal bunching may occur, which can reduce or eliminate vegetative cover and lead to erosion and water quality concerns.

To reduce the negative water quality impact of heavy use areas, consider locating them as far as possible from waterbodies or water courses. In some cases, this may require relocating the heavily used area rather than just armoring an area that is already in use.

To the extent possible, maintain a 2 foot separation distance between the bottom of the surface material and the seasonal high water table or bedrock.

To reduce the potential for air quality problems from particulate matter associated with a heavy use area, consider the use of NRCS CPS *Windbreak/Shelterbelt Establishment (Code 380)*, *Herbaceous Wind Barriers (Code 603)*, *Dust Control from Animal Activity on Open Lot Surfaces (Code 375)*, or *Dust Control on Unpaved Roads and Surfaces (Code 373)* to control dust from heavy use areas.

Consider ways to reduce the size of the heavy use area as much as possible. This may require changes in how the livestock are managed but in the long run may result in less maintenance and a more efficient operation.

For areas that will need to be cleaned frequently by scraping, loose aggregate or other non-cementitious materials may not be the best choice. Consider a more durable surface such as concrete.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for heavy use area protection that describe the requirements for installing the practice according to this standard. As a minimum the plans and specifications shall include—

- A plan view showing the location and extent of the practice. Include the location and distances to adjacent features and known utilities.
- Typical sections showing the type and required thickness of paving or stabilization materials.
- A grading plan, as needed.
- Where appropriate, plans for required structural details.
- Method and materials used to stabilize areas disturbed by construction.
- Construction specifications with site-specific installation requirements.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance (O&M) plan and review with the operator prior to practice installation. The minimum requirements to be addressed in the O&M plan are—

- Periodic inspections—annually and immediately following significant rainfall events.
- Prompt repair or replacement of damaged components, especially surfaces that are subjected to wear or erosion.
- For livestock heavy use areas, include requirements for the regular removal and management of manure, as needed.
- For vegetated heavy use areas, restrict use as needed to protect the stand and to allow vegetative recovery.

REFERENCES

American Concrete Institute. 2006. Design of Slabs-on-Ground. ACI Standard 360R-06. Farmington Hills, MI.

Korcak, R. F. 1998. Agricultural Uses of Coal Combustion Byproducts. P. 103-119. *In* Wright, R. J., et al (eds.) Agricultural Uses of Municipal, Animal and Industrial Byproducts. USDA-ARS, Conservation Research Report 44.

USDA-Natural Resources Conservation Service. 2014. Agricultural Engineering Note 4, *Earth and Aggregate Surfacing Design Guide*, Washington, DC.

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

UNDERGROUND OUTLET

CODE 620

(ft)

DEFINITION

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

PURPOSE

This practice is used to accomplish the following purpose:

- To carry water to a suitable outlet from terraces, water and sediment control basins, diversions, waterways, surface drains, other similar practices or flow concentrations without causing damage by erosion or flooding

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- Disposal of surface water is necessary.
- An outlet is needed for a terrace, diversion, water and sediment control basin or similar practice and a surface outlet is impractical because of stability problems, topography, climatic conditions, and land use or equipment traffic.

CRITERIA

General Criteria Applicable to All Purposes

Components of underground outlets, including inlet collection boxes and conduit junction boxes, must be designed with sufficient size to permit maintenance and cleaning operations.

Perforated components of underground outlets must be designed to prevent soil particle movement into the underground outlet. Refer to Conservation Practice Standard 606, Subsurface Drain, for criteria for design of filters.

Fire resistant materials must be used for underground outlet components if fire is an expected hazard. All plastics must be UV resistant or protected from exposure to sunlight.

Capacity

The design capacity of the underground outlet will be based on the requirements of the structure or practice it serves. The underground outlet can be designed to function as the only outlet for a structure or in conjunction with other types of outlets. The capacity of the underground outlet must be adequate for the intended purpose without causing inundation damage to crops, vegetation, or works of improvement.

