APPENDIX G — U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE STANDARDS & SPECIFICATIONS FOR SELECTED STORM WATER QUALITY MANAGEMENT MEASURES

This appendix contains reproduced copies of selected storm water management practices contained in the U.S. Department of Agriculture, Natural Resources Conservation Service Field Office Technical Guide. The practices included here were selected based on their ability to manage and treat storm water runoff from construction and post-construction activities.

The practices in this appendix have been included as an alternative to visiting a Natural Resources Soil Conservation/Soil and Water Conservation District office to view the complete Technical Guide which consists of several large binders of materials.

The standards and specifications contained herein are updated periodically and were current at the time of this manual's initial publication. Local Natural Resources Soil Conservation/ Soil and Water Conservation District offices should be contacted when there is a question or concern in regard the current date of a particular practice or practices.

Storm Water Management Practices

- Constructed Wetland
- Diversion
- Filter Strip
- Grade Stabilization Structure
- Grassed Waterway
- Lined Waterway or Outlet
- Mulching
- Pond
- Riparian Forest Buffer
- Sediment Basin
- Streambank and Shoreline Protection
- Stream Channel Stabilization
- Subsurface Drain
- Tree/Shrub Establishment
- Well Decommissioning

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Constructed Wetland

(Acre)

Code 656

DEFINITION

A constructed shallow water ecosystem designed to simulate natural wetlands.

PURPOSES

To reduce the pollution potential of runoff and wastewater from agricultural lands to water resources.

CONDITIONS WHERE PRACTICE APPLIES

- Where a constructed wetland is a component of a planned conservation system or agricultural waste management system
- Where wastewater or runoff originates from agricultural lands including livestock or aquaculture facilities
- Where a constructed wetland can be constructed, operated and maintained without polluting air or water resources

This practice does <u>not</u> apply to:

- wetland restoration (FOTG Standard 657) intended to rehabilitate a degraded wetland where the soils, hydrology, vegetative community, and biological habitat are returned to original conditions
- wetland enhancement (FOTG Standard 659) intended to rehabilitate a degraded wetland where specific functions and/or values are enhanced beyond original conditions
- wetland creation (FOTG Standard 658) for creating a wetland on a site location which historically was not a wetland, or was a wetland with a different hydrology, vegetation type, or functions that occurred naturally on site.

CRITERIA

<u>General Criteria Applicable To All Purposes</u>

Laws and Regulations. All federal, state, and local laws, rules and regulations governing the use of constructed wetlands must be followed. Constructed wetland for waste treatment shall not be designed to discharge to waters of the state unless permitted by state laws and regulations, and appropriate permits have been obtained to do so. In addition, if discharge is permitted, the receiving surface water must have the capacity to assimilate constructed wetland's effluent during low flow periods.

Location: Constructed wetlands shall be located outside the limits of wetlands of any classification

Constructed wetlands located within a floodplain shall be protected from inundation or damage from a 25-year flood event, or larger, if required by laws, rules, and regulations.

Type. Constructed wetlands shall be designed as surface flow systems consisting of adequate seepage control, a suitable plant medium, rooted emergent hydrophytic vegetation, and the structural components needed to contain and control the flow.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Indiana NRCS FOTG – December 2001.

Influent. The influent to the constructed wetland shall be pretreated to reduce the concentrations of solids, organics, and nutrients to levels that will be tolerated by wetland plants and not cause excessive accretion within the wetland.

Where significant sediment and organic debris are expected in the wastewater or runoff to be treated, provisions for its entrapment before entry into the wetland must be provided.

Water budget. A water budget that evaluates runoff or wastewater volumes, precipitation, evaporation, and water use shall be used to determine the required hydraulic retention time in the wetland and storage requirements of the wetland pretreatment and post treatment facilities when included.

Embankment. The perimeter embankment shall have a minimum top width of 10 feet. Interior embankments shall have a minimum top width of 8 feet. All embankment side slopes shall be 2 horizontal to 1 vertical or flatter.

The embankments shall be seeded according to Table 1.

Table 1. Seeding mixes for embankments.

Species	PLS Rates/AC
[1,2] Orchardgrass	6
Timothy	2
Annual Lespedeza	4
Ladino Clover	¼
[1] Redtop	2
Orchardgrass	6
Annual Lespedeza	4
Ladino Clover	¼
[1] Redtop	2
Timothy	2
Red Clover	2
Annual Lespedeza	4
Orchardgrass	6
Timothy	2
Alfalfa	6
Ladino Clover	¼
[3] Smooth Brome	10
Alfalfa	6
Ladino Clover	¼
Birdsfoot Trefoil	4
[4] Timothy	2
Smooth Bromegrass	10
Alsike Clover	1
Birdsfoot Trefoil	4
[1] Timothy	2
Ky. Bluegrass	3
Annual Lespedeza	4
Birdsfoot Trefoil	4
Switchgrass	8

Species	PLS Rates/AC
[4] Redtop	2
Timothy	2
Alsike Clover	2
Birdsfoot Trefoil	4
[1] Redtop	2
Ky. Bluegrass	3
Annual Lespedeza	4
Ladino Clover	¼
[1] Orchardgrass	6
Timothy	2
Red Clover	2
Ladino Clover	¼
Annual Lespedeza	4
[3] Smooth Bromegrass	10
Timothy	2
Ladino Clover	¼
Birdsfoot Trefoil	4
[1] Orchardgrass	6
Timothy	2
Red Clover	2
Sweet Clover	3
[1] Timothy	2
Ky. Bluegrass	3
Annual Lespedeza	4
Red Clover	2
Orchard grass	6
Timothy	2
Ladino Clover	¼
Birdsfoot Trefoil	4

[1] Better suited for the Southern part of Indiana
[2] Can be used on droughty sites
[3] Better suited for the Northern part of Indiana
[4] Can be used on wet sites

Indiana NRCS FOTG – December 2001.

Note: 2 to 8 oz of any single or combination of the forb species listed below can be added to any of the above mixtures for added wildlife and aesthetic benefits or substituted for one of the legumes in the mix.

Forb Species

Blackeyed Susan	Illinois Bundle Flower	Stiff Goldenrod
Butterflyweed	New England Aster	Sunflower Heliopsis
Button Blazing Star	Partridge Pea	Tall Coreopsis
Dense Blazing Star	Prairie Dock	Virginia Mountain Mint
Entire-Leaf Rosinwood	Purple Coneflower	Wild Bergamot
Gray-Headed Coneflower	Sawtooth Sunflower	

Vegetation. Vegetation shall be established in wetland cells prior to loading. Vegetation selected for the constructed wetland cells shall be hydrophytic plants suitable for local climatic conditions and tolerant of the concentrations of nutrients, pesticides, and other constituents in the runoff or wastewater stream and selected for their treatment potential.

Preference shall be given to native wetland plants with localized genetic material. Plant materials collected or grown from material collected within a 200-mile radius from the site is considered local. See Table 2 for recommended plants.

Table 2. Recommended Plants

Deep Water Emergent Community (1-3 foot depth)	
Yellow Pond Lily	Nuphar advena
White Water Lily	Nymphaea odorata
Shallow Water Emergent Community (0-1 foot depth)	
Lake Sedge	Carex lacustris
Soft Rush	Juncus effusus
Hardstem Bulrush	Scripus acutus
Woolgrass	Scripus cyperinus
Three-Square Bulrush	Scripus pugens
Softstem Bulrush	Scripus validus
Sweet Flag	Acorus calamus
Pickerel Weed	Pontederia cordata
Common Arrowhead	Sagittaria latifolia
Blue Flag Iris	Iris virginica shrevei
Giant Burreed	Sparganium eurycarpum
Sedge Meadow Community (saturated soils)	
Frank's Sedge	Carex frankii
Bottlebrush Sedge	Carex granularis
Awl-Fruited Sedge	Carex stipata
Tussock Sedge	Carex stricta
Fox Sedge	Carex vulpinoidea
Virginia Wildrye	Elymus virginicus
Rice Cutgrass	Leersia oryzoides
Fowl Manna Grass	Glyceria striata
Switchgrass	Panicum virgatum
Dark Green Bulrush	Scripus atrovirens
Red Bulrush	Scripus pendulus
Swamp Milkweed	Asclepias incarnata
New England Aster	Aster novae-angliae
Swamp Aster	Aster puniceus
Spotted Joe-Pye Weed	Eupatorium maculatum
Boneset	Eupatorium perfoliatum
Autumn Sneezeweed	Helenium autumnale
Cardinal Flower	Lobelia cardinalis
Great Blue Lobelia	Lobelia siphilitica
Obedient Plant	Physostegia virginiana
Riddell's Goldenrod	Solidago riddellii
Blue Vervain	Verbena Hastata

Planting medium. The soil used for the planting medium shall have a cation exchange capacity, pH, electrical conductivity, soil organic matter, and textural class that is conducive to wetland plant growth and retention of contaminants.

Seepage control. The constructed wetland shall be located in soils with a permeability that meets all applicable regulations, or it shall be lined. Measures for controlling seepage shall meet the criteria of Waste Treatment Lagoon (Practice Standard 359), and Waste Storage Structure (Practice Standard 313).

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Livestock shall be excluded from the wetland.

Use Part 637 Environmental Engineering, National Engineering Handbook, Chapter 3 Constructed Wetlands as a guide for design.

Additional Criteria for Waste Treatment

Topography. Site topography shall accommodate the requirements for length to width ratios of the wetland and the wetland cells, and the requirement that the wetland cells be level side to side and grades of less than 0.05 ft/ft lengthwise. The wetland shall have a bottom elevation that is a minimum of 2 feet above the high water table.

Inlet. An inlet structure that will allow control of flow discharged to wetland and separation of solids from influent to prevent debris from entering wetland shall be provided. Design of the inlet structure shall assure its function throughout the life of the wetland considering accretion. The inlet shall be designed to direct or exclude flows to each row of cells. Criteria in NRCS Practice Standard 313, Waste Storage Facility, for fabricated structures shall apply as appropriate.

Influent. Constructed wetlands for wastewater treatment shall not allow for direct inclusion of contaminated and/or uncontaminated runoff.

Wastewater will be of sufficient volume and duration to keep the constructed wetland moist at all times or accommodations shall be made for the addition of supplemental water.

Surface Area. The surface area of the wetland shall be determined using a recognized design procedure in consideration of loading, temperatures, and the desired level of treatment,

Configuration. The constructed wetland shall have an overall length to width ratio of 1:1 to 4:1. Individual cells within the constructed wetland shall have a length-to-width ratio of 10:1 to 15:1. The wetland shall consist of at least two rows of parallel cells.

Flow depth. The design depth shall be based on the most severe season of operation, the desired level of treatment, and the required littoral zone of the plant species being used. The design depth shall be a minimum of 0.33 ft. and a maximum of 1.5 ft.

Embankments. Height of the constructed wetland perimeter embankment shall be the sum of the following:

- Design depth
- Wetland accretion -- a minimum of 1 inch per year for the design life
- 25-year, 24-hour precipitation
- 12 inches of freeboard

The height of wetland's interior embankments shall be the sum of the following:

- Normal design flow depth
- Wetland accretion -- minimum of 1 inch per year for the design life

Overflow Device. An ungated overflow device shall be provided to operate when the 25-year, 24-hour precipitation is exceeded. The overflow device shall operate without infringing on the wetland perimeter embankment's freeboard.

Outlet. Wastewater discharged from the constructed wetland shall be transferred to a waste storage facility, a waste treatment lagoon, or other facility for further treatment and/or utilization unless discharge is permitted by regulations.

An outlet structure shall be provided that allows maintenance of proper water level in the wetland and controls the flow from the wetland.

Additional Criteria For Runoff Treatment

Design Storm. The constructed wetland system shall be designed to contain a 2-year storm runoff. Limited area sites handling only the "first flush" volume shall have a minimum capacity to store 0.5 inch of runoff volume from the entire drainage area. When less than full runoff is stored, bypass of the excess storm flow shall be provided.

Detention time and surface area. The detention time and surface area shall be calculated on the time required to achieve the required level of treatment based on the limiting contaminant present.

Wetland Cells. Length to width ratios are to be 4:1 to 10:1. Other dimensions and shapes that provide a more natural landscape appearance that meet treatment requirements can be used.

The standards and specifications for Dike (FOTG Standard 356) and Structure for Water Control (FOTG Standard 587) will be used as appropriate. Refer to the Engineering Field Handbook, Chapters 13, "Wetland Restoration, Enhancement, and Creation," and 6, "Structures," for additional design information. Existing drainage systems will be utilized, removed, or modified as needed to achieve the intended purpose.

Depth. Maximum water depth shall be 24 inches except in those instances where deep water areas are included as a special design.

Outlet. A water control structure to automatically regulate storage release in accordance with the design detention time shall be installed.

CONSIDERATIONS

Locate constructed wetlands downgrade and as near the source of wastewater as practical.

Constructed wetlands shall be located to provide sufficient separation distances so prevailing winds and landscape elements such as building arrangement, landforms, and vegetation will minimize odors and protect aesthetic values.

Install measures to exclude or minimize attractiveness of the constructed wetland to wildlife that could be adversely affected by the constructed wetland. Take measures to exclude burrowing animals should they frequent the wetland. Consider the use of fences as an exclusion measure and for safety in populated areas.

Recycle constructed wetland effluent back through the agricultural waste management system when practical.

In northern cold climates consideration should be given to storage of wastewater during winter months instead of wetland operation.

PLANS AND SPECIFICATIONS

Plans and specifications shall be prepared in accordance with the criteria of this standard and shall describe the requirements for applying the practice to achieve its intended use. Plans shall include construction sequence, vegetation establishment, and management and maintenance requirements.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed that is consistent with the purposes of the practice, its intended life, safety requirements, and the criteria for its design. Operational requirements should include:

- Control of water level in wetland cells appropriate for vegetation.
- Control flow to wetland according to water budget.
- Monitoring of wetland performance.
- Sampling effluent for nutrients prior to utilization.
- Surveillance of inlet and outlet.

Maintenance requirements should include:

- Repair of embankments.
- Control of wetland vegetation in cells.
- Repair of fences or other ancillary features.
- Replacement of wetland plants.
- Repair of pipelines.
- Control of animals (varmints).
- Maintain vegetation on embankments.
- Manage nutrients

REFERENCES

1. Natural Resources Conservation Service, *Part 637 Environmental Engineering, National Engineering Handbook, Chapter 3 Constructed Wetlands*

Indiana NRCS FOTG – December 2001.

2. Environmental Protection Agency Website: www.epa.gov/owow/wetlands/constructed publication *Guiding Principals for Constructed Treatment Wetlands: Providing Water Quality and Wildlife Habitat*

3. Natural Resources Conservation Service, *Engineering Field Handbook, Chapter 13, Wetland Restoration, Enhancement, or Creation*

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Diversion

(Feet)

Code 362

DEFINITION

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

PURPOSES

This practice may be applied as part of a resource management system to support one or more of the following purposes.

- Break up concentrations of water on long slopes, on undulating land surfaces, and on land that is generally considered too flat or irregular for terracing.
- Divert water away from farmsteads, agricultural waste systems, and other improvements.
- Collect or direct water for water-spreading or water-harvesting systems.
- Increase or decrease the drainage area above ponds.
- Protect terrace systems by diverting water from the top terrace where topography, land use, or land ownership prevents terracing the land above.
- Intercept surface and shallow subsurface flow.
- Reduce runoff damages from upland runoff.
- Reduce erosion and runoff on urban or developing areas and at construction or mining sites.
- Divert water away from active gullies or critically eroding areas.

Supplement water management on conservation cropping or stripcropping systems.

CONDITIONS WHERE PRACTICE APPLIES

This applies to all cropland and other land uses where surface runoff water control and or management is needed. It also applies where soils and topography are such that the diversion can be constructed and a suitable outlet is available or can be provided.

CRITERIA

Criteria Applicable to All Purposes.

Diversions shall be planned, designed, and constructed to comply with all Federal, State, and local laws and regulations.

Capacity. Diversions as temporary measures, with an expected life span of less than 2 years, shall have a minimum capacity

for the peak discharge from the 2-year frequency, 24-hour duration storm.

Diversions that protect agricultural land shall have a minimum capacity for the peak

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Indiana NRCS FOTG, April 2003

discharge from a 10-year frequency, 24-hour duration storm.

Diversions designed to protect areas such as urban areas, buildings, roads, and animal waste management systems shall have a minimum capacity for the peak discharge from a storm frequency consistent with the hazard involved but not less than a 25-year frequency, 24-hour duration storm. Freeboard shall be at least 0.3 ft.

Design depth is the channel storm flow depth plus freeboard.

Cross section. The channel shall be either parabolic, V-shaped or trapezoidal. The diversion shall be designed to have stable side slopes. The side slopes shall be no steeper than 2:1.

The ridge shall have a minimum top width of 4 feet at the design depth. The ridge height shall include an adequate settlement factor with a minimum of 10 percent.

The top of the constructed ridge at any point shall not be lower than the design depth plus the specified overfill for settlement.

The design depth at culvert crossings shall be the culvert headwater depth for the design storm plus freeboard.

Grade and Velocity. Channel grades and velocities shall not exceed that considered non-erosive for the soil and planned vegetation or lining.

Maximum channel velocities for permanently vegetated channels shall not exceed those recommended in the NRCS Engineering Field Handbook (EFH) Part 650, Chapter 9, Table 9-1, or Agricultural Research Service (ARS) Agricultural Handbook 667, Stability Design of Grass-Lined Open Channels (Sept. 1987).

When the capacity is determined by the formula Q = A V and the V is calculated by using manning's equation, the highest expected value of "n" shall be used.

Location. The outlet conditions, topography, land use, cultural operations, cultural resources, and soil type shall determine the location of the diversion. A diversion in a cultivated field must be aligned to permit use of modern farming equipment.

Protection Against Sedimentation. Diversions are not normally used below high sediment producing areas. When they are, a practice or combination of practices, needed to prevent damaging accumulations of sediment in the channel shall be installed. This includes practices such as land treatment erosion control practices, cultural or tillage practices, vegetated filter strip, or structural measures. Install practices in conjunction with or before the diversion construction.

If movement of sediment into the channel is a problem, the design shall include extra capacity for sediment or periodic removal as outlined in the operation and maintenance plan.

Outlets. Each diversion must have a safe and stable outlet with adequate capacity. The outlet shall be a grassed waterway, a lined waterway, a vegetated or paved area, a grade stabilization structure, an underground outlet, a stable watercourse, a sediment basin, or a combination of these practices. The outlet must convey runoff to a point where outflow will not cause damage. Vegetative outlets shall be installed and established before diversion construction to ensure establishment of vegetative cover in the outlet channel.

The release rate of an under ground outlet, when combined with storage, shall be such that the design storm runoff will not overtop the diversion ridge.

The design depth of the water surface in the diversion shall not be lower than the design elevation of the water surface in the outlet at their junction when both are operating at design flow.