The underground outlet must be designed to account for anticipated water surface conditions at the outlet during design flow.

Flood routing techniques may be used to determine the relationship between flooding duration, underground release rate, and basin storage volume.

Underground outlets may be designed for either pressure or gravity flow. If designed as a pressure system, all pipes and joints must be adequate to withstand the design pressure, including surge pressure and vacuum conditions.

For gravity flow systems, utilize a flow restricting device such as an orifice or weir to limit flow into the conduit or choose conduit sizes that are large enough to prevent pressure flow

An underground outlet must not be designed to discharge into a structure unless the structure is designed to accommodate the additional inflow.

Pressure-relief wells may be used to allow excess flow to escape the conduit and flow over the ground surface. Use pressure relief wells only where there is a stable outlet for the flow from the relief well. Pressure relief wells should be covered with a grate or other appropriate covering to prevent the entry of small animals and debris.

Inlet
An inlet can be a collection box, blind inlet (gravel), perforated riser, perforated conduit, or other appropriate device.

Open inlets must have a trash guard. Design the inlet to permit trash or debris entering the inlet to pass through the flow restricting device and conduit without plugging.

Perforated riser inlets must be durable, structurally sound, and resistant to damage by rodents or other animals. Perforations must be smooth, free of burrs, and have adequate capacity to prevent the riser from restricting flow in the underground outlet.

Blind inlets may be used where the installation of an open or above ground structure is impractical. Design the blind inlet to prevent soil particle movement into the conduit.

Conduit
The minimum allowable diameter of conduits is 4 inches. Conduit joints must be hydraulically smooth and consistent with the manufacturer’s recommendation for the conduit material and installation.

Design the underground outlet to ensure that maximum allowable loads on the conduit are not exceeded for the type and size of conduit. Depth of cover requirements must be assessed to prevent damage to the underground outlet from tillage operations and frost action.

Thrust blocking or anchoring must be provided where needed to prevent undesired movement of the conduit. Placement and bedding requirements for the conduit are required to ensure integrity of the installation.

The flow velocity in the conduit must not exceed the maximum allowable design velocity for the conduit materials and installation condition. Gravity flow systems must maintain a positive grade throughout the conduit length towards the outlet.

Refer to Conservation Practice 606, Subsurface Drain, for criteria for design loading, thrust blocking, placement and bedding requirements, and minimum and maximum design velocity in the conduit.

Materials
All materials specified in Conservation Practice Standard 606, Subsurface Drain, may be used for underground outlets. Materials must meet applicable site specific design requirements for leakage, external loading, and internal pressure including vacuum conditions.

Underground outlets must be conduits of continuous tubing, tile or pipe and may be perforated or non-perforated. Perforated outlets must be designed to prevent soil particle movement into the conduit.

Outlet
The outlet must be stable and protected against erosion and undermining for the range of design flow conditions.

The outlet must consist of a continuous section of pipe, 10 feet or longer, without open joints or perforations, and with stiffness necessary to withstand expected loads, including those caused by ice.

A shorter section of closed conduit may be used if a headwall is used at the outlet of the conduit.

All outlets must have animal guards to prevent the entry of rodents or other animals. Design animal guards to allow passage of debris while blocking the entry of animals large enough to restrict the flow in the conduit.

A vertical outlet may be used to discharge water to the ground surface where topography does not allow adequate conduit cover using a horizontal outlet, or where it is practical to discharge over a vegetated filter strip.

The vertical outlet (relief well) must be adequately perforated and placed in an envelope of coarsely graded aggregate to allow the system to drain during periods when not in use.

Stabilization
Reshape and regrade all disturbed areas so that they blend with the surrounding land features and conditions. For areas that will not be farmed, refer to Conservation Practice Standard 342, Critical Area Planting, for establishment of vegetation criteria. Permanent vegetation must be established on all disturbed areas as soon as possible after construction.