Temporary Diversions. Temporary diversions shall be used where their life expectancy is less than two years. They shall be used above newly constructed slopes and across graded right-of-way to intercept and divert storm runoff. Temporary diversions shall be planned and installed to be stable through their useful life and shall meet the following criteria:

1. Drainage areas shall not exceed three acres.
2. The minimum cross section will be as follows:

Top Width	Height	Side Slopes
0	1 ft. Min.	4:1 or Flatter
4	1 ft. Min.	2:1 or Flatter

Vegetation. Disturbed areas that are not to be cultivated shall be seeded as soon as practicable after construction.

If needed, apply lime to raise the pH to the level desired for species of vegetation being seeded.

Fertilize according to soil tests or at a minimum rate of 500 lbs. of 12-12-12 fertilizer, or its equivalent, per acre as soon as the diversion has been constructed. Seed during the preferred seeding periods of March 1 to May 10 or August 1 to September 30. Establish vegetation as soon as conditions permit. Seed with one of the mixes in Table 1.

Seed during the preferred seeding periods of March 1 to May 10 or August 1 to September 30. Establish vegetation as soon as conditions permit.

Lining. If the soils or climatic conditions preclude the use of vegetation for erosion protection, non-vegetative linings such as gravel, rock riprap, cellular block, or other approved manufactured lining systems shall be used.

The following species may be added for additional wildlife value.

Partridge pea	2 Lbs./ac.	
Annual Lespedeza	2 Lbs./ac.	South of I-70 Spring seed only.
Ladino Clover	0.25 lb./ac.	
Timothy	1 lb./ac.	

TABLE 1

Mixes	Lbs. Of PLS*/acre	Comments
Tall Fescue	35	Fits most situations.
Creeping Red Fescue Kentucky Bluegrass	12 10	Shady sites, low velocity sites.
Kentucky Bluegrass	45	Low velocity sites.
Orchardgrass Perennial Ryegrass	10 8	PRG** for quick establishment Orchardgrass may take two years to establish.
Orchardgrass Redtop	8 3	Redtop for quick establishment Best seeded in spring.
Switchgrass Redtop	8 1.5	Seed before June 30. 10 acre maximum watershed.
Redtop	8	Quick establishment, low fertility sites.
Orchardgrass Timothy Perennial Ryegrass	6 3 4	PRG** for rapid growth. Best seeded in the fall.
Timothy Perennial Ryegrass Tall Fescue	4 8 6	Best seeded in the fall.

*Pure Live Seed ** Perennial Ryegrass

Note: Switchgrass / Redtop mix should be seeded only in the spring and only on diversions with drainage areas of 10 acres or less.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Indiana NRCS FOTG, April 2003

CONSIDERATIONS

A diversion in a cultivated field should be aligned and spaced from other structures or practices to permit use of modern farming equipment. The side slope lengths should be sized to fit equipment widths when cropped.

At non-cropland sites, consider planting native vegetation in areas disturbed due to construction.

To reduce the risk of vegetative failure use mulch or erosion control blankets to protect the soil until vegetation is established. Refer to the Natural Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG) Standard 484, Mulching, for guidance on materials, quantities and techniques for mulching and erosion control blankets.

Maximize wetland functions and values with the diversion design. Minimize adverse effects to existing functions and values. Diversion of upland water to prevent entry into a wetland may convert a wetland by changing the hydrology. Any construction activities should minimize disturbance to wildlife habitat. Opportunities should be explored to restore and improve wildlife habitat, including habitat for threatened, endangered, and other species of concern.

PLANS AND SPECIFICATIONS

Plans and specification for installing diversions shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be prepared for use by the client. The plan shall include specific instructions for maintaining diversion capacity, storage, ridge height, and outlets.

The minimum requirements to be addressed in the operation and maintenance plan are:

1. Provide periodic inspections, especially immediately following significant storms.
2. Promptly repair or replace damaged components of the diversion as necessary.
3. Maintain diversion capacity, ridge height, and outlet elevations especially if high sediment yielding areas are in the drainage area above the diversion. Establish necessary cleanout requirements.
4. Each inlet for underground outlets must be kept clean and sediment buildup redistributed so that the inlet is at the lowest point. Inlets damaged by farm machinery must be replaced or repaired immediately.
5. Redistribute sediment as necessary to maintain the capacity of the diversion.
6. Vegetation shall be maintained and trees and brush controlled by hand, chemical and/or mechanical means.
7. Keep machinery away from steep sloped ridges. Keep equipment operators informed of all potential hazards.
8. Do not graze diversion during establishment and when soil conditions are wet.
9. Protect diversion from damage by farm equipment and vehicles. Do not use diversions as a roadway and practice care when crossing to prevent tillage marks or wheel tracks.
10. Mow diversion as needed to maintain a healthy, vigorous sod. Time the first mowing after nesting birds have hatched (about July 15). Remove excess top growth. Do not burn or overgraze.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Indiana NRCS FOTG, April 2003

REFERENCES

NRCS Engineering Field Handbook Part 650, Chapter 9. Diversions, 1986.

NRCS Engineering Field Handbook Part 650, Chapter 7. Grassed Waterways, 1986.

Agricultural Research Service, Agricultural Handbook 667, Stability Design of Grass-lined Open Channels.

NRCS, NHCP Practice Standard, Diversion Code 362.

Indiana NRCS Field Office Technical Guide, Practice Standard, Grassed Waterway Code 412.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Indiana NRCS FOTG, April 2003

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Filter Strip

(Acre)

Code 393

DEFINITION

A strip or area of herbaceous vegetation situated between cropland, grazing land, or disturbed land (including forest land) and environmentally sensitive areas.

PURPOSES

1. To reduce sediment, particulate organic matter, and sediment adsorbed contaminant loading in runoff.

2. To reduce dissolved contaminant loading in runoff.

3. To reduce sediment, particulate organic matter, and sediment adsorbed contaminant loading in surface irrigation tailwater.

4. To serve as Zone 3 of a Riparian Forest Buffer, Practice Standard 391.

5. To restore, create or enhance herbaceous habitat for wildlife and beneficial insects.

6. To maintain or enhance watershed functions and values.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies (1) in areas situated below cropland, grazing land, or disturbed land (including forest land) (2) where sediment, particulate organic matter and/or dissolved contaminants may leave these areas and are entering environmentally sensitive areas; (3) in areas where permanent vegetative establishment is needed to enhance wildlife and beneficial insects, or maintain or enhance watershed function. This practice applies when planned as part of a conservation management system.

This practice does not apply to areas subject to long duration flooding, typically greater than 45 days during spring or summer. Sites where it is historically difficult to maintain a stand of perennial grasses or legumes due to frequency or timing of flooding should be planned for a riparian buffer.

CRITERIA

General criteria applicable to all purposes

Filter strips shall be designated as vegetated areas to treat runoff and are not part of the adjacent cropland rotation.

Overland flow entering the filter strip shall be primarily sheet flow. Concentrated flow shall be dispersed by grading or shaping to assure sheet flow.

Prevent erosion where filter strips outlet into streams or channels

Do not use the filter strip as a roadway.

Filter strip establishment shall comply with local, state and federal regulations.

Additional criteria to reduce sediment, particulate organic matter, and sediment adsorbed contaminant loading in runoff

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Indiana NRCS FOTG – April 2000.

The minimum flow length for this purpose shall be 20 feet. Flow length may be increased to meet other resource needs.

Filter strip location requirements:

The filter strip shall be located along the downslope edge of a field or disturbed area. The average watershed slope above the filter strip shall be greater than 0.5% but less than 10%.

The average annual sheet and rill erosion rate above the filter strip shall be less than 10 tons per acre per year.

The filter strip shall be established to permanent herbaceous vegetation consisting of a single species or a mixture of grasses, legumes and/or other forbs adapted to the soil, climate, and nutrients, chemicals, and practices used in the current management system.

For herbaceous cover establishment, refer to Table 1 for Purposes 1, 2, and 3 and Table 2 for Purposes 4, 5, and 6.

Additional criteria to reduce dissolved contaminants in runoff

This criteria supplements "Additional criteria to reduce sediment, particulate organic matter, and sediment adsorbed contaminant loading in runoff".

Filter strip flow length required to reduce dissolved contaminants in runoff shall be based on management objectives, contaminants of concern, and the volume of runoff from the filter strip's drainage area compared with the filter strip's area and infiltration capacity.

The flow length determined for this purpose shall be in addition to the flow length determined for reducing sediment, particulate organic matter, and sediment adsorbed contaminant loading in runoff. The minimum flow length for this purpose shall be 30 feet. Flow length may be increased to meet other resource needs.

Additional criteria to serve as Zone 3 of a Riparian Forest Buffer, Practice Standard 391

Except for the location requirements, the criteria given in "Additional criteria to reduce sediment, particulate organic matter, and sediment adsorbed contaminant loading in runoff" also apply to this purpose.

If concentrated flows entering Zone 3 are greater than the filter strip's ability to disperse them, other means of dispersal, such as spreading devices, must be incorporated.

Additional criteria to reduce sediment, particulate organic matter, and sediment adsorbed contaminant loading in surface irrigation tailwater

Filter strip vegetation may be a small grain or other suitable annual with a plant spacing that does not exceed 4 inches.

Filter strips shall be established early enough prior to the irrigation season so that the vegetation can withstand sediment deposition from the first irrigation.

The flow length shall be based on management objectives.

Additional criteria to restore, create, or enhance herbaceous habitat for wildlife and beneficial insects

If this purpose is intended in combination with one or more of the previous purposes, then the minimum criteria for the previous purpose(s) must be met. Additional filter strip flow length devoted to this purpose must be added to the length required for the other purpose(s).

Any addition to the flow length for wildlife or beneficial insects shall be added to the downhill slope of the filter strip. Vegetation to enhance wildlife may be added to that portion of the filter strip devoted to other purposes to the extent they do not detract from its primary functions.

Plant species selected for this purpose should be selected from Table 2 for permanent vegetation adapted to the wildlife or beneficial insect population(s) targeted.

If this is the only purpose, filter strip width and length shall be based on requirements of the targeted wildlife or insects. Density of the

vegetative stand established for this purpose shall consider targeted wildlife habitat requirements and encourage plant diversity. Dispersed woody vegetation shall be used to the extent it does not interfere with herbaceous vegetative growth, or operation and maintenance of the filter strip.

The filter strip shall not be mowed during the nesting season of the target wildlife.

Livestock and vehicular traffic in the filter strip shall be excluded during the nesting season of the target species.

Additional criteria to maintain or enhance watershed functions and values

Filter strips shall be strategically located to enhance connectivity of corridors and non-cultivated patches of vegetation within the watershed.

Filter strips shall be strategically located to enhance aesthetics of the watershed.

Plant species selected for this purpose shall be for establishment of permanent vegetation.

SEEDING MIXTURES FOR FILTER STRIPS

Instructions: Select one grass mix according to the purpose and add one legume at the rate indicated or two legumes at half the rate. Forbs can be added if desired for extra wildlife benefits.

Table 1. Seeding Mixtures for Purposes 1 to 3.

Grass Mix	Rate (lbs/PLS*/Ac)	Seeding Dates
Switchgrass [1/] Redtop	8 0.5	Frost Seed [2/] April 15 to June 1
Orchardgrass Low Endophyte Tall Fescue	5 10	March 1 to May 1 August 1 to September 15
Orchardgrass Timothy	8 1	March 1 to May 1 August 1 to September 15
Orchardgrass Redtop	6 2	March 1 to May 1
Tall Fescue	25	March 1 to May 1 August 1 to September 15
Smooth Brome	40	February 1 to May 1 August 1 to September 15

[1/] Use 20 foot cool season grass (CSG) strip on the side with highest contaminant load except where filter strip will be shaded.
[2/] Frost seed by broadcasting switchgrass into thin wheat nurse crop, bean stubble, or disturbed corn stalks. Frost seeding should be completed by February 20th south of US 40 and by March 15th north of US 40 to assure adequate soil heaving for good seed to soil contact.

Legumes	Rate (lbs/PLS*/Ac)	Seeding Dates
Annual Lespedeza[1/]	4	Frost Seed [2/] March 15 to May 1
Red Clover	4	Frost Seed [2/] March 15 to May 1 August 1 to September 1
Alsike Clover	1.5	Frost Seed [2/] March 15 to May 1 August 1 to September 1
Ladino Clover	1	Frost Seed [2/] March 15 to May 1 August 1 to September 1

[1/] South of US 40, can be used with either warm season grasses (WSG's) or CSG's.

[2/] Frost seed by broadcasting legumes into thin wheat nurse crop, bean stubble, or disturbed corn stalks. Frost seeding should be completed by February 20th south of US 40 and by March 15th north of US 40 to assure adequate soil heaving for good seed to soil contact.

Table 2. Seeding Mixtures for Purposes 4 to 6.

Grass Mix	Rate (lbs/PLS*/Ac)	Seeding Dates
Switchgrass	5	Frost Seed [2/] April 15 to June 1
Smooth Brome Timothy	10 1	February 1 to May 1 August 1 to September 15
Switchgrass Redtop	3 0.5	Frost Seed [2/] April 15 to June 1
Orchardgrass Timothy	4 0.5	March 1 to May 1 August 1 to September 15
Orchardgrass Redtop	4 0.5	March 1 to May 1
Orchardgrass Kentucky Bluegrass	4 1	March 1 to May 1 August 1 to September 15
Orchardgrass Virginia Wildrye	4 4	March 1 to May 1 August 1 to September 15
Orchardgrass Timothy Redtop	3 0.5 0.5	March 1 to May 1 August 1 to September 15
Little Bluestem [1/]	6	April 15 to June 1
Little Bluestem [1/] Sideoats Grama	4 1.5	April 15 to June 1

[1/] These seeding mixtures have a flooding tolerance of three days or less.

[2/] Frost seed by broadcasting switchgrass into thin wheat nurse crop, bean stubble, or disturbed corn stalks. Frost seeding should be completed by February 20th south of US 40 and by March 15th north of US 40 to assure adequate soil heaving for good seed to soil contact.

Legumes	Rate (lbs/PLS*/Ac)	Seeding Dates
Annual Lespedeza[1/]	4	Frost Seed [2/] March 15 to May 1
Red Clover	4	Frost Seed [2/] March 15 to May 1 August 1 to September 1
Alsike Clover	1.5	Frost Seed [2/] March 15 to May 1 August 1 to September 1
Ladino Clover	1	Frost Seed [2/] March 15 to May 1 August 1 to September 1
Sweet Clover	4	Frost Seed [2/] March 15 to May 1
Alfalfa	5	March 1 to May 1 August 1 to September 1

[1/] South of US 40, can be used with either WSG's or CSG's.

[2/] Frost seed by broadcasting legumes into thin wheat nurse crop, bean stubble, or disturbed corn stalks. Frost seeding should be completed by February 20th south of US 40 and by March 15th north of US 40 to assure adequate soil heaving for good seed to soil contact.

*To figure percent Pure Live Seed (PLS) rates, multiply the percent purity by the percent germination. Divide the seeding rate by the %PLS to find the bulk seed needed per acre. Example: 98% Purity X 60% Germination = .588 PLS, 10 pounds seed per acre/.588 PLS = 17 pounds of bulk seed per acre.

CONSIDERATIONS

Determine landowner's objectives.

Establish filter strips as a component of an overall conservation management system.

Evaluate the type and quantity of pollutant(s).

Determine soil types and slopes.

Estimate average ground water depth.

Determine noxious weed pressure.

Determine fire hazard and other special needs.

Filtering benefits are generally maximized within a 100-foot flow length.

Filter strips established on slopes less than 5 percent are most effective. Steeper slopes require a greater area and width. Filter strips may lose significant effectiveness on slopes greater than 10 percent.

Filter strips should be strategically located to reduce runoff, and increase infiltration and ground water recharge throughout the watershed.

Filter strips for the single purposes of wildlife/beneficial insect habitat or to enhance watershed function should be strategically located to intercept contaminants thereby enhancing the water quality of the watershed.

To avoid damage to the filter strip consider using vegetation that is somewhat tolerant to herbicides used in the watershed. Check recent herbicide use for possible carryover.

Consider using this practice to enhance the conservation of declining species of wildlife,

including those that are threatened or endangered.

Consider using this practice to protect National Register listed or eligible (significant) archaeological and traditional cultural properties from potential damaging contaminants.

Filter strip size should be adjusted to a greater flow length to accommodate harvest and maintenance equipment.

Preferred seeding method for Purposes 1 - 3: Broadcast the seed after tilling and culti-packing twice. The seed should be packed in with another pass of the culti-packer. A brillion seeder or similar implement would also be acceptable. A drill, no-till or conventional, is acceptable but not preferred. Drills have 5" to 10" of space between the rows. Grass stands thus established may not be as effective in filtering as those established by broadcast methods or with a brillion type seeder.

A warm season grass drill is the preferred method for establishing warm season grasses for any of the purposes. It is designed to seed the light, fluffy warm season grass seed. Broadcasting warm season grasses often results in failure as the seeds may be planted too deep. (Switchgrass is an exception. It may be seeded with conventional equipment or may be broadcast.)

A no-till or conventional drill is an acceptable method of seeding for Purposes 4 - 6.

PLANS AND SPECIFICATIONS

Based on this standard, plans and specifications shall be prepared for each specific field site where a filter strip will be installed. A plan includes information about the location, construction sequence, vegetation establishment, and management and maintenance requirements.

Specifications will include:

1. Length, width, and slope of the filter strip to accomplish the planned purpose (length refers to flow length across the filter strip).
2. Species selection and seeding or sprigging rates to accomplish the planned purpose.
3. Planting dates, care, and handling of the seed to ensure that planted materials have an acceptable rate of survival.
4. A statement that only viable, high quality, and regionally adapted seed will be used.
5. Site preparation sufficient to establish and grow selected species.

OPERATION AND MAINTENANCE

For the purposes of filtering contaminants, permanent filter strip vegetative plantings should be harvested as appropriate to encourage dense growth, maintain an upright growth habit, and remove nutrients and other contaminants that are contained in the plant tissue. Warm season grasses should not be mowed closer than 10 inches and cool season grasses should not be mowed closer than 6 inches.

Control undesired weed species, especially state-listed noxious weeds.

Prescribed burning may be used to manage and maintain the filter strip when an approved burn plan has been developed.

Inspect the filter strip after storm events and repair any gullies that have formed, remove unevenly deposited sediment accumulation that will disrupt sheet flow, re-seed disturbed areas, and take other measures to prevent concentrated flow through the filter strip.

Apply supplemental nutrients only as needed to maintain the desired species composition and stand density of the filter strip.

To maintain or restore the filter strip's function, periodically re-grade the filter strip area when sediment deposition at the filter strip-field interface jeopardizes its function, and then reestablish the filter strip vegetation, if needed. If wildlife habitat is a purpose, destruction of vegetation within the portion of the strip devoted to that purpose should be minimized by re-grading only to the extent needed to remove

sediment and fill concentrated flow areas.

Grazing shall not be permitted in the filter strip unless a controlled grazing system is being implemented. Grazing will be permitted under a controlled grazing system only when soil moisture conditions support livestock traffic without excessive compaction. Warm season grasses should not be grazed closer than 10 inches and cool season grasses should not be grazed closer than 6 inches.

Redistribute organic wastes that accumulate in the filter strip to minimize damage to the vegetation.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Grade Stabilization Structure

(Number)

Code 410

DEFINITION

A structure used to control the channel grade in natural or constructed watercourses.

PURPOSES

To stabilize grade, reduce gully erosion and/or improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

In areas where the concentration and flow velocity of water requires structures to stabilize the channel grade or to control gully erosion. This practice does not apply to structural inlets to sink holes.

CRITERIA

General criteria. Planned work shall comply with all federal, state and local laws and regulations.

The structure shall be designed for stability after installation. The crest of the inlet shall be set at an elevation that stabilizes the upstream head cutting. The outlet of the structure shall be such that there is minimum erosion at the outlet.

Earth embankments and emergency spillways of structures for which criteria are not provided under the standard for ponds (NRCS Practice Code 378) or floodwater retarding dam (NRCS Practice Code 402), must be stable for all anticipated conditions. If earth spillways are used, they must be designed to handle the total capacity flow indicated in Tables 2 or 4 without overtopping the embankment. The foundation preparation, compaction, top width, and side slopes must ensure a stable embankment for anticipated flow conditions. Discharge from the structure shall be controlled to minimize crop damage resulting from flow detention.

Sediment storage capacity shall equal the expected life of the structure, unless a provision is made for a periodic cleanout.

The structures, earthfill, vegetated spillways, and other areas shall be fenced as necessary to protect the structure. Precautions shall be taken to prevent serious injury or loss of life. Protective guardrails, warning signs, fences, or lifesaving equipment shall be added as needed.

The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded, or sodded or otherwise protected as necessary to prevent erosion.

Embankment dams. Class (a) dams having a product of storage times the effective height of the dam of less than 3,000 ac-ft^2 and an effective height of 35 ft. or less shall meet or exceed the requirements specified for ponds (NRCS Practice Code 378). Principal and emergency spillway capacity requirements shall meet or exceed Table 1.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Class (a) dams having a product of storage times the effective height of the dam of 3,000 ac-ft^2 or more, those more than 35 ft. in effective height, and all class (b) and class (c) dams shall meet or exceed the hydrologic, hydraulic, and embankment requirements specified in NRCS Technical Release No. 60, Earth Dams and Reservoirs (TR-60) Revised Oct. 1985.

Pond size dams. If principal spillways are required, the minimum capacity of the principal spillway shall be that required to pass the peak flow expected from a 24-hour duration design storm of the frequency shown in Table 1, less any reduction attributed to detention storage. Detention storage is the volume between the normal pool elevation and the crest of the emergency spillway.

If (1) the effective height of the dam is less than 20 feet and (2) the emergency spillway has a stable grade throughout its length, with no overfalls, and good vegetation along its reentry into the downstream channel, then the principal spillway capacity may be reduced. However, the principal spillway capacity can be no less than 80 percent of the 2-year frequency, 24-hour duration storm as indicated by footnote 3 in Table 1.

Grade stabilization structures with a settled fill height of less than 15 ft. and a 10-year frequency, 24-hour storm runoff of less than 10 acre-ft, shall be designed to control the 10-year frequency storm without overtopping. The principal spillway, regardless of size, shall be considered in design and an emergency spillway is not required if the combination of storage and principal spillway discharge will handle the total design storm. The embankment can be designed to meet the standard for water and sediment control basins (NRCS Practice Code 638) rather than the requirements for ponds (NRCS Practice Code 378).

Table 1. Design Criteria for Dams with Storage Capacity

Limiting Factors			Frequency of Minimum Design Design Storm, years 24-Hour Duration Peak Flow	
Maximum Drainage Area (Acres)	Maximum Effective Height of Dam[5/] (Feet)	Storage Capacity[6/] (Ac-Ft)	Principal Spillway Capacity[1/]	Total Capacity[2/]
100	<20	Less than 50	2[3/]	10
320	<20	Less than 50	5[3/]	25
<640	<20	50 or greater	10	50
All others			50% pmp[4/]	

1/ To below emergency spillway crest.
2/ Before overtopping the lowest part of earth embankment portion of structure. Total Capacity = Principal Spillway Capacity + Emergency Spillway Capacity + Freeboard.
3/ Can be reduced to 80% of a 2-year frequency if emergency spillway has stable, well vegetated outlet with no overfalls.
4/ Based on a 6-hour probable maximum precipitation (pmp) storm as required by IDNR.
5/ The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.
6/ Storage is the total volume of storage available below the emergency crest elevation or top of fill elevation if there is no emergency spillway.

Full-flow open structures. Full-flow open structures are those which shall pass the design storm through the principal and emergency spillways without creating storage above the design flow's normal depth.

Drop, chute, and box inlet drop spillways shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices, the National Engineering Handbook, and other applicable NRCS publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2. Structures must not create unstable conditions upstream or downstream. Provisions must be made to insure reentry of bypassed storm flows.

Table 2. Design criteria for establishing minimum capacity of full-flow open structures.

Maximum drainage area (acres)	Vertical drop (feet)	Frequency of minimum design, 24-hour duration storm peak flow	
		Principal spillway capacity[2/] (year)	Total capacity[3/] (year)
320	5 or less	5 [1/]	10
640	10 or less	10	25
All others		25	100

1/ Rock chutes, grouted rock chutes, block chutes, concrete chutes and reinforced vegetated chutes shall be designed to carry a 10-year storm as a minimum unless it can be shown that allowable design velocities will not be exceeded should the head water reach the maximum freeboard level. If the minimum design capacity exceeds the downstream channel, then the capacity may be reduced to be equal with the downstream channel.

2/ To below emergency spillway crest.

3/ Before overtopping the lowest part of earth embankment portion of structure. Total Capacity = Principal Spillway Capacity + Emergency Spillway Capacity + Freeboard.

Table 3. Minimum Capacity for Drop Boxes to Culverts

Box Inlet or Riser to Existing Road Culvert	
Condition	Design Capacity
Culvert capacity less than Q_{50}	1.25 culvert capacity
Culvert capacity greater than Q_{50}	Culvert capacity not to exceed 1.5 Q_{50}

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Table 4. Design Criteria for Establishing Minimum Capacity of Side Inlet, Open Weir or Pipe Drop Drainage Structures [1]/

Limiting Factors			Minimum Design Storm 24-Hour Duration Years	
Maximum Drainage Area, Acres	Vertical Drop, [5/] Feet	Receiving Channel Depth, [6/] Feet	Principal Spillway [2/] Capacity [3/]	Total Capacity [4/]
320	0-5	0-10	2	5
320	5-10	10-20	5	10
640	0-10	0-20	10	25
All Others	All	All	25	50

1/ For structures outletting into a drainage channel whose drainage area is at least two times the structure drainage area and the channel frequently runs bank full. This table does not apply to rock chutes, grouted rock chutes, block chutes, concrete chutes and reinforced vegetated chutes.
2/ To auxiliary or emergency spillway.
3/ B drainage curve capacity may be used if average watershed slope for side inlet structure is less than 1.0%.
4/ Before overtopping earth embankment portion of structure. Total Capacity = Principal Spillway Capacity + Emergency Spillway Capacity + Freeboard.
5/ Controlled drop in grade.
6/ From low bank to channel grade.

Toe wall drop structures can be used if the vertical drop is 4 ft. or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is equal to or greater than one-third of the height of the overfall.

The ratio of the capacity of drop boxes to new or existing road culverts shall be as required by the responsible road authority or as specified in Tables 2, 3 or 4, whichever is greater.

Island-type structures. If the principal spillway is designed as an island-type structure, its minimum capacity shall equal the capacity of the downstream channel. The structural spillway shall carry at least the 2-year, 24-hour storm or the design drainage curve runoff. The minimum emergency spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2 for total capacity without exceeding the capacity of the structural spillway. Provisions must be made for safe reentry of bypassed flow in excess of the design capacity as necessary.

Side-inlet drainage structures. The design criteria for minimum capacity of open-weir or pipe structures used to lower surface water from field elevations or lateral channels into deeper open channels are shown in Table 4.

Side inlet conduits are to meet the principal spillway thickness and fill height over the pipe conduit requirements of the Standards and Specifications for Pond (NRCS Practice Code 378). Protection against seepage shall be provided. This may be provided by the use of an anti-seep diaphragm, anti-seep collar or toe plate extension on flared inlets. Site conditions may limit anti-seep diaphragms to the bottom half only.

Freeboard of one foot shall be provided over the side inlet conduit where no emergency spillway is provided. Where an emergency spillway is provided, one half foot of freeboard is required, with a minimum total difference of one foot

between crest of emergency spillway and top of fill over the conduit

CONSIDERATIONS

In highly visible, public areas and those associated with recreation, careful considerations should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Shorelines can be shaped and islands created to add visual interest and valuable wildlife habitat. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

Consideration should be given to the effect a structure will have on the aquatic habitat of a channel. If the channel supports fish, the effect of a structure on the passage of fish should be considered.

Structures installed in natural channels should be compatible with the fluvial geomorphic conditions at the site to ensure the stability of the structure.

PLANS AND SPECIFICATIONS

Plans and specifications for installing grade stabilization structures shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Vegetative establishment. A protective cover of vegetation shall be established on all exposed surfaces of the embankment, spillway, borrow area and disturbed areas if soil and climatic conditions permit. Temporary vegetation may be used until permanent vegetation can be established.

If needed, apply lime to raise the pH to the level desired for the species of vegetation being seeded.

Fertilize, at the time of seeding, according to soil tests or at a minimum rate of 500 lbs. of 12-12-12 fertilizer, or its equivalent, per acre

Use the grassed waterway seeding mix around the structure site when built in association with the grassed waterway.

Use one of the following mixes when not using the grassed waterway (NRCS Practice Code 412) mix.

Mixes	Lbs. Of PLS*	Comments
Tall Fescue	35	Fits most situations.
Creeping Red Fescue Kentucky Bluegrass	12 10	Shady sites, low velocity sites.
Timothy Perennial Ryegrass Tall Fescue	4 8 6	Best seeded in the fall.

* Pure Live Seed

Seed during the seeding periods of March 1 to May 10 or August 10 to September 30. Establish vegetation as soon as conditions permit. Use straw mulch, filter fences, or nurse crop to protect the vegetation until it is established.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover.

1. Protect area of the grade stabilization structure from overgrazing.

2. Fertilize to maintain a vigorous vegetative cover in protected area. Caution shall be used with fertilization to maintain water quality.

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3. Mow, spray or chop out undesirable vegetation periodically to prevent growth of large woody-stemmed weeds, water plants such as cattails or trees (such as willows) from embankment and spillway areas.

4. Promptly repair eroded areas.

5. Promptly remove any burrowing rodents that may invade area of embankment.

6. Re-establish vegetative cover immediately where scour erosion has removed established seeding.

7. Keep open all spillways and remove trash that may accumulate around entrance.

8. Periodically inspect area for any new maintenance needs and if any are observed take immediate action to protect from further damage or deterioration.

REFERENCES

National Engineering Field Handbook, Part 650
NRCS, Conservation Practice Standards
Code 342, Critical Area Planting
Code 378, Pond
Code 402, Dam, Floodwater Retarding
Code 638, Water and Sediment Control Basin
Code 412, Grassed Waterway
NRCS, Technical Release No. 55, Urban Hydrology for Small Watersheds June 1986
NRCS, Technical Release No. 60, Earth Dams and Reservoirs Revised Oct. 1985

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Grassed Waterway

(Acre)

Code 412

DEFINITION

A natural or constructed channel that is shaped or graded to required dimensions and established with suitable vegetation.

PURPOSES

This practice may be applied as part of a resource management system to support one or more of the following purposes:

- To convey runoff from terraces, diversions, or other water concentrations without causing erosion, flooding or ponding.
- To reduce gully erosion.
- To protect/improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

In areas where added water conveyance capacity and vegetative protection are needed to control erosion resulting from concentrated runoff and where such control can be achieved by using this practice alone or combined with other conservation practices.

CRITERIA

General Criteria Applicable to All Purposes
Grassed waterways shall be planned, designed, and constructed to comply with all Federal, State, and local laws and regulations.

The soil, hydrology and vegetative characteristics existing on the site and the contributing watershed shall be documented before construction of the waterway begins.

The effect of any modification to the existing surface and/or subsurface drainage system on other landowners will be evaluated in the design. Surface and subsurface drainage that affects upstream or downstream landowners shall have written permission.

Capacity. The minimum capacity shall be that required to confine the peak runoff expected from a storm of 10-year frequency, 24-hour duration obtained by using the procedure in the NRCS Engineering Field Handbook (EFH) Part 650, Chapter 2.

When the waterway grade is less than 1 percent, out-of bank flow may be permitted if such flow will not cause excessive erosion. The minimum capacity in such cases shall be that required to carry within the channel the discharge as determined by using the "B" drainage curve.

Velocity. Design velocities shall not exceed those obtained by using the procedures, "n" values, and recommendations in the NRCS Engineering Field Handbook (EFH) Part 650, Chapter 7, or Agricultural Research Service (ARS) Agricultural Handbook 667, Stability Design of Grass-lined Open Channels. Velocities that are less than 1.5 feet per second shall require special considerations in the O & M section.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Width. The bottom width of trapezoidal waterways shall not exceed 50 feet unless multiple or divided waterways or other means are provided to control meandering of low flows.

Side Slopes. Side slopes shall not be steeper than a ratio of two horizontal to one vertical. They shall be designed to accommodate the equipment used for normal farming operations.

Crossings. Provide livestock and vehicular crossings as necessary to prevent damage to the waterway and its vegetation.

Depth. The minimum design depth of a waterway that receives water from terraces, diversions, or other tributary channels shall be that required to keep the design water surface elevation at, or below the design water surface elevation in the terrace, diversion, or other tributary channel at their junction when both are flowing at design depth.

Drainage. Designs for sites having prolonged flows, a high water table, or seepage problems shall include Subsurface Drains (NRCS Practice Code 606), Underground Outlets (NRCS Practice Code 620), Stone Center Waterways (EFH Chapter 7) or other suitable measures to avoid saturated conditions.

Outlet. All grassed waterways shall have a stable outlet with adequate capacity to prevent ponding or flooding damages.

Vegetative Establishment. Whenever possible, excess water shall be directed away from the waterway until vegetation is established. Any protective works shall be removed and the disturbed areas within the waterway cross section seeded to permanent grass after the vegetation in the waterway is established.

Apply lime as needed to adjust pH to at least 6.5.

Fertilize according to soil tests or at a minimum rate of 500 lbs. of 12-12-12 fertilizer, or its equivalent, per acre as soon as the waterway has been constructed within the seeding periods.

Seed with one of the following mixes.

Note: Switchgrass / Redtop mix should be seeded only in the spring and only on waterways with drainage areas of 10 acres or less.

Mixes	lbs. of PLS*/acre	Comments
Tall Fescue	35	Fits most situations
Creeping Red Fescue Kentucky Bluegrass	12 10	Shady sites, low velocity sites
Kentucky Bluegrass	45	Low velocity sites
Orchardgrass Perennial Ryegrass	10 8	PRG** for quick establishment, Orchardgrass may take two years to establish.
Orchardgrass Redtop	8 3	Redtop for quick establishment. Best seeded in the spring
Switchgrass Redtop	8 1.5	Seed before June 30. 10 acre maximum watershed
Redtop	8	Quick establishment, low fertility sites.
Orchardgrass Timothy Perennial Ryegrass	6 3 4	PRG** for rapid growth. Best seeded in the fall.
Timothy Perennial Ryegrass Tall Fescue	4 8 6	Best seeded in the fall

The following species may be added for additional wildlife value.

Partridge pea	2 lb./ac.	
Annual Lespedeza	2 lb./ac.	South of I-70
Ladino Clover	0.25 lb./ac.	
Timothy	1 lb./ac.	

*Pure Live Seed **Perennial Rye Grass

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Work the fertilizer and lime into the soil to a depth of 2 to 3 inches with a harrow or disk. Prepare a firm seedbed with a cultipacker or cultipacker type seeder.

Seed during the periods of March 1 to May 10 or August 1 to September 30.

Erosion Control Blanket

An erosion control blanket (ECB) shall be installed on all grassed waterway sections where either of the following exists:

1. The velocity at D retardance is 3.0 feet per second (fps) or greater.

2. Earthfill is used to fill in an eroded area.

The blanket shall be a minimum of 1-ply netting sewn to a straw, excelsior or other accepted mulch material. Severe conditions, such as high velocities coupled with greater depth and/or low likelihood of rapid vegetative establishment will require a heavier ECB. The blanket shall cover the waterway to at least half of the design depth. Installation shall be according to the manufacturer's recommendations.

After temporary seeding only, if the waterway is stable and needs no additional earthwork and the temporary seeding is adequate and the waterway can be seeded with a no-till drill then the erosion control blanket requirement may be waived.

Temporary Seeding:

Waterways constructed between May 10th and August 1st shall be seeded with one of the following species :

Oats @ 2 bushel (64lb.) per acre PLS

Japanese or Pearl Millet @ 30 lb. per acre PLS

Sorghum – Sudan Grass @ 20 lb. per acre PLS

CONSIDERATIONS

Generally, the design velocity for capacity should be based on "C" retardance and the stability should be based on "D" retardance. For sites where Switchgrass / Redtop mixtures are desirable, "B" and "D" retardance should be used.

Special attention should be given to maintaining and improving visual resources and habitat for wildlife where applicable.

The soil loss from the watershed draining into the waterway should be evaluated when the sedimentation from upland erosion on land not controlled by the landowner/user will impair the proper functioning of the waterway.

The waterway should not be constructed until a consideration of upstream erosion control is in place or appropriate land use and/or management changes, have been made to reduce the erosion to an acceptable level.

If possible, consider constructing all waterways with 1 foot of depth as a minimum.

Reducing the amount of trickle flow will enhance vegetative establishment and improve the stability of the waterway. Surface water inlets at the upper reaches of waterway systems may be used to accomplish this. Design drainage according to the "CSM" method in the Engineering Field Handbook Chapter 7.

Water-tolerant vegetation may be an alternative on some wet sites. Contact the NRCS State Forester/Botanist for assistance in selecting appropriate species.

To reduce the risk of vegetative failure, consider using mulch or erosion control blankets on all waterways with velocities greater than 1.5 fps to protect the soil until vegetation is established. Refer to FOTG Standard 484, Mulching, for guidance on materials, quantities and techniques for mulching and erosion control blankets.

Consider increasing the seeding rates by at least 50% on sites considered to be at high risk due to soil type, velocity or other conditions.

An application of 150 lbs. of actual N per acre should be applied to waterways with high design velocity and low in organic matter and fertility, 6 to 8 weeks after seeding. Nitrogen should only be applied to grass during periods of active growth.

Use irrigation in dry regions or supplemental irrigation as necessary to promote germination and vegetation establishment.