CONSIDERATIONS

Pressure relief wells and vertical outlets, if not properly covered, can present a safety hazard for people or animals and may be damaged by field equipment. Pressure relief wells and vertical outlet locations should be identified with a high visibility marker.

Consideration should be given to the effects that the underground outlet may have on water quantity downstream. Consider these long term environmental, social, and economic effects when making design decisions for the underground outlet and the structure or practice it serves. Refer to Conservation Practice Standard 554, Drainage Water Management, for criteria on flow restriction from natural basins.

To prevent sediment from collecting in the conduit, underground outlets should be designed with a minimum velocity of 1.4 ft/sec.

If perforated pipe is used for the subsurface conduit, locate the practice so that it has a minimal effect to the hydrology of wetlands.

Where wetlands may be affected, the cooperator will be advised and current NRCS wetland policy will apply.

Seasonal water sources can be beneficial for migratory waterfowl and other wildlife. Consider the use of a water control structure, on the inlet of an underground outlet, during non-cropping periods to provide water for wildlife. Refer to Conservation Practice Standard 646, Shallow Water Development and Management, for information on managing seasonal water sources for wildlife.

Underground outlets can provide a direct conduit to receiving waters for contaminated runoff from crop land. Underground outlets and the accompanying structure or practice should be installed as part of a

conservation system that addresses issues such as nutrient and pest management, residue management and filter areas.

The construction of an underground outlet in a riparian corridor can have an adverse effect on the visual resources of the corridor. Consider the visual quality of the riparian area when designing the underground outlet.

Consider potential effects of soil physical and soil chemical properties influence on area where a conduit or system of conduits are installed to convey surface water. Refer to soil survey data as a preliminary planning tool for assessment of areas. Consult the Web Soil Survey to obtain soil properties and qualities information.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for underground outlets that describe the requirements for applying this practice according to this standard. The plans and specifications for an underground outlet may be incorporated into the plans and specifications for the structure or practice it serves. As a minimum the plans and specifications must include:

- A plan view of the layout of the underground outlet.
- Typical cross sections and bedding requirements for the underground outlet.
- Profile of the underground outlet.
- Details of the inlet and outlet.
- Seeding requirements if needed.
- Construction specifications that describe in writing the site specific installation requirements of the underground outlet.

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. The minimum requirements to be addressed in a written operation and maintenance plan are:

- Periodic inspections, especially immediately following significant runoff events, to keep inlets, trash guards, and collection boxes and structures clean and free of materials that can reduce flow.
- Prompt repair or replacement of damaged components.
- Repair or replacement of inlets damaged by farm equipment.
- Repair of leaks and broken or crushed lines to insure proper functioning of the conduit.
- Periodic Inspection of the outlet and animal guards to ensure proper functioning.
- Repair of eroded areas at the pipe outlet.
- Maintenance of adequate backfill over the conduit.
- To maintain the permeability of surface materials on blind inlets, periodic scouring or removal and replacement of the surface soil layer may be necessary.

REFERENCES

USDA, NRCS. National Engineering Handbook, Part 650 Engineering Field Handbook, Chapters 6, 8 & 14.

Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/app/

Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

VEGETATED TREATMENT AREA

CODE 635

(ac)

DEFINITION

An area of permanent vegetation used for agricultural wastewater treatment.

PURPOSE

This practice is used to accomplish the following purpose:

- Improve water quality by using vegetation to reduce the loading of nutrients, organics, pathogens, and other contaminants associated with livestock, poultry, and other agricultural operations

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where:

- A vegetated treatment area (VTA) can be constructed, operated and maintained to treat contaminated runoff from such areas as feedlots, feed storage, compost areas, solid manure storage areas, barnyards, and other livestock holding areas; or to treat process wastewater from agricultural operations.
- A VTA is a component of a planned agricultural waste management system.

CRITERIA

General Criteria Applicable to All Purposes

Vegetated treatment areas shall comply with all applicable laws, rules, regulations, and permit requirements including those applicable to the discharges of waters to the state.

Flows leaving a Vegetated Treatment Area that is built, operated, and maintained according to this standard are not considered process wastewater by New York State Department of Environmental Conservation (DEC).

Size the total treatment area for the VTA on both the contributing site water runoff and vegetation nutrient balances.

- Water balance is the soil's capacity to infiltrate and retain runoff within the root zone. Base the runoff determination on the most restrictive soil layer within the root zone regardless of its thickness. Use the soil's water holding capacity in the root zone, infiltration rate, permeability, and hydraulic conductivity to determine its ability to absorb and retain runoff.
- Nutrient balance utilizes the nutrients from the waste runoff to meet the nutrient removal in the harvested vegetation considering volatilization, soil adsorption, denitrification, organic matter deposition, and allowable percolation. Base the nutrient balance on the most limiting nutrient (i.e. nitrogen or phosphorus).

Evaluate the site for nitrogen leaching using the Nitrogen Leaching Index.

- On sites with a Leaching Index greater than 10 and soil hydrologic group A, select either a different site, replace the in-situ soil, or modify the soil properties to lower the soil hydrologic group to a B, C, or D classification.
- On sites with a Leaching Index greater than 10 and soil hydrologic group B, C or D, a VTA may be used by increasing the treatment area by 10 percent for each index value of 1 over 10.

Evaluate the site for phosphorus loading using the Morgan P soil test procedure or equivalent. Collect composite samples (six cores per acre prorated based on the size of the site) from the full root zone (6 to 8 inches). Soils with phosphorus results which are greater than 80 pounds per acre Morgan P or equivalent are not acceptable. Soil may be removed and replaced to achieve an acceptable P level.

Divert uncontaminated water from the treatment area to the fullest extent possible.

Establish permanent herbaceous vegetation in the treatment area. Permanent herbaceous vegetation shall be designed to achieve a minimum stand density of 85 percent ground cover within one year. Use grasses, legumes, and other forbs adapted to the soil and climate. Select species to meet the current site conditions and intended use. Selected species will have the capacity to achieve adequate density, vigor, and yield to treat contaminated runoff before discharge into a receiving surface water or wetland. Complete site preparation and seeding at a time and in a manner that best ensures survival and growth of the selected species.

Select vegetation that will withstand anticipated wetting or submerged conditions. Harvest vegetation as appropriate to encourage dense growth, maintain an upright growth habit, and remove nutrients and other contaminants that are contained in the plant tissue.

Exclude all livestock, including grazing, from the VTA.

Design the VTA based on the need to treat the runoff volume from the 25-year, 24-hour storm event from the agricultural animal management facility. Infiltrate a portion or the entire volume of the design storm, based on management objectives. Where required by specific water quality criteria, store the non-infiltrated portion of the design volume for utilization or treatment.

Apply discharge into and through vegetated treatment area as sheet flow at design depth of no greater than 0.5 inches. To encourage sheet flow across the treatment area, provide a means to disperse concentrated flow, such as a ditch, curb, gated pipe, level spreader, or a sprinkler system. Complete land grading and install structural components necessary to maintain sheet flow throughout the treatment area.

Vegetated treatment areas must have a minimum flow length of 100 feet. Limit the natural or constructed slope of the VTA from 0.3 to 6 percent. Install provisions to remove standing water on slopes flatter than 1 percent. The minimum entrance slope to the VTA is 1 percent. Slopes greater than 6 percent may be used where the soils saturated hydraulic conductivity is above 1.4 micrometer per second (0.2 inches per hour). Increase the length of the VTA by 20 feet for each percent of slope greater than 6 percent. Confirm that the VTA will not erode.

Use NRCS Conservation Practice Standard (CPS) Code 632, Waste Separation Facility, to pre-treat influent with waste separation (i.e., settling basin and filter screens) to reduce organic loading and nutrients to levels that are tolerated by the VTA and to prevent excessive accumulation of solids in the treatment area.