Establish filter strips on each side of the waterway to improve water quality since any chemicals applied to the waterway in the course of treatment of adjacent cropland may move directly into the surface waters in the case where there is a runoff even shortly after spraying.

Add width of appropriate vegetation to the sides of the waterway for wildlife habitat.

PLANS AND SPECIFICATIONS

Plans and specifications for grassed waterways shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s).

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be provided to and reviewed with the landowner. The plan shall include the following items and others as appropriate.

A maintenance program shall be established to maintain waterway capacity, vegetative cover, and outlet stability. Vegetation damaged by machinery, herbicides, or erosion must be repaired promptly.

Seeding shall be protected from concentrated flow and grazing until vegetation is established.

Grazing shall not be permitted in the grassed waterway unless a controlled grazing system is being implemented. Grazing will be permitted under a controlled grazing system only when soil moisture conditions support livestock traffic without excessive compaction. Warm season grasses should not be grazed closer than 10 inches and cool season grasses should not be grazed closer than 6 inches.

Inspect grassed waterways regularly, especially following heavy rains. Damaged areas should be filled, compacted, and seeded immediately. Remove sediment deposits to maintain capacity.

Landowners should be advised to avoid areas where forbs have been established when applying herbicides. Avoid using waterways as turn-rows during tillage and cultivation operations. Mowing may be appropriate to enhance wildlife values, but must be conducted at a time to avoid peak nesting seasons and reduced winter cover.

Mow or periodically graze vegetation to maintain a healthy, vigorous sod and to maintain capacity and reduce sediment deposition. Time the first mowing after ground nesting birds have hatched (about July 15).

Control noxious weeds.

Do not use as a field road. Avoid crossing with heavy equipment when wet.

Fertilize waterways according to soil tests (not to exceed 500 lbs./acre of 12-12-12, or equivalent) the first spring or fall after seeding and thereafter as necessary to maintain a vigorous stand of grass. Caution should be used during fertilization to maintain water quality.

Repair all broken subsurface drain lines adjacent to or in the waterway.

Re-establish vegetative cover immediately where scour erosion has removed established seeding.

Maintain effective erosion control of the contributing watershed to prevent siltation in the waterway and the resulting loss of capacity.

Velocities that are less than 1.5 feet per second require special attention. The waterway shall be mowed to maintain a maximum grass height of 6 inches. Sediment deposits shall be removed as quickly as possible to maintain the capacity and integrity of the waterway.

REFERENCES

NRCS Engineering Field Handbook Part 650, Chapter 2. Estimating Runoff and Peak Discharges, 1990

NRCS Engineering Field Handbook Part 650, Chapter 7. Grassed Waterways, 1986

Agricultural Research Service, Agricultural Handbook 667, Stability Design of Grass-lined Open Channels.

Minnesota NRCS Field Office Technical Guide, Practice Standard, Grassed Waterway Code 412.

Missouri NRCS Field Office Technical Guide, Practice Standard, Grassed Waterway Code 412.

Indiana NRCS Field Office Technical Guide, Practice Standard, Filter Strips Code 393.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Lined Waterway or Outlet

(Feet)

Code 468

DEFINITION

A waterway or outlet having an erosion-resistant lining of concrete, stone, synthetic turf, reinforcement fabrics, or other permanent material.

PURPOSES

This practice may be applied as part of a resource management system to support one or more of the following purposes:

- Provide for safe conveyance of runoff from conservation structures or other water concentrations without causing erosion or flooding
- Stabilize existing and prevent future gully erosion
- Protect and improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies if the following or similar conditions exist:

1. Concentrated runoff is of such that a lining is needed to control erosion.
2. Steep grades, wetness, prolonged base flow, seepage, or piping would cause erosion.
3. The location is of such that use by people or animals preclude use of vegetated waterways or outlets.
4. Limited space is available for design width which requires higher velocities and lining.
5. Soils are highly erosive or other soil or climatic conditions preclude using vegetation.

This practice is not applicable to watercourses where construction of a waterway would destroy woody wildlife cover and the present watercourse is capable of handling the concentrated runoff without serious erosion. Such situations are usually recognized by a meandering condition, steep side slopes that are stabilized by woody plants or herbaceous vegetation, and the watercourse is without rapidly advancing overfalls.

CRITERIA

The planning, installation and maintenance of the lined waterway or outlet shall comply with all fedral, state and local laws, rules and regulations.

Capacity. The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft^3/s . The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year-frequency storm. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish	0.012 to 0.013
Float finish	0.013 to 0.017
Gunite	0.016 to 0.022
Flagstone	0.020 to 0.025
Riprap	Determine from figure 1.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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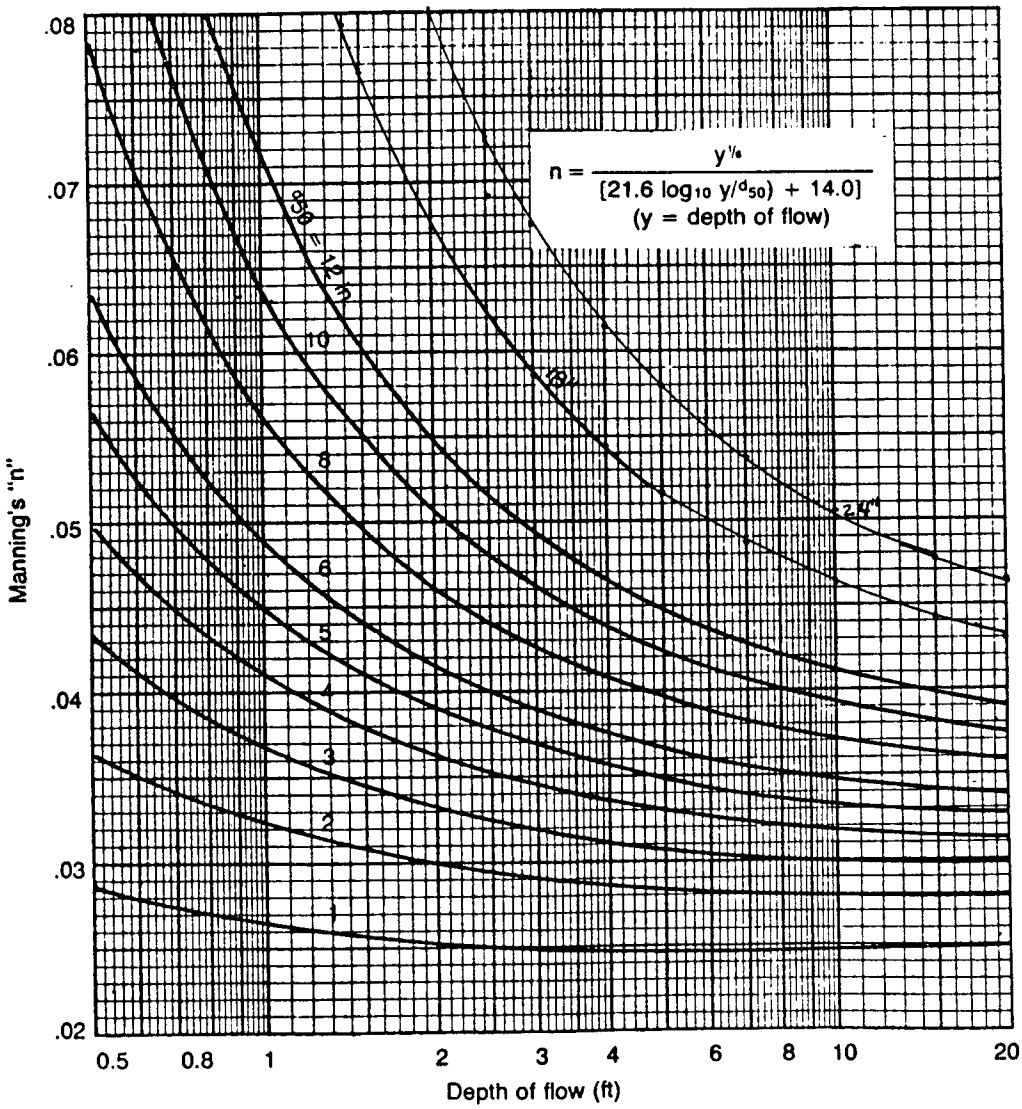

Figure 1. Values of n for riprap-lined channels, d_{50} size vs depth of flow.

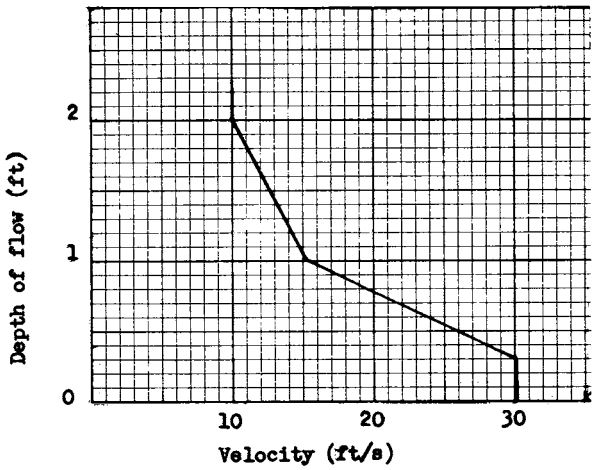

Figure 2. Maximum velocity vs depth of flow for concrete channels.

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Velocity. Maximum design velocity for concrete channels shall be as shown in figure 2. Maximum design velocities for riprap sections shall be less than velocities listed below:

D50 Rock Size	Allowable Velocity
inches	feet per second
4	5.8
5	6.4
6	6.9
7	7.4
8	7.9
9	8.4
10	8.8
11	9.2
12	9.6

Except for short transition sections, flow in the range of 0.7 to 1.3 of the critical slope must be avoided unless the channel is straight. Velocities exceeding critical shall be restricted to straight reaches.

Waterways or outlets with velocities exceeding critical shall discharge into an energy dissipator to reduce velocity to less than critical.

Cross section. The cross section shall be triangular, parabolic, or trapezoidal. Cross sections made of monolithic concrete may be rectangular.

Freeboard. The minimum freeboard for lined waterways or outlets shall be 0.25 feet above design high water in areas where erosion-resistant vegetation cannot be grown adjacent to the paved side slopes. No freeboard is required if vegetation is established and maintained.

Side slope. The steepest permissible side slopes, horizontal to vertical, shall be:

Material	Height of Lining	Side Slope
Hand-placed, formed concrete	1.5 feet or less	vertical
Hand-placed, screened concrete or mortared in-place flagstone	less than 2 feet more than 2 feet	1 to 1 2 to 1
Slip form concrete	less than 3 feet	1 to 1
Rock riprap		2 to 1

Lining thickness. Minimum lining thickness shall be:

Material	Minimum Lining Thickness
Concrete	4 inches (in most problem areas, minimum thickness shall be 5 inches with welded wire fabric reinforcing).
Riprap	Maximum stone size plus thickness of filter or bedding.
Flagstone	4 inches including mortar bed.

Related structures. Side inlets, drop structures, and energy dissipaters shall meet the hydraulic and structural requirements for the site.

Outlets. All lined waterways and outlets shall have a stable outlet with adequate capacity prevent erosion and flooding damages.

Geotextiles. Geotextiles shall be used where appropriate as a separator between rock, flagstone, or concrete linings and soil to prevent migration of soil particles from the subgrade, through the lining material. Geotextiles shall be designed according to AASHTO M288, Section 7.3.

Filters or bedding. Filters or bedding shall be used to prevent piping. Drains shall be used to reduce uplift pressure and to collect water, as required. Filters, bedding, and drains shall be designed according to NRCS standards. Weep holes may be used with drains if needed.

Concrete. Concrete used for lining shall be proportioned so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product shall be required. Specify a mix that can be certified as suitable to produce a minimum strength of at least 3,000 lb/in^2. Cement used shall be Portland cement, Types I, II or if required, Types IV or V. Aggregate used shall have a maximum size of 1½ inches.

Mortar. Mortar used for mortared in-place flagstone shall consist of a workable mix of cement, sand, and water with a water-cement ratio of not more than 6 gallons of water per bag of cement.

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Contraction joints. Contraction joints in concrete linings, if required, shall be formed transversely to a depth of about one-third the thickness of the lining at a uniform spacing in the range of 10 to 15 feet.

Provide for uniform support to the joint to prevent unequal settlement.

Rock riprap or flagstone. Stone used for riprap shall be dense and hard enough to withstand exposure to air, water, freezing, and thawing. Flagstone shall be flat for ease of placement and have the strength to resist exposure and breaking.

CONSIDERATIONS

Consider using a Rock Lined Chute or other practice when overfall is greater than 2 feet (vertically) at a waterway outlet.

Effects on water quantity and quality shall be considered. This practice may have a minor effect on the quantity of surface and ground water. This practice will reduce the erosion in concentrated flow areas resulting in the reduction of sediment and substances delivered to the receiving waters. When used as a stable outlet for another practice, lined waterways may increase the likelihood of dissolved and suspended substances being transported to surface water due to high flow velocities.

Special attention shall be given to maintaining and improving visual resources and habitat for wildlife where applicable. The landowner/user will be advised if wetlands will be affected and USDA/NRCS wetland policy will apply. All work planned shall be in compliance with General Manual Title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local Laws and Regulations.

PLANS AND SPECIFICATIONS

Plans and specifications for constructing lined waterways or outlets shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover. Items to consider are:

1. Do not graze lined waterway during establishment and when soil conditions are wet.
2. Protect lined waterway from damage by farm equipment and vehicles. Do not use lined waterway as a roadway and practice care when crossing to prevent tillage marks or wheel tracks.
3. Maintain constructed width by lifting or disengaging tillage equipment properly, and avoid farming operations along lined waterway that would hinder water entry.
4. Observe lining for any deterioration or movement of rock in riprap lined waterways. Perform needed maintenance as soon as possible to eliminate further deterioration or damage.
5. Do not spray with herbicides or cross lined waterways during spray operations unless the equipment is completely shut off.
6. Fertilize vegetated portions of lined waterways the first spring after seeding and thereafter as necessary to maintain a vigorous stand of grass. Caution should be used with fertilization to maintain water quality.
7. Mow vegetated portions of lined waterways regularly to maintain a healthy, vigorous sod. Time the first mowing after ground-nesting birds have hatched (about August 1). Remove excess top growth. Do not burn or overgraze.
8. Repair all broken subsurface drain lines adjacent to or in the waterway.
9. Re-establish vegetative cover immediately where scour erosion has removed established seeding or vegetated portion of lined waterway.
10. Maintain effective erosion control of the contributing watershed to prevent siltation and the resulting loss of capacity.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Mulching

(Acre)

Code 484

DEFINITION

Applying plant residues or other suitable materials not produced on the site to the soil surface.

PURPOSES

To conserve moisture, prevent surface compaction or crusting; reduce runoff and erosion; control weeds; and help establish new plant cover.

CONDITIONS WHERE PRACTICE APPLIES

On soils subject to erosion on which low-residue-producing crops, such as grapes and small fruits are grown; on critical areas; and on soils that have a low infiltration rate.

CRITERIA

General criteria applicable to all purposes

This standard shall be used in compliance with all federal, state and local laws and regulations.

Additional criteria to conserve moisture; prevent surface compacting or crusting; reduce runoff and erosion; and help establish plant cover:

When possible, concentrated flow of surface runoff water shall be diverted from above the area to be mulched.

All areas to be mulched shall be free of rills and gullies.

Immediately after seeding and fertilizing (unless a dormant seeding is to be made), uniformly apply 1 1/2 to 2 tons per acre of straw that is clean and free of noxious weed seeds. At the appropriate application rate, some soil can be seen.

Straw mulch shall be anchored using one of the following methods:

- Crimp or punch mulch into the ground to an approximate depth of 2 inches.
- Apply emulsified asphalt (or other suitable tackifier material) to the mulch according to manufacturer's recommendations. Emulsified asphalt shall not be used when air temperatures are below 32°F. Follow manufacturer's recommendations on mixing and temperature control.
- Apply mulch netting of lightweight paper, jute, cotton or plastic and fasten it to soil according to manufacturer's recommendation.

Alternative mulch materials may be used in lieu of straw mulch at rates and requirements listed in Table 1.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Table 1. Alternative mulch materials

Material	Quality	Rate	Remarks
Hay	Air-dried; free of mold; Free of noxious weeds	2 tons per acre	Anchor like straw
Wood excelsior	Green or air dried burred wood fiber.	2 tons per acre	Anchor with tackifier or netting
Wood fiber cellulose	Partially digested wood fiber; usually with green dye and a dispersing agent.	2,000 lb per acre	Apply with hydroseeder
Jute mat	Undyed, unbleached plain weave; warp 78 ends/yd; weft 41 ends/yd; 60-90 lb rolls.	48 in x 50 yd or 48 in x 75 yd.	Secure as per manufacturer's specification
Excelsior wood fiber mats	Interlocking web of excelsior fibers with photodegradable plastic netting.	48- x 100- inch 2-sided plastic or 48- x 180-inch 1-sided plastic.	Secure as per manufacturer's specification
Straw, coconut or combined mats	Photodegradable plastic net on one or two sides.	6.5 x 83.5 ft, 81 rolls per acre.	Secure as per manufacturer's specification

Additional criteria to conserve moisture and control weeds:

Orchards

Approximately four tons per acre of dry matter shall be applied around the trees.

Mulch shall be extended out to or beyond the tree's dripline, and shall be thick enough to smother any grass and weeds beneath the tree.

Mulch shall be kept back two feet from trunk of tree to discourage mouse damage.

Vineyards and Berries

After vineyard is established, apply mulch six (6) or more inches deep to replace cultivation and conserve moisture.

Row Crops

Weeds shall be controlled by use of cultivation or chemicals before applying mulch.

Apply approximately two (2) tons per acre of clean, dry straw that is free of noxious weeds.

Mulch shall be applied, as soon as possible, after weed control and before crop height prevents spreading of mulch.

After application of mulch, do not cultivate. Control weeds, as needed, by use of chemicals.

CONSIDERATIONS

- Mulching can reduce erosion and the movement of sediment and sediment-attached substances carried by runoff.
- Consider fire potential.

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- In areas of high erosion potential, such as waterways with high velocities (design velocity at > 3 feet per second), an erosion control blanket should be installed according to manufacturer's recommendations in lieu of loose mulch.

PLANS AND SPECIFICATIONS

Plans and specifications will be developed for specific field sites in accordance with this practice standard.

OPERATION AND MAINTENANCE

An operation and maintenance plan will be developed in keeping with this practice standard.

REFERENCES

U.S. Department of Agriculture, Natural Resources Conservation Service, National Agronomy Manual, Part 506, *Plant Attributes*, 1999.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Pond

(Number)

Code 378

DEFINITION

A water impoundment made by constructing a dam or an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at spillway elevation is 3 feet or more.

PURPOSES

To provide water for livestock, fish and wildlife, recreation, fire control, and other related uses, and to maintain or improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

This standard establishes the minimum acceptable criteria for the design and construction of ponds if:

1. Failure of the dam will not result in loss of life; or damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.

2. The product of the storage times the effective height of the dam is less than 3,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the auxiliary spillway or the top of fill if there is no auxiliary spillway. The effective height of the dam is the difference in elevation, in feet, between the auxiliary spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no auxiliary spillway, the top of the dam is the upper limit.