Utilize inlet control structures to control the rate and timing of inflow during normal operations and to control inflow as necessary for operation and maintenance.

Site the VTA to ensure that the lower edge is no closer than 25 feet flow path from the nearest receiving surface water body and the entire treatment area is 100 feet or more from a well.

Where the required separation distance from the receiving surface water cannot be achieved, construct a berm to hold the 25-year, 24-hour runoff to block the flow path from the water body.

Locate VTAs outside of floodplains. However, if site restrictions require location within a floodplain, provide protection from inundation or damage from a 25-year flood event, or larger, if required by regulation.

Install VTAs where the water table is either naturally deep or artificially lowered so that the infiltrated runoff does not mingle with the groundwater at the bottom of the root zone. Maintain a minimum 2 feet of soil depth to groundwater table. The water table must not be closer than 2 feet from the bottom of unlined distribution trenches. Subsurface drainage within the VTA is not allowed. Subsurface drainage may be used to lower the seasonal high water table to an acceptable level provided the subsurface drain lines are at least 10 feet away from the VTA boundary or at least 1/2 the NY Drainage Guide recommendation tile spacing for the specific soil type recommendation, whichever is larger.

A minimum of 2 feet of soil depth is required between the bottom of unlined distribution trenches and bedrock. Maintain a minimum of 2 feet of soil depth between bedrock and the surface of the treatment area.

Unless soil moisture can be maintained to prevent drying and cracking, do not plan infiltration areas where soil features such as cracking will result in preferential flow paths that transport untreated runoff from the surface to below the root zone.

Ensure that appropriate erosion control measures and sheet flow control measures (i.e., gravel spreaders) are adequately addressed over the entire length of the VTA.

Additional Criteria for Runoff from Concentrated Livestock Areas

A VTA will be installed only in conjunction with a Comprehensive Nutrient Management Plan (CNMP). Source reduction to remove manure solids from the barnyard is an essential design and maintenance component for the continued functioning of the treatment area.

1. Influent Pre-treatment
    - A constructed settling basin shall have sufficient capacity, at a minimum, to store the runoff computed for 15 minutes duration at the peak inflow rate resulting from a 2-year, 24-hour rainfall event. Any basin outflow shall be disregarded in computing minimum storage. Additional storage capacity, based on frequency of cleaning, shall be provided for manure and other solids settled within the basin. When the basin is cleaned after every significant runoff event, additional storage equivalent to at least 0.5 inch from the concentrated livestock area shall be provided. If only annual cleaning of the basin is planned, additional storage equivalent to at least 6 inches from the concentrated waste area shall be provided.
2. Size of Vegetated Treatment Area
    - N loading from a barnyard will not exceed 500 pounds of N per acre of treatment area per year.
    - Minimum hydraulic dimensions shall be based on the routed peak outflow from the concentrated waste area or settling facility, based on a 25-year, 24-hour rainfall when storage is provided, but in no case less than the peak flow from a 2-year, 24-hour rainfall event when storage is not provided.
    - The flow length of a VTA shall be sufficient to provide at least 15 minutes of flow through time and any adjustments required for slopes over 6 percent. Table 1 gives flow velocities and minimum flow lengths for a VTA relative to the average land slope, for barnyard runoff treatment for various slopes as calculated using Manning's formula. Shallower depths would result in lower velocities and shorter flow lengths, with corresponding wider flow widths.

TABLE 1

VTA 15 minute flow length at maximum 0.5 inches of flow depth for barnyard runoff (Manning n = 0.24)

Average Land Slope (%)	Avg. Flow Velocity at 0.5 inch depth (feet/sec)	Flow Length (feet)
2	0.11	100
4	0.15	135
6	0.18	165
8	0.21	189 (229 min*)
10	0.24	212 (292 min*)
12	0.26	232 (352 min*)

** Adjusted length for extra slopes over 6 percent*

- Install mechanisms, where needed, to prevent continual flows into the VTA.

Additional Criteria for Treatment of Milking Center Wastes

Milking Center Waste VTAs apply to operations with 75 cows or less.

1. Influent Pre-treatment
   - Design measures to sufficiently handle all inputs from milkhouse waste stream.
   - A 3-day dosing or a 7-day maximum alternating VTA that allows alternating use and resting are required for systems producing greater than 300 gallons per day and all milking parlor applications.
   - Provide a settling tank that will exclude floating milk fats from the treatment system and provide a minimum 3-day storage capacity.
   - Pumping and gravity dosing will not be done from the settling tank.
2. Size of Vegetated Treatment Area
   - Provide a minimum of 10 square feet of treatment area per gallon per day of wash water.
   - Either use a flow meter, or estimate volume as 4 gallons per cow per day for milkhouse operations and 8 gallons per cow per day for milking parlor operations.
   - The effluent flow path shall be a minimum of 300 feet to the nearest receiving surface water as measured from the top of the VTA.

Additional Criteria for Treatment of Bunk Silo Leachate

1. Influent Pre-treatment
   - Use source control to reduce leachate volume and solids loadings to treatment area.
   - A VTA will be used only when concentrated low flows have been controlled and eliminated from the treatment area.
   - The amount of low flow collection will be monitored and adjusted to prevent a large kill zone from developing.
2. Size of Vegetated Treatment Area
   - Provide 1/3 acre of VTA for each one acre of contributing watershed area.
   - Effluent flow path shall be a minimum of 300 feet as measured from the top of the VTA to the end of the active treatment area.

Additional Criteria for Treatment of Compost Pad Runoff

1. Influent Pre-treatment
   - Compost and/or compost ingredients on pad shall be less than 70 percent moisture or have positive control of any leachate, such as roofs or tarps and/or leachate collection systems to insure that no leachate flows from the compost or ingredients.
   - A pad will only discharge effluent to the VTA when a precipitation event is occurring.
2. Size of Vegetated Treatment Area
   - Provide 1/3 acre of VTA for each acre of compost pad contributing watershed area.

- If effluent is collected and released then use Table 1 to determine flow length of the VTA.
- Effluent flow path shall be a minimum of 300 feet to the nearest receiving surface water as measured from the top of the VTA.

Additional Criteria for Calf Hutch Area Runoff

1. Influent Pre-treatment
   - Calf hutch layout and bedding amounts will provide no opportunity for liquid discharge without precipitation.
   - Collection systems will be installed as needed to insure that continuous discharges from the calf hutch area are eliminated.
   - A calf hutch area will only discharge effluent to the VTA when a precipitation event is occurring.
2. Size of Vegetated Treatment Area
   - Provide 1/3 acre of VTA for each acre of calf hutch contributing watershed area.
   - If effluent is collected and released then use Table 1 to determine flow length of the VTA.
   - Effluent flow path shall be a minimum of 300 feet to the nearest receiving surface water as measured from the top of the VTA.
   - An alternative size, for a long row of calf hutches, will be a VTA parallel to the pad 1/2 the flow path length of the contributing watershed area. Effluent flow path length to the nearest receiving surface water, measured from the bottom of the VTA, shall be 3 times the flow path distance through the linear calf hutch contributing watershed area of the VTA.

Additional Criteria for Pressure Dosing Systems

Distribute the effluent over the VTA through sprinkler irrigation or other pressure dosing system. Match the application rate of sprinkler nozzles to the most restrictive soil infiltration rate or other factors to prevent effluent application from discharging from the VTA.