3. The effective height of the dam is 35 feet or less, and the dam is hazard class (a). See National Engineering Manual 520.23 (b) for documentation of hazard classification.

Site conditions. Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary spillway, or (3) a principal spillway.

Drainage area. The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure.

The drainage area shall be large enough so that surface runoff and ground water flow will maintain an adequate supply of water in the pond. The ratio of pond area to drainage area should fall within the following guidelines:

(a) For slowly permeable soils (Hydrologic Group C & D soils) having slopes greater than seven (7) percent – not less than 1:4 or more than 1:20.

(b) For moderately permeable soils (Hydrologic Group B & C soils) and slowly

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permeable soils with less than seven (7) percent slopes – not less than 1:6 or more than 1:25.

(c) For permeable soils (Hydrologic Group A soils) – not less than 1:10 or more than 1:30.

The water quality shall be suitable for its intended use. Runoff water from barnyards, feedlots, septic tanks, barn drains, or other sources of contamination shall be diverted so as not to flow into ponds to be used for livestock water supply, fish and wildlife, or recreation.

Reservoir area. The topography and soils of the site shall permit storage of water at a depth and volume that ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

CRITERIA

General Criteria for Embankment and Excavated Ponds

The design, construction and operation of the pond shall comply with all federal, state and local laws, rules and regulations.

Minimum depth shall be 8 feet over at least 25 percent of pond or pit area at permanent water level, or where underlying rock prevents excavation to that depth, a minimum of 6 feet over at least 50 percent of the area.

When the primary purpose is for fish production, at least 75 percent of the shoreline shall be steepened to a slope of three horizontal to one vertical to a depth of 3 feet below permanent pool level. Ponds or pits primarily for fish production shall have a minimum surface area of not less than 0.25 acre when stocked with a single species or a minimum surface area of 0.5 acre when stocked with two or more species.

All others shall have a surface area adequate for the intended purpose, with a minimum surface area of 0.15 acre for excavated ponds and 0.25 acre for embankment ponds.

Vegetation. A protective cover of vegetation shall be established on all exposed surfaces of the embankment, spillway, borrow and spoil areas and to a minimum of 50 feet on all sides of pond and 100 feet upstream of the pool area. Open areas to be vegetated will be limed, fertilized, seeded and mulched according to the construction specification. No woody vegetation shall be planted on or within 25 feet of the embankment or spillway.

Fencing. When embankment ponds are used for livestock water, the entire fill, spillways and pond area shall be fenced to exclude livestock. Fencing shall be a minimum of 30 feet from all sides of the pond and a minimum of 50 feet upstream of the pool area. Flash grazing is allowed only with a grazing plan. Watering facilities for stock shall be provided outside the fenced area. All fencing shall be in accordance with the Field Office Technical Guide (FOTG) Standard (382) Fence.

Additional Criteria for Embankment Ponds

Foundation and soil investigation. The foundation on which a dam is to be placed shall have sufficient bearing strength to support the dam without excessive consolidation. Investigation shall be made of the fill site, pool area, and borrow areas to determine if the requirements listed for Foundation Cutoff can be met. The investigation shall be in sufficient detail to determine that adequate borrow is available, that the auxiliary spillway can be excavated as planned, that the mechanical spillway foundation is suitable, and the pond can maintain normal pool level. A more extensive investigation must be done in karst areas. Soil materials shall be classified using the Unified Soil Classification System.

Foundation cutoff. A cutoff of relatively impervious material shall be provided under the dam. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up the abutments as required and be deep enough (2 foot minimum) to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. Where the possibility of subsurface drains exist, the cutoff shall be deep enough to intercept them. The cut off trench shall have an 8-foot minimum bottom

width to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall not be steeper than one horizontal to one vertical.

The most impervious material available shall be used to backfill the cutoff trench and to construct the core of the dam.

Seepage control. Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage may create swamping downstream, (3) such control is needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage may be controlled by (1) foundation, abutment, or embankment drains; (2) reservoir blanketing or sealing; or (3) a combination of these measures.

Earth embankment. The minimum top width for a dam is shown in Table 1. If the embankment top is to be used as a public road, the minimum width shall be 16 feet for one-way traffic and 26 feet for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority.

Table 1. Minimum top width for dams.

Total Height of Embankment (feet)	Top Width (feet)
<10	6
10 to <15	8
15 to <20	10
20 to <25	12
25 to <35	14

The combined upstream and downstream side slopes of the settled embankments shall not be less than five horizontal to one vertical with the upstream slope never steeper than two and one-half horizontal to one vertical, and the downstream slope never steeper than two horizontal to one vertical. Slopes shall be designed to be stable, even if flatter side slopes and/or berms are required. The downstream slope shall be two and one-half horizontal to one vertical or flatter, if the dam is to be mowed.

If needed to protect the slopes of the dam, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (NRCS Technical Releases 56 and 69).

The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the reservoir with the auxiliary spillway flowing at design depth. The minimum difference in elevation between the crest of the auxiliary spillway and the settled top of the dam shall be 2 feet for all dams having more than a 20-acre drainage area or more than 20 feet in effective height.

The design height of the dam shall be increased by the amount needed to insure that after settlement the height of the dam equals or exceeds the design height. This increase shall not be less than 5 percent, except where detailed soil testing and laboratory analyses show a lesser amount is adequate.

Principal spillway. A pipe conduit, with needed appurtenances, shall be placed under or through the dam except:

1) Where rock, concrete, or other type of mechanical spillways are used;

2) For drainage areas less than 10 acres not fed by springs or seep;

3) Where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

When design discharge of the principal spillway is considered in calculating peak outflow through the auxiliary spillway, the crest elevation of the inlet shall be such that the full flow will be generated in the conduit before there is discharge through the auxiliary spillway. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long-duration, continuous, or frequent flows without flow through the auxiliary spillways. The minimum diameter of pipe, minimum frequency design and detention

storage shall be determined from Table 2 for the principal spillway.

Pipe conduits under or through the dam shall meet the following requirements. The pipe shall be capable of withstanding external loading without yielding, buckling, or cracking. Flexible pipe strength shall not be less than that necessary to support the design load with a maximum of 5 percent deflection. Pipe strength shall not be less than that of the grades indicated in Table 3 or 4 for plastic pipe and in Table 5 for corrugated aluminum, aluminized corrugated steel and galvanized steel pipe. The inlets and outlets shall be structurally sound and made of materials compatible with those of the pipe. All pipe joints shall be made watertight by the use of coupling, gaskets, caulking, or by welding.

For dams 20 feet or less in effective height, acceptable pipe materials are cast or ductile iron, steel, corrugated steel or aluminum, concrete, plastic, and cast-in-place reinforced concrete. Concrete pipe shall be laid in a concrete bedding. Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet-resistant materials and protected by coating or shielding, or provisions for replacement should be made as necessary. Connections of plastic pipe to less flexible pipe or structure must be designed to avoid stress concentrations that could rupture the plastic.

For dams more than 20 feet in effective height, conduits shall be plastic, reinforced concrete, cast in-place reinforced concrete, ductile iron, corrugated steel or aluminum, or welded steel pipe. Pipe shall be watertight. The joints between sections of pipe shall be designed to remain watertight after joint elongation caused by foundation consolidation. Concrete pipe shall have concrete bedding or a concrete cradle. Cantilever outlet sections, if used, shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed. Other suitable devices such as a Saint Anthony Fall stilling basin (S.A.F.), stilling basin, or an impact basin may be used to provide a safe outlet. Protective coatings of fiber bonded, asphalt coated, or vinyl coating on galvanized corrugated metal pipe, or coal tar enamel on welded steel pipe shall be provided in areas that have a history of pipe corrosion, or where the saturated soil resistivity is less than 4,000 ohms-cm, or where soil pH is lower than 5.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Table 2

Minimum requirements for structures located in predominantly rural or agricultural areas and incorporating water detention and/or retention storage in their design where (1) the hazard class of the structure is "a", (2) the product of the storage[1] times the effective height of dam[2] is less than 3000, and (3) the effective height of dam[2] is 35 feet or less.

<table>
<tr><th>Drainage Area</th><th>Effective Height of Dam 2/</th><th>Storage 1/</th><th>Principal Spillway (24-hour Storm AMCII)</th><th>Auxiliary Spillway (24 hour Storm) 4/</th><th>Top of Settled Fill</th></tr>
<tr><td>10 acres or less without Conduit 3/</td><td>Less than 20 feet</td><td rowspan="4">Less than 50 acre feet</td><td>See Note 3</td><td rowspan="2">Route Q_{10} 6/</td><td rowspan="5">Minimum of 1 foot freeboard above the Hp value for the auxiliary spillway, but at least 2 feet above the crest of the auxiliary spillway for all dams having more than 20 acres drainage area or more than 20 feet in effective height. 9/</td></tr>
<tr><td rowspan="2">20 acres or less 5/</td><td>Less than 20 feet</td><td>1.0" Detention Storage (minimum) or Route Q_2. 8/</td></tr>
<tr><td>20 feet or more</td><td>1.5" Detention Storage 7/ minimum or Q Route 5 yr. freq. 8/</td><td>Route Q_{25} 6/</td></tr>
<tr><td>Over 20 acres 5/</td><td></td><td></td></tr>
<tr><td>ALL OTHERS 5/</td><td></td><td></td><td>2.0" Detention Storage 7/ (minimum) or Q Route 10 yr. freq. 8/</td><td>Route Q_{50} 6/</td></tr>
</table>

1/ Storage is defined in "Conditions Where Practice Applies".

2/ Effective height of dam is defined in "Conditions Where Practice Applies".

3/ Where the pond is spring fed or other source of steady base flow, a pipe shall be installed with a capacity at least equal to the maximum spring or base flow.

4/ Auxiliary spillway crest shall be set above the storage requirements of the principal spillway, but not lower than the elevation at which the principal spillway conduit flows full. The crest of the auxiliary spillway shall be at least 0.5 feet above the crest of the principal spillway for less than 20 acres drainage area and at least 1.0 feet above the crest of the principal spillway for greater than 20 acres drainage area.

5/ A principal spillway conduit is required. Minimum pipe diameter shall be 4 inches smooth pipe or 6 inches corrugated metal pipe.

6/ Flow through the principal spillway shall not be included if the pipe diameter is less than 10 inches.

7/ Minimum pipe diameter shall be 10 inches.

8/ Storage may be determined by short cut methods on Engineering Field Handbook pages 11.55a, 11.55b, and 11.55c or Hydro-yardage computer program.

9/ Where IDNR approval is required, additional freeboard may be required. Consult the NRCS State Conservation Engineer for instructions.

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Specifications in Tables 3, 4, and 5 are to be followed for polyvinyl chloride (PVC), high density polyethylene (HDPE), steel, and aluminum pipe.

Cathodic protection is to be provided for coated welded steel and galvanized corrugated metal pipe where soil and resistivity studies indicate that the pipe needs a protective coating, and where the need and importance of the structure warrant additional protection and longevity. If cathodic protection is not provided for in the original design and installation, electrical continuity in the form of join-bridging straps should be considered on pipe that have protective coatings. Cathodic protection shall be added later if monitoring indicates the need.

National NRCS practice standard 430-FF Irrigation Water Conveyance, Pipeline, Steel provides criteria for cathodic protection of welded steel pipe.

When concrete pipe is used for the conduit, concrete shall also be placed around the outside of the riser enclosing the first joint of the conduit.

Risers or inlets for pipe conduits shall be of the same material as the conduit, or of comparable life materials such as reinforced concrete, concrete blocks, concrete culvert pipe, welded steel pipe or corrugated metal pipe. Hooded or canopy inlet may be used in lieu of a riser.

Risers shall have a cross-sectional area at least 1.5 times that of the principal spillway conduit which outlets from it, but not less than 18 inches diameter.

Risers shall have a height adequate to ensure full pipe flow in the barrel. All pipe risers shall have an extra foot of length below the invert of the conduit encased in concrete to the invert of the conduit.

Closed conduit spillways designed for pressure flow must have adequate anti-vortex devices.

To prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser.

The riser or inlet will be protected from ice and floating debris by a semi-circular berm not less than 4 feet from the riser. No berm is necessary when a hooded or canopy inlet is used but the invert of the inlet shall project one (1) foot vertically above the fill slope.

Table 3. Acceptable PVC pipe for use in earth dams. [1]

Nominal pipe size (inches)	Schedule for standard dimension ratio (SDR)	Maximum depth of fill over pipe (feet)
6 or smaller	SDR 26	10
	Schedule 40	15
	Schedule 80	20
8, 10, 12	SDR 26	10
	Schedule 40	10
	Schedule 80	15

1/ Polyvinyl chloride pipe, PVC 1120 or PVC 1220, that conform to ASTM-D-1785 or ASTM-D-2241.

Table 4. Acceptable HDPE pipe for use in earth dams. [1]

Pipe Values	Maximum height of fill over the top of pipe[2] (feet)
SDR 21-32.5 PS 34-50	10
SDR 17 PS 100	11.5

1/ High density polyethylene pipe, ASTM-D3350 flexural modulus cell class 4 or greater, conforming to ASTM F714 for smooth wall HDPE pipe or AASHTO M-252 or M-294 for double wall HDPE pipe. These materials will typically have standard dimension ratio (SDR) values ranging from 32.5 to 21 or pipe stiffness (PS) values ranging from 34 to 100 psi respectively.

2/ The maximum height of fill over top of the pipe. This is based on 0 degree bedding (line support at the invert only). Backfill is assumed to be at 85 to 95% of maximum standard proctor density.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Table 5. Minimum sheet thickness for corrugated steel pipe (2-2/3 in x ½ in corrugations). [1,2]

Diameter of pipe (inches)	Fill height (feet)		
	1 to <15	15 to <20	20 to 25
21 and less	0.064	0.064	0.064
24	0.064	0.064	0.064
30	0.064	0.064	0.079
36	0.079	0.079	0.109
42	0.109	0.109	0.138
48	0.138	0.138	0.138

Minimum sheet thickness (in) of aluminum pipe. [3]

Diameter of pipe (inches)	Fill height (feet)		
	1 to <15	15 to <20	20 to 25
21 and less	0.060	0.060	0.060
24	0.060	0.075	0.105
30	0.075	0.105	0.135
36	0.075	0.105	[4]

1/ Pipe with 6, 8 and 10-inch diameters has 1-1/2 in x ¼ in corrugations.
2/ Conforming to ASTM A760, A762 and A885.

3/ Riveted or helical fabrication, that conforms to ASTM B745 and B790.
4/ Not permitted.

Seepage control along a pipe conduit spillway or pond drain shall be provided in the normal saturation zone. Seepage along pipes extending through the embankment shall be controlled by use of a filter and drainage diaphragm, unless it is determined that antiseep collars will adequately serve the purpose.

The drain is to consist of sand, meeting fine concrete aggregate requirements (at least 15% passing the No. 40 sieve but no more than 10% passing the No. 100 sieve). If unusual soil conditions exist, a special design analysis shall be made.

The drain shall be a minimum of 2 feet thick and extend vertically upward and horizontally at least three times the pipe diameter, and vertically downward at least 18 inches beneath the bedding or cradle. The drain diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam.

The drain shall be outletted at the embankment downstream toe, preferably using a drain backfill envelope continuously along the pipe to where it exits the embankment. Riprap shall be used to cover the drain outlet to protect it from surface erosion.

When anti-seep collars are used in lieu of a drainage diaphragm, they shall have a watertight connection to the pipe. Collar material shall be compatible with pipe materials. Maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe, but not more than 25 feet. The first collar shall not be more than 14 feet downstream of the inlet. The antiseep collar(s) shall increase by 15% the seepage path along the pipe.

Where the downstream channel conditions are stable, the pier may be omitted for conduits of 15 inch diameter or less with the outlet invert one (1) to two (2) feet above the stable channel bottom. The outlet section shall be a minimum of 20 feet in length with a four (4) feet to eight (8) feet overhang downstream from the intersection of the flow line of the pipe and the design fill slope.

For conduits larger than 15-inch diameter, conduits with outlets higher than two (2) feet above the grade of the channel bottom or conduits outletting in unstable outlet channels, a cantilever propped outlet or other suitable devices such as a S.A.F. stilling basin, or impact basin will be provided. For cantilevered (propped) outlets, the outlet section of pipe shall be a minimum of 20 feet long, with the prop (or pier) located at or downstream from the intersection of the fill slope and the outlet channel grade. Approximately one-third of the outlet pipe section (minimum of 8 feet) shall be downstream of the pier centerline. A stilling

basin shall be excavated and lined with riprap if necessary to prevent erosion at the outlet.

A pipe with a suitable valve shall be provided to drain the pool area if needed for proper pond management. The principal spillway conduit may be used as a pond drain if it is located where it can perform this function. The drain shall be large enough to draw the pond down 8 feet in 2 weeks (approximately 16 GPM or 0.04 cfs. per A.F. of storage).

Supply pipes through the dam to watering troughs and other appurtenances shall have an inside diameter of not less than 1¼ inches.

Auxiliary spillways. An auxiliary spillway must be provided for each dam, unless the principal spillway is large enough to pass the peak discharge from the routed design hydrograph and the trash that comes to it without overtopping the dam. The following are minimum criteria for acceptable use of closed conduit principal spillway without an auxiliary spillway: a conduit with a cross-sectional area of 3 square feet or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

The minimum capacity of a natural or constructed auxiliary spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2.

The auxiliary spillway shall safely pass the peak flow, or the storm runoff shall be routed through the reservoir. The routing shall start either with the water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days' drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the auxiliary spillway or from the elevation that would be attained if the entire design storm were impounded, whichever is lower. Auxiliary spillways shall provide for passing the design flow at a safe velocity to a point downstream where the dam will not be endangered.

Constructed auxiliary spillways are open channels that usually consist of an inlet channel, a control section, and an exit channel. They shall be trapezoidal and shall be located in undisturbed or compacted earth. The side slope shall be stable for the material in which the spillway is to be constructed, but not steeper than two horizontal to one vertical except when cut in rock. The minimum auxiliary spillway bottom width shall be 10 feet.

The control section shall be level for a minimum distance of 10 feet. The inlet channel shall be at least the same width as the control section and may be curved to fit existing topography. The grade of the exit channel of a constructed auxiliary spillway shall fall within the range established by discharge requirements and permissible velocities. The constructed exit channel shall be straight and uniform to a point downstream of the toe of the dam.

Structural auxiliary spillway. If chutes or drops are used for principal spillways or auxiliary spillways, they shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices and the National Engineering Handbook-Section 5, Hydraulics; Section 11, Drop Spillways; and Section 14, Chute Spillways. The minimum capacity of a structural spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2.

Additional Criteria for Excavated Ponds

General. This type of reservoir is generally constructed in flat land areas where an embankment pond is not feasible. The water supply is obtained from underground seepage, high water table, springs, subsurface drains or surface runoff. An adequate water supply which will maintain desired water level in pond must be assured.

Outlet. Provisions shall be made for a pipe and auxiliary spillway if necessary (see Table 2). Runoff flow patterns shall be considered when locating the pit and placing the spoil.

Depth. Depth requirements shall be the same as for embankment ponds, except that if the water supply is derived from seeps or spring flows, the

pit must have a depth of at least 4 feet over 25 percent of the pit area.

Side slopes. Side slopes of excavated ponds shall be stable and shall not be steeper than the minimum side slopes shown in Table 6.

Table 6. Steepest Allowable Side Slopes

Texture	Horizontal:Vertical
Peat and Muck	1:1
Fine Sand	2.5:1
Coarse Sand and Gravel	2:1
Silt Loam or Loam	2:1
Sandy Loam	2:1
Clay Loam or Silty Clay Loam	1.5:1

Inlet protection. If surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Excavated material. The material excavated from the pond shall be placed so that its weight will not endanger the stability of the pond side slopes and so that it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

1. Uniformly spread to a height that does not exceed 3 feet with the top graded to a continuous slope away from the pond.

2. Uniformly placed or shaped reasonably well with side slopes assuming a natural angle of repose. The excavated material will be placed at a distance equal to the depth of the pond but not less than 12 feet from the edge of the pond.

3. Shaped to a designed form that blends visually with the landscape.

4. Used for low embankment and leveling.

5. Hauled away.

Safety. Ponds and pits can create a safety hazard. Appropriate safety features and devices shall be installed to protect people and animals from accidents such as falling or drowning, if appropriate.

CONSIDERATIONS

Considerations should be given to the use of construction materials, grading practices, vegetation and other site development elements that minimize visual impacts and maintain or supplement existing landscape uses.

Excess excavated material may be used to construct earth fishing piers into the pond and/or nesting islands.

The visual design of ponds should be carefully considered in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that it is generally curvilinear rather than rectangular. Excavated material can be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and to attract wildlife.

Consider using a trickle tube to keep auxiliary spillways from eroding from wetness when no principal spillway pipe is installed.

PLANS AND SPECIFICATIONS

Plans and specifications for construction of ponds shall be in keeping with this standard and shall describe the requirements for properly installing the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance plan will be developed for the landowner in keeping with this practice standard. At a minimum, the following items shall be addressed:

1. Remove any woody growth from embankments and spillway areas. Keep grasses mowed for better visual inspection.

2. Remove debris and trash from spillways and outlets immediately. Inspect the outlet regularly, especially after storm events.

3. Control burrowing animals. Repair any holes caused by burrowing animals on or near the embankment.

4. Repair any erosion of the embankment.

5. Inspect the embankment for seepage downstream.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Indiana NRCS FOTG – October, 2002.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Riparian Forest Buffer

(Acres)

Code 391

DEFINITION

An area of predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies.

PURPOSES

- Create shade to lower water temperatures to improve habitat for aquatic organisms.
- Provide a source of detritus and large woody debris for aquatic and terrestrial organisms.
- Create wildlife habitat and establish wildlife corridors.
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow ground water flow.
- Provide a harvestable crop of timber, fiber, forage, fruit, or other crops consistent with other intended purposes.
- Provide protection against scour erosion within the floodplain.
- Restore natural riparian plant communities.
- Moderate winter temperatures to reduce freezing of aquatic over-wintering habitats.
- To increase carbon storage.

CONDITIONS WHERE PRACTICE APPLIES

On areas adjacent to permanent or intermittent streams, lakes, ponds, wetlands and areas with ground water recharge that are capable of supporting woody vegetation.

CRITERIA

General Criteria Applicable to All Purposes

- Plans and application of riparian forest buffer shall comply with all applicable federal, state, and local laws and regulations.
- Dominant vegetation shall consist of existing, planted or seeded trees and shrubs adapted to the site and the intended purpose.
- The species, type of plant material, location, layout and density of the planting shall accomplish the intended purpose and function.
- Native plant species shall be used whenever possible. Known non-native invasive species shall not be used.
- Removal of trees for timber products shall not compromise the intended purpose of the buffer.
- Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose.
- Riparian buffers shall be designed to meet the minimum buffer width as designated in Table 1.
- Woody plants shall be established without compromising the integrity of:
  1. Property Lines
  2. Fences
  3. Utilities

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4. Roads
5. Legal Drains
6. Other Easement Areas or Right of Ways

- Where subsurface drains (tile lines) cross through a tree/shrub planting, and where these drains will remain functional, non-perforated tile shall be installed through the planting and extend a minimum of 50 feet on either side of the planting, or trees/shrubs shall not be planted within 50 feet on either side of the perforated tile line.

- **Buffer Configuration**

All buffers shall consist of at least two zones, Zone 1 and Zone 2. In addition, Zone 3 shall be required if needed to control erosion up-gradient of Zone 2.

Zone 1 – Streamside Forest

Shall begin at the normal water line, or at the top upper edge of the active channel or shore, extend a minimum distance of 25 feet measured horizontally on a line perpendicular to the water body. Tree removal is minimized in this zone to allow trees to grow to maturity. Mature trees are needed to lower water temperatures and to provide a source of detritus for fish and other aquatic organisms. Occasional removal of trees for forest products is permitted provided that the intent of the buffer is not compromised. Felling and skidding of trees shall be directed away from the water course or water body. Skidding shall be done in a manner that minimizes soil erosion.

Exception for legal drains (only with written permission): Zone 1 can begin 30 feet from the top of bank to provide an access strip for equipment ingress and egress.

The access strip is allowable if the primary purpose of the buffer is attainable with the presence of the access strip. The access strip shall be maintained in herbaceous plants.

- Written permission shall be obtained for all easements.

Zone 2 – Managed Forest

Shall begin immediately from Zone 1 and extend a minimum distance listed in Table 1. Minimum Zone Widths.

Criteria for Zone 1 applies except that removal of trees for forest products is permitted on a periodic and regular basis provided the intended purpose is not compromised.

Table 1. Minimum Zone Widths (in feet)

Stream Order[1]	Zone 1	Zone 2	Total
1,2	25	25	50
3 and larger	25	75	100
Others[2]	25	25	50

[1] Stream order is a description of a drainage pattern. It is a measure of the position of a stream in the hierarchy of tributaries. First order streams are those which have no tributaries. Stream order increases when 2 streams of equal order join. For example, it takes 2 second order streams joining to make a third order stream.
[2] Includes open ditches and streams that have surface flow for less than 6 months out of the year. Also includes buffers around wetlands, lakes, and ponds.

Zone 3 – Stiff-Stemmed Grasses

Where ephemeral, concentrated flow or sheet and rill erosion is a concern in the area up-gradient of Zone 2, install a vegetated filter strip of grasses and/or forbs. When Zone 3 is used it shall be applied in accordance with FOTG (391) *Filter Strip* with a minimum width of 20 feet.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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- **Plant Establishment**

Tree and/or shrub plantings shall follow site preparation/weed control for establishment, planting dates, planting and storage guidelines as detailed in FOTG (612) *Tree/Shrub Establishment.*

The planting of a riparian buffer shall establish a minimum of 300 trees/acre using one of the planting and/or establishment methods as detailed in FOTG (612) *Tree/Shrub Establishment*.

If seedlings are planted a minimum of 436 trees/acre shall be planted using a 10' X 10' spacing or equivalent.

Criteria to Create Shade to Lower Water Temperatures to Improve Habitat for Aquatic Organisms

Buffer species shall be capable of achieving desired height and crown density required for shade production. The buffer canopy shall be established to achieve at least 50% crown cover with an average projected canopy shade length equal to or greater than the planned width of the water body that needs shade protection. Use Table 2, Shadow Length Table as a tree height guide with Table 3, on pages 4-5 to select suitable species.

Place trees and shrubs with high shade values nearest the water course or body. Shoreline or channel relief (e.g. deeply incised channels) and topographic shading will be taken into account in selecting species.

Table 2. Shadow Length Table[1]

Tree Height (ft.)	June	July	August
40	23	25	32
50	29	31	40
60	35	38	48
70	41	44	56
80	47	50	64
90	52	57	72

[1]Shadow length at 10 AM and 2 PM, from the ASHRE Handbook, 1972

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Table 3. - Plant List for Riparian Buffers (see page 5 for definitions of abbreviations used in this table)

Common Name/ Scientific Name	Indiana Suitability	Flood Tolerance	Large Debris	Soil Drainage	Shade Value	Mature Height	Wildlife		
							Food	Cavity Nesting	Bat Roost
Ash, Green *Fraxinus pennsylanica*	All	H	M	VPD-WD	H	60	M	M	M
Ash, White *Fraxinus americana*	All	M	M	MWD-WD	H	70	M	M	M
Baldcypress *Taxodium distichum*	So. IN[1]	VH	M	VPD-WD	M	80	M	M	M
Birch, River *Betula nigra*	All	M	H	VPD-WD	M	50	M	M	M
Blackgum *Nyssa sylvatica*	All	M	M	PD-WD	H	60	H	M	M
Buttonbush *Cephalanthus occidentalis*	All	VH	L	VPD-SPD	L	5	H	L	L
Cherry, Black *Prunus serotina*	All	L	M	MWD-WD	L	70	H	L	M
Chokeberry, Black *Aronia melanocarpa*	All	L	L	SPD-WD	L	10	H	L	L
Cottonwood *Populus deltoides*	All	H	H	PD-ED	M	90	L	H	M
Cranberry, Highbush *Viburnum trilobum*	All	L	L	VPD-WD	L	9	H	L	L
Dogwood, Red-Osier *Cornus stolonifera*	All	H	L	VPD-WD	L	10	H	L	L
Dogwood, Silky *Cornus amomum*	All	H	L	VPD-WD	L	10	H	L	L
Elderberry *Sambucus canadensis*	All	H	L	VPD-WD	L	9	H	L	L
Hickory, Shellbark *Carya laciniosa*	All	M	M	VPD-WD	H	70	H	M	H
Hackberry *Celtis occidentalis*	All	M	M	SPD-WD	M	50	M	M	M
Maple, Red *Acer rubrum*	All	H	H	VPD-WD	H	70	M	H	M
Maple, Silver *Acer saccharinum*	All	H	H	VPD-WD	H	80	M	H	M
Oak, Bur *Quercus macrocarps*	All	H	M	PD-ED	H	80	H	H	M
Oak, Cherrybark *Quercus pagodafolia*	So. IN[1]	M	M	SPD-WD	H	75	H	H	M
Oak, Pin *Quercus palustris*	All	H	H	VPD-WD	M	75	H	H	M

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Common Name/ Scientific Name	Indiana Suitability	Flood Tolerance	Large Debris	Soil Drainage	Shade Value	Mature Height	Wildlife		
							Food	Cavity Nesting	Bat Roost
Oak, Overcup *Quercus lyrata*	So. IN[1]	VH	M	VPD-WD	M	70	H	H	M
Oak, Red *Quercus rubra*	All	L	H	MWD-WD	H	80	H	H	M
Oak, Swamp Chestnut *Quercus michauxii*	So. IN[1]	M	H	SPD-WD	H	70	H	H	M
Oak, Swamp White *Quercus bicolor*	All	M	M	VPD-WD	H	70	H	H	M
Oak, White *Quercus alba*	All	L	H	MWD-WD	H	90	H	H	M
Pawpaw *Asimina triloba*	All	L	L	SPD-WD	L	20	M	L	L
Pecan *Carya illinoensis*	So. IN[1]	H	M	SPD-WD	H	120	H	H	M
Persimmon *Diospyros virginiana*	All	M	M	MWD-WD	M	50	H	M	M
Sweetgum *Liquidambar styraciflua*	So. IN[1]	M	M	PD-WD	M	85	L	M	M
Sycamore *Platanus occidentalis*	All	H	H	PD-WD	H	90	L	H	M
Tuliptree (Yellow Poplar) *Liriodendron tulipifera*	All	L	M	PD-WD	M	90	M	M	M
Walnut, Black *Juglans nigra*	All	M	M	MWD-WD	M	80	H	M	M
Willow, Black *Salix nigra*	All	VH	L	VPD-WD	L	60	L	M	M
Willow, Peachleaf *Salix amygdaloides*	All	VH	L	VPD-WD	L	30	L	L	L
Willow, Pussy *Salix discolor*	All	VH	L	VPD-WD	L	20	L	L	L
Willow, Sandbar *Salix interior*	All	VH	L	VPD-WD	L	10	L	L	L

[1]Counties south of U.S. 40

Letter Definitions

H	High
M	Medium
L	Low

Soil Drainage Class

VPD	Very Poorly Drained
PD	Poorly Drained
SPD	Somewhat Poorly Drained
MWD	Moderately Well Drained
WD	Well Drained

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Criteria to Provide a Source of Detritus and Large Woody Debris for Aquatic and Terrestrial Organisms

Within Zone 1, establish, favor or manage species capable of producing stems and limbs of sufficient size to provide an eventual source of large woody debris (>10 inches in diameter) for in-stream habitat for fish and other aquatic organisms.

Refer to Table 3 on page 4 and 5 for species recommendations.

Criteria to Create Riparian Habitat and to Establish Corridors for Wildlife

The riparian forest buffer shall be planned for the target wildlife species. Woody plants shall be selected from Table 3, and/or from FOTG (645) *Upland Wildlife Habitat Management* and/or from FOTG (644) *Wetland Wildlife Habitat Management.* Refer to Table 4. for the minimum buffer widths for applicable wildlife species.

Table 4. Buffer Widths (minimum) for Selected Species

Species	Minimum Width, feet
Bald eagles, herons, egrets and cranes	600
Pileated woodpeckers, barred owls	450
Beaver, mink, waterfowl	300
Gray and fox squirrels	300
Deer	200
Amphibians and aquatic reptiles	50

Criteria to Reduce Sediment, Nutrients, Pesticides in Surface Runoff and to Provide Protection Against Scour Erosion within the Floodplain.

- To reduce sediment outflow the design width of Zone 2 shall be increased to include areas of debris and/or sediment deposits not to exceed the width of the 100 year flood plain. When Zone 2 cannot be increased Zone 3 shall be established to a minimum width of 20 feet.
- Manage the dominant tree canopy to maintain the vigor of the overstory and understory species. Periodic thinning may be required to allow adequate light to reach the forest floor to maintain a good cover of herbaceous plant species.
- The design with of Zone 2 shall be increased to include areas of overland flow, scour erosion, and overland flow channels up to the width of the 100 year floodplain

Criteria to Provide a Harvestable Crop of Timber and to Increase Carbon Storage

The riparian buffer shall be established and managed for timber products without compromising the buffers ability to support other planned criteria.

To promote rapid canopy closure and to produce a forest containing well-formed trees a minimum of 544 trees/acre shall be planted (8' X 10' spacing or equivalent) or established using direct seeding methods.

All timber harvesting activities shall be in compliance with the "Indiana Logging and Forestry Best Management Practices - BMP Field Guide"

CONSIDERATIONS

Consider the landowners objectives for riparian forest buffer, so that the planned objective for the planting is achievable.

Bare root seedlings should be considered as the standard method to establish trees and shrubs.

Planting bare root seedlings has proven to be the most economical and successful method to

establish trees and shrubs. However, other methods to establish trees and shrubs may be applicable in some circumstances.

Seed sources for direct seeding and woody planting stock should be locally adapted and come from no more than 200 miles north or south of the planting site.

Consider selecting species from Conservation Tree/Shrub Suitability Groups (CTSG), species to plant, Section II (FOTG). Trees to plant from CTSG's can be viewed at the NRCS Indiana web site.

Monocultures and off site species are discouraged for riparian forest buffers.

Consider using a support stake when planting container trees and balled and burlapped stock.

Consider planting a mixture of species (5-10 species) adapted to the site (including shrubs) to improve plant diversity.

Seek technical assistance from a professional forester for reforestation or other conservation tree planting projects.

To improve plant growth, consider 2 additional years of chemical weed control after plants are established. Weed control should be performed using narrow bands (2'-3' wide) on each side of a plant row unless the entire site is treated.

Fine hardwood species should be mixed with other tree species and shrubs to promote diversity.

Sites that are frequently flooded or ponded for long or very long duration may be difficult and impractical for tree/shrub establishment.

Consider using natural regeneration on these sites to establish woody plants and allow the site to revegetate to herbaceous and/or woody plant cover.

Consider that natural regeneration is often likely to occur, but not guaranteed on sites that have a seed source from a forested floodplain system where seeds are deposited in sufficient quantity to establish woody vegetation. On these sites, natural regeneration of light seeded species (e.g. green ash, silver maple, cottonwood , etc.) may establish large numbers of tree seedlings.

Consider selecting species from FOTG Wildlife Upland Habitat Management (645) and/or FOTG Wetland Wildlife Habitat Management (644) to enhance wildlife benefits.

Shrub species may be direct seeded to provide wildlife habitat. Refer to Direct Seeding of Shrubs, IN-NRCS, Forestry Technical Note No. 16.

When planning this practice, consider how it can enhance and/or protect air quality.

PLANS AND SPECIFICATIONS

Plans and specifications for tree/shrub establishment will be prepared for each site in accordance with the criteria for this practice. The plan will include planting dates, site preparation, weed control, plant spacing, species, type of stock used, and planting and storage guidelines.

OPERATION AND MAINTENANCE

Check survivability of planted species after 3 years to insure that at least 300 desirable stems/acre of woody plants are established. If less than 300 stems/acre are established additional planting will be completed if it is determined that additional natural regeneration will not be sufficient to colonize the site within an acceptable time frame (usually 5 years).

Control weed competition during establishment (3 years). Competing weeds, brush, and vines can adversely affect survival, form and rate of tree growth. Additional years of weed control may be needed in some instances e.g. to control johnsongrass, quackgrass, or other hard to control weed species.

Use the following or combination of methods as needed to control weed competition (see Table 1 for specific treatments, FOTG (612) *Tree/Shrub Establishment*):

- shallow cultivation
- mowing
- spraying approved herbicides
- cutting woody plants and applying approved pesticides

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Correlatively prune hardwood species, as needed depending on species and growth form desired. Refer to FOTG (660) *Tree Shrub Pruning*.

Protect the planting from fire. Plan access roads and firelanes prior to planting. See Indiana Field Office Technical Guide, Section IV for *Access Road* (560) and *Firebreak* (394).

Fence if necessary to protect the planting from excessive livestock browsing and trampling damage, refer to FOTG Standards, Use Exclusion (472) and Fence (382).

Protect from disease, rodents, deer, and insects using approved pesticides, hunting, fencing, or other appropriate methods. Additional information can be viewed from the "Illinois Direct Seeding Handbook", Wildlife Damage Management.

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Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Indiana NRCS FOTG, February 2004

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Sediment Basin

(Number)

Code 350

DEFINITION

A basin constructed to collect and store debris or sediment.