CONSIDERATIONS

VTA Siting Considerations

- On-farm traffic patterns
- Accessibility to the milk house wastewater components
- Adjacent land uses and visibility
- Location and height of air vents to avoid the odors that may be prevalent in the pipeline
- Visual aesthetics to blend the system into the surrounding landscape
- Site, soil, and environmental factors
- Locating the VTA where prevailing winds will minimize odors and other aesthetic problems for neighbors
- Requiring more than 2 feet of soil depth where groundwater concerns are identified by the N index or where fractured bedrock or limestone is close to surface

Influent Pre-treatment Considerations

- Pre-treating overland flow influent with solid/liquid separation to reduce organic loading, odor generation, and maintenance requirements; site a settling facility before the pump station when waste is pumped to a VTA.

Size of VTA Considerations

- VTA sizing may be based on the Vegetated Treatment Area N-Loading calculator posted on the NY Field Office Technical Guide.
- Additional nutrient and infiltration design guidance in Vegetated Treatment Systems for Open Lot Runoff, (Koelsch, et. al., 2006). Consider that this manual was developed in a region with less

annual precipitation and more annual evaporation than New York State, and where VTA's typically include total collection of water in an irrigation lagoon.

- In general, longer, narrower treatment areas are preferable to shorter, wider areas. Use a serpentine or switchback VTA to provide a greater length of flow, if adequate treatment length of flow to provide the desired reduction of pollutants is not available.
- Install VTA on the contour and provide sufficient width to pass the routed peak or peak flow at a depth of 0.5 inches or less.
- Consider additional field level spreading mechanisms at 50 feet intervals to facilitate redistribution of the effluent flows to sheet flow. Direct contaminated effluent to a waste storage facility during excessively wet or cold conditions.
- Install fences or other measures to exclude or minimize access of the VTA to humans, vehicles or animals.
- Install a berm around the lower end of the VTA to contain excess runoff that may occur. Install a pumping system at the bottom of the VTA to either recirculate the effluent to the top of the VTA or transfer to a waste storage facility.
- Effluent from the VTA may be stored for land application, recycled through the wastewater management system, or otherwise used in the agricultural operation.
- Provide more than one vegetated treatment area to allow for resting, harvesting vegetation, maintenance, and to minimize the potential for overloading.

Vegetation Considerations

- To maximize nutrient uptake, use warm and cool season species in separate areas to ensure that plants are actively growing during different times of the year.
- During the vegetation establishment period, consider a temporary mechanism to divert flows from the VTA. In some cases, a temporary mechanism may be used to intermittently distribute flow on various portions of the VTA without adversely affecting the vegetation.
- Consider suspension of application to the treatment area when weather conditions are not favorable for aerobic activity or when soil temperatures are lower than 39° F. When soil temperatures are between 39° F and 50° F, consider reducing application rate and increasing application period while maintaining a constant hydraulic loading rate.

For Bunk Silos, Barnyards and Calf Hutch Areas

- To remove solid materials from the influent, consider using added storage and/or solid settling and skimming, such as a 3 tier screen system.
- Provide additional storage in the basin collection area to minimize or eliminate discharge into the VTA during rainfall events. Delay application until rainfall has ended to improve infiltration and nutrient uptake.

For Milking Center Wastes

- Consider source control to remove as much milk, debris, and manure from the waste stream as possible. Special consideration must be given when high Biological Oxygen Demand (BOD) loading and high solid contents are present. These conditions will occur when waste milk is dumped into the waste stream or manure from milking parlor floors is washed into the waste stream. Additional settling capacity and more frequent clean out will be required with high solid waste.
- Provide more than one vegetated treatment area to allow for resting, harvesting vegetation, and maintenance, and to minimize the potential for overloading.

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice to achieve its intended use.

As a minimum include:

- Critical construction perimeters, necessary construction sequence, vegetation establishment requirements, level spreader mechanism requirements, associated practices, and agronomic nutrient removal.
- Plan view showing the location of the VTA and pertinent adjacent land use information.
- Details of the length, width, and slope of the treatment area to accomplish the planned purpose (length refers to flow length down the slope of the treatment area).
- Herbaceous species, seed selection, and seeding rates to accomplish the planned purpose.
- Planting dates, care, and handling of the seed to ensure that planted materials have an acceptable rate of survival.
- Site preparation sufficient to establish and grow selected species.
- Show details of influent collection, pretreatment, storage and transfer systems.
- Describe the temporary influent diversion measures proposed to enable vegetation establishment.