PURPOSES

To preserve the capacity of reservoirs, ditches, canals, diversions, waterways, and streams; to prevent undesirable deposition on bottom lands and developed areas; to trap sediment originating from construction sites; and to reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, stone, agricultural wastes, and other detritus.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where physical conditions or land ownership preclude treatment of a sediment source by the installation of erosion control measures to keep soil and other material in place, or where a sediment basin offers the most practical solution to the problem.

CRITERIA

General. The capacity of the sediment basin shall equal 1 ½ times the volume of sediment expected to be trapped at the site during the planned useful life of the basin or the improvements it is designed to protect. If it is determined that periodic removal of debris will be practicable, the capacity may be proportionately reduced.

Agricultural Lands – The minimum volume of sediment storage for permanent sediment basins in agricultural areas shall be a 1 ½ times the estimate determined for a 15-year period or the period required for stabilization of the sediment source area.

The procedure outlined in Chapter 11 of the Engineering Field Manual will be used to determine the amount of sediment, which will accumulate in a basin.

Disturbed Areas – The minimum sediment storage volume shall be 1 ½ times that expected from the source area during the expected life of the structure. When periodic cleanout is planned, the minimum storage volume will be 1 ½ times that required for the expected period between cleanout but not less than that required for one year. Consult procedure outlined in Chapter 11 of the Engineering Field Manual.

Classification. Sediment Basins shall be classified as follows:

Class 1 – 1. Drainage Area, 5 acres or less
2. No permanent pool
3. Embankment effective height 5 feet or less
4. Temporary basin

Class II – Any sediment basin exceeding one or more of the criteria for Class I sediment basins.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Class I basins. The minimum capacity shall be that required to store all of the runoff from a 10-year, 24-hour storm from the contributing drainage area plus the required sediment storage.

The embankment shall have a minimum top width of 4 ft and side slopes of 2:1 or flatter.

An outlet shall be provided of earth, pipe, stone, or other devices adequate to keep the sediment in the basin and to handle the 10-year frequency discharge without failure or significant erosion. Outlet conduits shall meet the standard and specifications for ponds (378).

The detention time of the basin affects the efficiency of sediment removal from the incoming runoff. The minimum detention time should be 24 hours. This may be met by providing a maximum design outflow of 0.025 c.f.s. per acre-inch of runoff. Longer detention times are encouraged where practical or necessary to meet downstream water quality.

An emergency spillway is not required. A maximum of one foot may be added to the design height across the central storage area to provide for an emergency spillway around one or both ends of the embankment.

Class II basins. The basin may be either a wet type or dry type. The principal spillway and drawdown if used, shall be proportioned such that the inflow from a 10-year, 24-hour storm is detained a minimum of 24 hours.

Other provisions. Provisions are to be made for draining sediment pools if necessary for safety and vector control. Fencing and other safety measures shall be installed as necessary to protect the public from floodwater and soft sediment. Fencing shall be according to NRCS Standard 382.

The design of dams, spillways, and drainage facilities shall be according to NRCS standards for ponds (378) and grade stabilization structures (410) or according to the requirements in TR-60, as appropriate for the Class II and kind of structure being considered.

Other Factors to Consider to Improve Efficiency

Provisions at the entrance of a basin to reduce velocity of inflow.

Attempt to achieve a basin flow length to width ratio of 5 to 1.

Use a siphon arrangement in a nonperforated riser pipe.

Locating inflow and outflows as far apart as possible to prevent short-circuiting.

The use of baffles within the basin to help utilize the whole basin.

"Surface Mining Control and Reclamation Act of 1977"

Sediment basins designed to meet the sedimentation pond regulations of the above act shall also be designed to meet the following:

1. Provide a minimum of 3 years sediment storage volume.

2. Sediment storage volume equal to 0.1 acre feet per acre of disturbed area within the upstream drainage area, except that sediment volumes of no less than 0.035 acre-foot for each acre may be used where other sediment control measures equals the reduction in sediment storage volume for a total of 0.1 acre feet per acre of disturbed area.

3. Less than 24-hour theoretical detention time may be approved by regulatory authority to not less than 10 hours by demonstrated mechanical improvements or to any level by chemical treatment that meets effluent limitations.

4. The dewatering device shall not be located at a lower elevation than the maximum elevation of the design sediment storage volume.

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5. Sediment shall be removed from sedimentation basins when the volume of sediment accumulates to 60 percent or more of the designed sediment storage volume.

6. Emergency Spillway shall be at or above the 10-year, 24-hour precipitation event.

7. An appropriate combination of principal and emergency spillway shall be provided to discharge safely the runoff from a 25-year, 24-hour precipitation event.

8. The emergency spillway shall be a minimum of one foot above the crest of the principal spillway.

9. If the embankment has more than 20 feet vertical height between the elevations of ground at the upstream toe and the crest of the emergency spillway or has a storage volume of 20 acre feet or more, an appropriate combination of principal and emergency spillway shall be provided to safely discharge the runoff resulting from a 100-year, 24-hour precipitation event. Indiana Department of Natural Resources criteria will apply as appropriate.

Vegetation. The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded or sodded.

Seedbed preparation, seeding, fertilizing, and mulching shall be according to the Standards and Specifications for Critical Area Planting (342).

CONSIDERATIONS

Sediment basins should be part of the treatment needed to protect the soil, water, plants, animals and air resources. The management system must be planned to prevent excessive maintenance and operation problems.

Effects on water quantity and quality shall be considered. Sediment basins are a flow through type structure and are designed to detain the runoff, but not to store it. Therefore, the structure will not decrease the amount of surface runoff water delivered downstream, but will delay the time it takes the runoff to reach the downstream areas. There may be an increased recharge to ground water, depending on the time of detention, the permeability of the bottom of the basin, and the age of the structure.

If the basin has been in place a long enough time to collect a considerable amount of organic material in the bottom, and the bottom tends to remain wet; the bottom may be nearly impermeable. In this situation, there will be only small amounts of water percolating to beneath the basin.

Sediment basins will retain sediment, sediment associated materials and other debris from the water. Due to the detention of the runoff in the basin, there is an increased opportunity for soluble materials to be leached toward the ground water.

Special attention shall be given to maintaining and improving visual resources and habitat for wildlife where applicable. The landowner/user shall be advised if wetlands will be affected and USDA-NRCS wetland policy will apply. All work planned shall be in compliance with General Manual Title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local Laws and Regulations. If archaeological and historical properties are encountered, the USDA-NRCS policy in General Manual Title 420-GM, Part 401 shall be followed.

PLANS AND SPECIFICATIONS

Plans and specifications for installing sediment basins shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction of sediment basins within the scope of the standard for ponds (378) shall have, as a minimum, specifications commensurate with those for ponds (378). Those within the scope of TR-60 shall be in accord with the guide specifications contained in the National Engineering Handbook, Section 20.

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OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover. Items to consider are:

1. Do not graze protected area of embankment and pond.

2. Fertilize to maintain a vigorous vegetative cover in protected area.

3. Mulch, spray or chop out undesirable vegetation periodically to prevent growth of large woody-stemmed weeds, water plants such as cattails or trees (such as willows) from embankment and spillway areas.

4. Promptly repair eroded areas.

5. Promptly remove any burrowing rodents that may invade area of embankment.

6. Reestablish vegetative cover immediately where scour erosion has removed established seeding.

7. Keep open all spillways and remove trash that may accumulate around entrance.

8. Remove sediment from basin when volume of sediment storage becomes depleted.

9. Periodically inspect area for any new maintenance items and if any observed take immediate action to protect from further damage or deterioration.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Streambank and Shoreline Protection

(Feet)

Code 580

DEFINITION

Using vegetation or structures to stabilize and protect banks of streams, lakes, estuaries, or excavated channels against scour and erosion.

PURPOSES

To stabilize or protect banks of streams, lakes, estuaries, or excavated channels for one or more of the following purposes:

1. To prevent the loss of land or damage to utilities, roads, buildings, or other facilities adjacent to the banks,
2. To maintain the capacity of the channel,
3. To control channel meander that would adversely affect downstream facilities,
4. To reduce sediment loads causing downstream damages and pollution, or
5. To improve the stream for recreation or as a habitat for fish and wildlife.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to natural or excavated channels where the streambanks are susceptible to erosion from the action of water, ice, or debris or to damage from livestock or vehicular traffic. It also applies to controlling erosion on shorelines where the problem can be solved with relatively simple structural measures, vegetation, or upland erosion control practices and where failure of structural measures will not create a hazard to life or result in serious damage to property.

CRITERIA

Criteria for streambank protection measures

Because each reach of a channel, lake, or estuary is unique, measures for streambank and shore protection must be installed according to a plan adapted to the specific site.

Designs for streambanks shall be according to the following principles:

1. Protective measures to be applied shall be compatible with improvements planned or being carried out by others.

2. The grade must be controlled, either by natural or artificial means, before any permanent type of bank protection can be considered feasible, unless the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

3. Streambank protection shall be started at a stabilized or controlled point and ended at a stabilized or controlled point on the stream.

4. Channel clearing to remove stumps, fallen trees, debris, and bars that force the streamflow into the streambank shall be an initial element of the work.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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5. Changes in channel alignment shall be made only after an evaluation of the effect on the land use, interdependent water disposal systems, hydraulic characteristics, and existing structures.

6. Structural measures must be effective for the design flow and be able to withstand greater floods without serious damage. They shall also be designed to avoid an increase in erosion downstream of planned measures.

7. When the streambank protection is to protect improvements such as buildings or structures, consideration will be given to items such as: (a) cost of the stabilization compared to the value of the structure(s) protected, (b) possibility of relocation of the structure needing protection, (c) remaining service life of the structure needing protection, and (d) effect of the streambank stabilization of the future management system of the landowner/user.

8. Extensive clearing of trees and brush along channel banks for the purpose of placing streambank protection will not be performed. Clearing under the area which streambank protection is to be placed is permissible. If removal of trees and brush is required, only the minimum necessary to accomplish the work will be performed. Lack of proper equipment to place the riprap or reduce construction costs are not justifiable reasons for removing more woody vegetation than absolutely necessary.

9. Vegetative protection shall be considered on the upper parts of eroding banks, especially on areas that are susceptible to infrequent inundation. When the 10-year frequency flow or the bank full flow has a velocity of 5 ft. per second or less, riprap or other nonerosive material to stabilize only the toe of the slope may be placed if all of the following conditions are met: (a) the upper edge or line of stabilizing material is 1 foot or more above the zone of saturation for base flow conditions on the bank slope, (b) banks have a slope of 2:1 or flatter, (c) the watershed or drainage area upstream from the area being protected is less than 100 square miles in size.

10. Scrap materials such as junked auto bodies will not be used for streambank or shoreline protection.

Streambank protection measures. The following is a partial list of elements that may be in a plan for streambank protection.

___Removal of fallen trees, stumps, debris, minor ledge outcroppings, and sand and gravel bars that may cause local current turbulence and deflection.

___Removal of trees and brush that adversely affect the growth of desirable bank vegetation.

___Reduction of the slope of streambanks to provide a suitable condition for vegetative protection or for the installation of structural bank protection.

___Placed or dumped heavy stone, properly underlain with a filter blanket, if necessary, to provide armor protection for streambanks.

___Deflectors constructed of posts, piling, fencing, rock, brush, or other materials that project into the stream to protect banks or curves and reaches subjected to impingement by high velocity currents.

___Pervious or impervious structures built on or parallel to the stream to prevent scouring streamflow velocities adjacent to the streambank.

___Obstructions, such as fences, to protect vegetation needed for streambank protection or to protect critical areas from damage from stock trails or vehicular traffic. Where needed, construct a permanent fence capable of excluding livestock from the streambanks. If livestock watering places are provided, the ramps leading to low water shall be on a slope of 4:1 or flatter. The ramps shall be surfaced with a suitable material to prevent erosion. Floodgates may be used at channel crossings, property and other fence lines.

___Banksloping. All banks to be seeded only and not riprapped shall be sloped to a 2:1 side slope or flatter. All material excavated from a

sloped bank may be placed on the bank, leveled, and seeded to prevent erosion during high water or hauled to other areas for use. Excavated material should not be pushed into the stream or lake or form barriers which interfere with runoff entering natural channels.

___Jetties. Brush, riprap, and/or piles may be used as deflecting jetties. Jetties must not extend out in the stream so the channel capacity is reduced.

___Revetments.

(1) Riprap. This type of construction is particularly effective in the following situations: (a) sharp bends; (b) constrictions such as bridges where velocities are increased; (c) along the opposite bank where another stream junctions; and (d) on large streams, the bank should be sloped to a 1 ½ side slope or flatter. The thickness and gradation requirements shall conform to criteria in Chapter 16 of the Engineering Field Manual.

(2) Gabions. Gabions are wire or plastic mesh baskets connected together and filled with rock in place. Banks shall be sloped to a 1.5:1 side slope or flatter. If the bank material is a fine-grained soil, use a well-graded pit-run sand and gravel filter or filter cloth.

___Stream Crossings. Stream crossings are installed to provide crossings for equipment and/or livestock. The crossing may consist of rubble or paved surfaces placed on the stream bottom and sides or may be culverts or bridges. NRCS does not provide designs for bridges. However, standard plans for timber bridges are available. Bridges and culverts must meet the requirements for capacity required by the Indiana Department of Natural Resources. Permits are usually required.

Crossing consisting of rock or rubble shall be placed in a manner which does not interfere with streamflows. Adequate thickness shall be provided to insure a firm base.

The following minimum guidelines shall apply for stream crossings:

(1) Firm Foundations - use on of the following:

a. 5 inches concrete over a minimum of 6 inches of pit-run sand-gravel or crushed stone.

b. 4 inches of surface gravel (IDOH size #5, #53 or #73) over 8 inches or more of crushed rock (d_{50} = 4”).

(2) Soft Foundations – use one of the following:

a. 5 inches concrete with 6 gate, 6” x 6” welded wire fabric over 6 inches pit-run sand and gravel or crushed stone.

b. 4 inches of surface gravel (IDOH size #5, #53 or #73) over 18 inches or more of crushed rock (d_{50} = 7-8”).

Crushed rock thickness should be increased 6 inches for equipment or vehicle crossings.

Concrete crossings shall be finished with a rough surface.

Ramps for livestock crossings shall not be steeper than 4 horizontal to 1 vertical. Ramps for equipment should be 6 horizontal to 1 vertical or flatter. Minimum width is 8 feet. Side slopes for ramps shall not be steeper than 2 horizontal to 1 vertical.

Standard plans shall be used when applicable.

Criteria for shoreline protection measures.

Design shall be according to the following principles.

1. Treatment depends on soil type and the slope characteristics both above and below the waterline. Slope characteristics below the waterline shall be representative of the slope for a minimum distance of 50 ft. from the shore.

2. End sections shall be adequately bonded to existing measures or terminate in stable areas.

3. Design water surface shall be the mean high tide or, in nontidal areas, the mean high water.

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4. Control of surface runoff and internal drainage shall be considered in the design and installation of all protection measures.

5. Protection measures to be applied shall be compatible with improvements planned or being carried out by others.

6. No work of improvement may increase the potential for erosion on an adjacent reach of shoreline.

Shoreline protection measures. The following is a partial list of protection measures that may be used.

___Bulkheads (timber, metal piling, concrete, concrete block).

___Revetments (prefabricated slope protection blocks, riprap, soil cement, piling).

___Groin systems (timber or concrete).

___Vegetation of the type that will grow across or along the waterline.

___Bank Sloping. All banks to be stabilized shall be sloped to a 2:1 slope or flatter. All material excavated from sloped banks should be placed on the bank, leveled and seeded to prevent erosion from runoff or wave runup or hauled to other areas for use. Excavated materials shall not be pushed into the lake.

___Beaching Slope. Shore protection with beaching slopes utilizes the movement of semi-fluid sands up the beach with breaking waves, and off the beach with receding waves to dissipate energy. For any given wave size, a beach will stabilize with a particular relationship between beach slope and the median grain size of beach material. Criteria for design of beaching slope is contained in Chapter 16 of the Engineering Field Manual.

Requirements for the design of beaching slopes are:

1. The median grain size of the material larger than 0.17mm is used to represent the material.

2. The minimum median grain size material used shall be 0.5mm.

3. Minimum thickness of blanket is 1 foot.

4. Extend the slope protection below still water elevation a distance of two times the design wave height.

5. Extend protection above still water elevations a distance equal to the computed runup plus one foot.

6. Materials shall be place according to the thickness, slope and gradation contained in Chapter 16 of the Engineering Field Manual.

___Riprap. This type revetment protects shorelines from wave action, ice action and slumping due to seepage. Riprap shall be placed between 1.5 times the wave height below the still water surface and the runup plus 0.5 feet above the still water surface. The wave height (H) may be determined from Table 1. The runup (R) may be determined by multiplying the ratio (R/H) in Table 2 by the wave height (H). The D_{50} rock size in inches for various slopes and wave heights is shown in Table 3.

Table 1 – Wave Heights*

Fetch Distance (F) (ft)	Wave Height (H) (ft)
500	0.7
1,000	1.0
1,500	1.2
2,000	1.4
3,000	1.7
4,000	1.9
5,000	2.1
7,500	2.6
10,000	3.0
12,500	3.3

*H = 0.0392 F
Wind velocity = 50 mph

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Table 2 – Ratio of Runup (R) Wave Height (H) for Various Shore Slopes

Shore Slope	Ratio
Horizontal:Vertical	R/H
2:1	2.3
3:1	1.9
4:1	1.5
6:1	0.9
10:1	0.5

Table 3 – D50 Rock Size for Various Shore Slopes and Wave Heights

Shore	Wave	D_{50}
Slope	Height (H)	Size
(Horz:Vert)	(ft)	(in)
2:1	1.0	4
	2.0	6
	3.0	8
3:1	1.0	4
	2.0	5
	3.0	7
4:1	1.0	4
	2.0	4
	3.0	7
6:1	1.0	4
	2.0	4
	3.0	6
10:1	1.0	4
	2.0	4
	3.0	4

Riprap shall be well graded with:

Percent passing by weight	Size
(%)	(inches)
100	2 x D_{50}
50-89	1.5 x D_{50}
25-50	D_{50}
10-30	0.5 x D_{50}
10	0.25 x D_{50}

A layer of bedding material no less than 6 inches thick or filter fabric is required on erodible soils. The bedding material shall be: 40-60% gravel (max. 3"); 40-60% sands; less than 5% finer than the #200 sieve.

On slopes 6 horizontal to 1 vertical and steeper, the riprap shall be anchored at the lowest elevation by excavating a "key-way" to a depth of 2 x D_{50} or increasing the thickness to 4 x D_{50} for a horizontal distance of 8 x D_{50}.

___Gabions. Gabions are wire or plastic mesh baskets connected together and filled with rock in place. They are flexible and stable if properly designed and installed. Like riprap, the apron will settle and conform to the final lake bed contour. Banks shall be sloped to a 1.5:1 side slope or flatter.