OPERATION AND MAINTENANCE

Develop an operation and maintenance plan consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design.

Include the following items as appropriate:

Influent Pre-treatment O&M

- Inspect and maintain the pre-treatment system and evaluate the source for volume and concentration changes.
- Inspect and clean out influent pre-treatment systems at regular intervals. Inspect and clean out influent pre-treatment systems exposed to surface runoff after each rain event.
- Inspect, clean, and repair effluent spreader and redistribution devices regularly and after storm events to address gullies, and prevent concentrated flow.

Vegetation Area O&M

- Inspect and repair vegetative treatment areas after storm events to address gullies, reseed disturbed areas, and prevent concentrated flow.
- Control undesired weed species, especially state-listed noxious weeds, and other pests that could inhibit proper functioning of the VTA.
- Conduct maintenance activities only when the surface layer of the VTA is dry enough to prevent compaction. Routinely dethatch or aerate a treatment area used for treating runoff from livestock holding areas in order to promote infiltration.
- Maintain or restore the treatment area as necessary by periodically grading or removing excess material when deposition jeopardizes its function. Re-establish herbaceous vegetation. Apply supplemental nutrients and soil amendments as needed to maintain the desired species composition and stand density of herbaceous vegetation.
- Monitor any tile outlet used to lower the water table.
- For a VTA with a slope less than 1 percent or where a containment berm is built, the site shall be inspected to ensure vegetation is not stressed by inundation. Excess water shall be removed according to the nutrient management plan.

- Soil test every 3 years and evaluate the P level in the lower 1/3 of the VTA to the full extent of the root zone (12 inches). Monitor all treatment areas to maintain optimal vegetative growth and environmental protection. Ensure that neither excess phosphorus is accumulating in the soil profile, nor excess nitrogen is leaching below the root zone.
- Annually check the rate of nitrogen being applied to vegetation treatment area plant species, for silage leachate, size of the kill zone is an indicator of excess loading. If too large of a kill zone exists reduce loading rate.
- Manage the VTA to maintain vegetative treatment effectiveness throughout the growing season. Time the harvest of the VTA plants so vegetation can regrow to a sufficient height to effectively treatment effluent late in the growing season. Providing rest periods to maintain an aerobic soil profile. Storage with periodic dosing or alternating treatment areas may be desirable.

REFERENCES

USDA NRCS, National Engineering Handbook, Part 651, Agricultural Waste Management Field Handbook.

Koelsch, R., B. Kintzer, and D. Meyer. (ed.) 2006. Vegetated Treatment Systems for Open Lot Runoff - A Collaborative Report. USDA NRCS.

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Wright, P.E., L.D. Geohring, and S.F. Inglis. 2005. Effectiveness of low flow collection of silage leachate and vegetative filter area for CAFO farms. Final project for EPA sponsor agreement X-982586-00, Biological and Environmental Engineering Department, Cornell University, Ithaca, NY. 36.

Faalkner, J.W., W. Zhang, and L.D. Geohring. 2007. Evaluating vegetative filter areas for treating agricultural wastewaters. ASABE Paper #07-2243, ASABE, St. Joseph, MI.

Kim, Y.J., L.D. Geohring, J.H. Jeon, A.S. Collick, S.K. Giri, and T.S. Steenhuis. 2006. Evaluation of the effectiveness of vegetative filter strips for phosphorus removal with the use of a tracer. Journal of Soil and Water Conservation 61(5);293-302.

The New York Nitrate Leaching Index http://nmsp.cals.cornell.edu/publications/nindex.html

The New York VTA Sizing Spreadsheet Vegetated Treatment Area N loading calculator spreadsheet found in the FOTG, Section IV, Table of Contents.