___Concrete. Concrete revetments for shore protection may be either (1) a sloping concrete apron which provides a nonerosive surface for waves to break against and run up on, or (2) a bulkhead type revetment used where steep banks prohibit the use of sloping forms of protection. The force of the waves acts on the bulkhead primarily in a horizontal direction. Footings for these structures should extend a minimum depth of 3 times the wave height below still water elevation. The top of the revetment should extend a minimum of 1 foot plus runup above still water elevation.

___Piling. Piling is another type of revetment used where natural shorelines are too steep for sloping protection. Piling may be installed either vertically or with a slight batter. Minimum thickness for piling are:

Material	Minimum Thickness (inches)
Metal Sheet	0.109
Wood Plank	2.0
Wood Pole	4.0

Wood planks and poles shall be pressure treated. The land side of piling should be backfilled to absorb wave energy. For design of piling, the lake bottom may be considered stable at a depth of three times the wave height below still water elevation. The top of the piling should be 1 foot plus runup above still water elevation.

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___Groins. Groins are used to replace beach material removed by long shore currents. With the beach restored, waves break further from shore, reducing erosion on the bank. Groins are effective only where appreciable long shore currents exist. If the amount of sand carried by long shore currents (littoral drift) is small, the areas between groins may have to be artificially filled to establish a beach. Since the placement of groins tends to increase erosion on unprotected downdrift reaches of shoreline, location must be selective. Groins may be built of riprap, timber, steel, or gabions.

Vegetative protection. Vegetation will be established on all disturbed areas such as channel and shoreline slopes, berms, spoil and other areas except where the slopes are permanently covered with water or where streambank or shoreline protection measures are placed or land use conditions are such that vegetation is impractical. Seedbed preparation, seeding, fertilizing, and mulching shall comply with practice standard Critical Area Planting (342). The vegetation shall be maintained and tree and brush controlled by hand, machine or chemicals as needed.

CONSIDERATIONS

Effects on water quantity and quality shall be considered. This practice will have a minor effect on the quantity of surface and ground water. There may be increased erosion and sediment yield from the area and surrounding areas during and immediately after construction. There should be minimal effect after the first period of use and establishment of the protection and vegetation of disturbed areas. This practice will decrease the flow and base load of the stream on which it is applied to protect the streambanks. When it is installed to protect shorelines, there can be local enhancement of water quality, but, generally, the shoreline is protected and there are only slight benefits on water quality.

Special attention shall be given to maintaining and improving visual resources and habitat for fish and wildlife where applicable. The landowner/user will be advised if wetlands will be affected and USDA-NRCS wetland policy will apply. All work planned shall be in compliance with General Manual title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local Laws and Regulations.

Consideration shall be given to the use of construction materials, grading practices, vegetation, and other site development elements that minimize visual impacts and maintain or complement existing landscape uses such as pedestrian paths, climate controls, buffers, etc.

PLANS AND SPECIFICATIONS

Plans and specifications for streambanks and shoreline protection shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction specifications

General. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within acceptable limits. Construction methods that enhance fish and wildlife will be used where practical. Trees, stumps, and brush removed from the construction area may be piled for fish and wildlife habitat when approved by the landowner/user.

The completed job shall present a workmanlike appearance and conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

Site preparation. Special attention shall be given to protecting and maintaining key shade, food, den trees, and visual resources. Removal

of any trees and brush shall be done in such a manner as to avoid damage to other trees and property.

All trees, stumps, brush, and similar materials are to be removed from the site or disposed of in such a way as to have the least detrimental effect on the environment.

Excavation. To the extent needed, all suitable materials removed from the specified excavation shall be used in the construction of the earth fill areas of the protection. All surplus or unsuitable materials shall be disposed of in a manner that will not interfere with the functioning of the protection.

Fill placement. Material placed in the fill areas of the protection shall be free of detrimental amounts of sod, roots, frozen soil, stones over 6 inches in diameter and other objectionable material. To the extent they are suitable, excavated materials are to be used as fill. The distribution and gradation of materials shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material.

Moisture control. The minimum moisture content of the fill material and foundation shall be such that, when kneaded in the hand, the fill material will form a ball, which does not readily separate. The maximum moisture content is when conditions are too wet for efficient use of the hauling and compaction equipment.

Topsoiling. Topsoil shall be removed and stockpiled on areas where establishment of vegetation is a problem on exposed subsoils (all subsoils except loam, silt loam and sandy loam, except where dense till is present). Topsoil shall be respread to provide a seedbed.

Where subsoil is exposed or is used in construction, topsoil will be placed in accordance with the following criteria.

- A minimum of four inches of topsoil ("A" horizon) will be placed where six or more inches of friable soil material with good moisture holding properties (more than 0.15 inches per inch) lies below the surface of the constructed surface.

- A minimum of eight inches of topsoil ("A" horizon) will be placed where less than six inches of friable soil materials with good moisture holding properties (more than 0.15 inches per inch) lies below the surface of the constructed surface.

- Topsoil will be placed in final shaping operations. The underlying soil, if needed, will be chiseled or scarified to permit proper bonding of topsoil.

Materials. The riprap material shall conform to the gradation shown on the drawings and be a durable rock. Riprap shall be dumped or placed in the manner consistent with good construction procedures and to the lines and grades shown on the drawings.

The area to be covered with a filter fabric or filter blanket shall be reasonably smooth. An even thickness of filter material shall be placed on the prepared surface. Care shall be exercised when placing the riprap to insure that the blanket is not ruptured or displaced.

Wire mesh baskets, when used for gabions, shall be fabricated from corrosion-resistant material to contain the rock material. Durable rock shall be used to fill gabions. The maximum dimension of individual rock particles shall not exceed one-half the minimum basket dimension. Minimum rock dimensions shall exceed the mesh size used in the basket construction. Soft materials such as sandstone and shale shall not be used. The foundation shall be smoothed and filter material, if required, shall be properly placed under and behind the gabions. The baskets shall be assembled in accordance with the manufacturer's recommendations.

Finish and cleanup. Construction areas will be finished in a relatively smooth condition ready for seeding. All rocks 3" in diameter or larger and roots shall be removed from the areas.

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Vegetative establishment

Vegetation will be established on all disturbed areas such as channel and shoreline slopes, berms, spoil and other areas except where the slopes are permanently covered with water or when bank materials or land use conditions are such that vegetation is impractical. Trees and shrubs should be established where practical. Disturbed areas are to be seeded or planted to trees as soon as possible after exposure. Use daily seeding whenever possible. Planned trees and shrubs shall be established according to Technical Guide Specification 612, Tree/Shrub Establishment.

Gullied and uneven areas should be smoothed before attempting to prepare seedbed.

If needed, apply lime to raise the pH to the level desired for species of vegetation being seeded.

Fertilize according to soil tests or at a minimum rate of 1000 lbs. of 12-12-12 fertilizer (or its equivalent) per acre as soon as the measure has been constructed within the seeding periods. Apply 150 lbs. per acre of ammonium nitrate 6-8 weeks after seeding on soils low in organic matter and fertility.

Work the fertilizer and lime into the soil to a depth of 2-3 inches with a harrow or disk.

Prepare a firm seedbed with a cultipacker or cultipacker type seeder.

Seed one of the following grass mixtures during the preferred seeding periods of March 1 to May 10 or August 10 to September 30.

When construction is completed between May 11 and August 9, a temporary cover crop should be established using one of the following:

Species	Minimum Rates
(1) Wheat	150#/acre
(2) Rye	150#/acre
(3) Spring oats	100#/acre
(4) Annual rye grass	20#/acre
(5) Corn	150-300#/acre

After August 10, temporary cover shall be removed or incorporated, fertilizer applied, seedbed prepared and permanent seeding done in normal manner.

On critical sites, mulch with 1-1/2 to 2 tons straw per acre. Anchor the mulch with asphalt spray, netting or a mulch anchoring tool. In areas such as sharp breaks in shoreline or channel slopes or where excessive velocities could cause bank scour, paper netting, jute netting, rock lining, erosion control blankets or sod should be used.

Streambank and Shoreline Seed Mixtures

Species	Seeding Rate (PLS)		Suitable pH	Site Suitability		
	(lbs/ac)	(lbs/100 ft$^{2)}$		Droughty	Well-drained	Wet
1. Tall fescue	20	0.5	5.5 – 8.0	1	1	1
Smooth bromegrass	20	0.5				
2. Tall fescue	20	0.5	5.0 – 7.5	1	1	1
Reed Canarygrass	20	0.5				
3. Kentucky bluegrass	15	0.375	5.5 – 7.0	2	1	2
Creeping red fescue	15	0.375				
Redtop	3	0.07				
4. Tall fescue	30	0.75	5.0 – 7.5	2	1	1

PLS – Pure Live Seed
Site Suitability: 1 – Preferred, 2 - Acceptable

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Mixture 3 may be used through urban or similar areas where lower growing vegetation is desired and close mowing will be practiced, also withstands shade better.

Five pounds of crownvetch seed per acre may be added to mixtures 1, 2 or 4 where high banks will be infrequently flooded.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain capacity and vegetative cover. Items to consider are:

1. Do not graze protected area during vegetative establishment and when soil conditions are wet.

2. Fertilize to maintain a vigorous vegetative cover. Caution should be used in fertilization to maintain water quality.

3. Control tree and brush growth as needed by hand, mechanical or chemical means.

4. Promptly repair eroded areas in or adjacent to the protected area.

5. Reestablish vegetative cover immediately where scour erosion has removed established seeding.

6. Periodically inspect area for any undermining or instability. If any undermining or instability is observed, take immediate action to protect from further damage.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Stream Channel Stabilization

(Feet)

Code 584

DEFINITION

Stabilizing the channel of a stream with suitable structures.

PURPOSES

To control aggradation or degradation in a stream channel.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to stream channels undergoing damaging aggradation or degradation that cannot be feasibly controlled by clearing or snagging, by the establishment of vegetative protection, or by the installation of upstream water control facilities.

CRITERIA

It is recognized that channels may aggrade or degrade during a given storm or over short periods. A channel is considered stable if over long periods the channel bottom remains essentially at the same elevation. The channel in hard bedrock may be considered stable, but the erosive energy will be expended on the softer alluvial bank materials, causing "skating" along the bedrock bottom.

In the design of a channel for stability, consideration shall be given to the following points:

1. The character of the materials comprising the channel bottom.

2. The quantity and character of the sediments entering the reach of channel under consideration. This shall be analyzed on the basis of both present conditions and projected changes caused by changes in land use or land treatment and upstream improvements or structural measures.

3. Streamflow peaks, velocities, and volumes at various flow frequencies.

4. The effects of changes in velocity of the stream produced by the structural measures.

Structures installed to stabilize stream channels shall be designed and installed to meet NRCS standards for the particular structure and type of construction.

<u>Vegetative establishment</u>

Vegetation will be established on all disturbed channel slope areas, berms, spoil and other areas according to Standards and Specifications Streambank and Shoreline Protection (580).

CONSIDERATIONS

Stream channel stabilization should be part of the treatment needed to protect the soil, water, plant and air resources. The management system must be planned to prevent excessive maintenance and operation problems.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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Effects on water quantity and quality shall be considered. This practice will have no significant change on the total volume of runoff or the potential for groundwater recharge. Water tables in areas adjacent to the practice may be altered causing changes in soil moisture storage, rooting depths and the transpiration rate of vegetation affected by the practice.

The surface disturbance of the construction area may temporarily increase the potential for erosion and delivery of sediment and sediment-attached substances to the stream. The constructed channel stabilization measure will provide a stable channel, and over time a decrease in sediment yield will result. Vegetation that is removed in the construction area to install the practice may reduce shade on the channel and water temperature may increase. The effect of the practice on aquatic communities residing in the channel would depend on the ecosystems present in the channel and adjacent area both before and after the construction and the length of time of the installation. The design of the stabilization measure should maintain or improve the quality of these fish and wildlife communities as far as can be compatible with the design and scope of the practice.

Special attention shall be given to maintaining and improving visual resources and habitat for fish and wildlife. The landowner/user shall be advised if wetlands will be affected and USDA-NRCS wetland policy will apply. All work planned shall be in compliance with General Manual, Title 450-GM, Part 405, Subpart A, Compliance with Federal, State, and Local Laws and Regulations. If archaeological and historical properties are encountered, the USDA-NRCS policy in General Manual, Title 420-GM, Part 401 shall be followed.

PLANS AND SPECIFICATIONS

Plans and specifications for stream channel stabilization shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Construction specifications

The construction specifications for stream channel stabilization will be according to the construction specifications for Standards and Specifications Streambank and Shoreline Protection (580). In addition to these specifications, there should be an effort to preserve and/or plant adapted trees to provide shade to prevent thermal pollution, prevent willow encroachment, help stabilize banks and provide wildlife habitat in those areas of perennial flow or where woody cover exists.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain stream channel stabilization and vegetative cover. Items to consider are:

1. Do not graze protected area.

2. Fertilize to maintain a vigorous vegetative cover. Caution should be used in fertilization to maintain water quality.

3. Periodically inspect area of the measure for any undermining or instability and if any are observed take immediate action to protect from further damage.

4. Reestablish vegetative cover immediately where scour erosion has removed established seeding.

5. Control undesirable trees and brush growth around the stream channel stabilization as needed by hand, mechanical or chemical means. Use only chemicals labeled for this purpose.

Indiana NRCS FOTG – August 1992.

NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

SUBSURFACE DRAIN

(Feet)

Code 606

DEFINITION

A conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.

PURPOSES

The purpose of subsurface drainage is to:

1. Improve the soil environment for vegetative growth, reduce erosion, and improve water quality by:
   a. regulating water table and ground water flows,
   b. intercepting and preventing water movement into a wet area,
   c. relieving artesian pressures,
   d. removing surface runoff,
   e. leaching of saline and sodic soils,
   f. serving as an outlet for other subsurface drains, and
   g. regulating subirrigated areas or waste disposal areas.
2. Collect ground water for beneficial uses.
3. Remove water from heavy use areas, such as around buildings, roads, and play areas; and accomplish other physical improvements related to water removal.
4. Regulate water to control health hazards caused by pests such as flukes, flies, or mosquitoes.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to areas having a high water table where the benefits of lowering the water table or controlling ground water or surface runoff justify installing such a system.

This standard applies to areas suitable for the intended use after installation of required drainage and other conservation practices. The soil shall have enough depth and permeability to permit installation of an effective and economically feasible system.

In areas where an outlet is available, either by gravity flow or by pumping, the outlet shall be adequate for the quantity and quality of effluent to be discharged. Septic tanks and other waste disposal systems shall not be connected directly to subsurface drain systems.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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CRITERIA

General Criteria Applicable To All Purposes

The design and installation shall be based on adequate surveys and investigations. This practice shall comply with all Federal, State, and Local laws and regulations.

Capacity. One or more of the following shall determine the required capacity:

1. Application of drainage coefficients, as recommended by the Drainage and Wet Soil Management, Drainage Recommendations for Indiana Soils, AY-300, Purdue Extension, June 2001 or Chapter 14, Water Management (Drainage), Subchapter C, Subsurface Drainage of the Engineering Field Handbook (EFH) to the acreage drained, including added capacity required to dispose of surface water entering through inlets.
2. Yield of ground water based on the expected deep percolation of irrigation water from the overlying fields, including the leaching requirement.
3. Comparison of the site with other similar sites where subsurface drain yields have been measured.
4. Measurement of the rate of subsurface flow at the site during a period of adverse weather and ground water conditions.
5. Application of Darcy's law to lateral or artesian subsurface flow.
6. Estimates of lateral or artesian subsurface flow.

Size. The size of subsurface drains shall be computed by applying Manning's formula. The size shall be based on the required capacity and computed by using one of the following assumptions:

1. The hydraulic gradeline is parallel to the bottom grade of the subsurface drain with the conduit flowing full at design flow.
2. The conduit flowing partly full where a steep grade or other conditions require excess capacity.
3. Conduit flowing under pressure with hydraulic gradeline set by site conditions on a grade that differs from that of the subsurface drain. This procedure shall be used only if surface water inlets or nearness of the conduit to outlets with fixed water elevations permit satisfactory estimates of hydraulic pressure and flows under design conditions.

All subsurface drains shall have a nominal diameter that equals or exceeds 3 inches. Unless special bedding arrangements are provided, the minimum diameters used in organic soils shall be five inches for plastic tubing and six inches for rigid tile. Rigid tile used in organic soils shall have a minimum length of two feet.

Existing subsurface drains used for outlets.

When an existing subsurface drain is to be used for an outlet, the following shall apply:

Case I – For areas to be drained that are five (5) acres or less.

This will apply principally to small systems and random lines where complete extensive systems are not needed.

An investigation shall be made of the existing subsurface drain to determine that:

1. It is in good physical condition based on observations at the junction point with the new system.
2. It has adequate capacity based on general observations made in the field. A survey or instrument check of the subsurface drain main downstream a distance of 200 to 300 feet from the junction is advisable to determine grade. It will not be necessary to continue this check to the outlet unless observations indicate the advisability of such survey.
3. It has sufficient depth to provide minimum cover for all new lines to be installed.

Case II – For areas to be drained in excess of five (5) acres.

The investigation shall include the following:

1. A physical inspection of the existing subsurface drain to determine that it is operative, free from breakdowns, and has an adequate outlet. The physical inspection will constitute observing the physical condition of the subsurface drain for the following conditions:

    a. Breakdowns which are usually accompanied by holes in the land over and along the line.

    b. Fractured tile, such as quartering (fractures on the quarter points, which result in an egg-shape cross-section).

    c. Deposition of soil. If excessive deposition appears, make a further study to determine the cause and correct the situation.

    d. Physical material deterioration that would seriously subject it to failure, due to high absorption rate, soil acidity, or alkalinity, etc.

1. Determine the capacity of the existing tile by checking the grades and sizes in the critical areas, particularly the flat reaches.

2. The existing subsurface drain outlet will be considered adequate if the capacity of the subsurface drain, as determined in Step 2, is greater than 80% of the required capacity, and if the existing tile is not deteriorated because of holes, quartering, roots or submergence of the outlet, except where such damages are repaired, and/or corrected.

If the surface drain is a drain of record or legal drain, all of the information available from the record, shall be used in making the determination as to the adequacy of the tile outlet.

Depth, Spacing, and Location. The depth, spacing, and location of the subsurface drain shall be based on site conditions, including soils, topography, ground water conditions, crops, land use, and outlets.

The minimum depth of cover over subsurface drains in mineral soils shall be 2 feet. This minimum depth shall apply to normal field levels and may exclude sections of line near the outlet or sections laid through minor depressions where the conduit is not subject to damage by frost action or equipment travel.

The minimum depth of cover in organic soils shall be 2.5 feet for normal field levels, as defined above, after initial subsidence. Structural measures shall be installed if it is feasible to control the water table level in organic soils within the optimum range of depths.

The maximum depth of cover for standard duty corrugated plastic tubing shall be 10 feet for trench widths of 2 feet or less (measured at tubing and to 1 foot above top of tubing). Heavy-duty tubing shall be specified for depths greater than 10 feet, trench widths more than 2 feet, or in rocky soils.

Depth of mains shall be designed so that the laterals can be joined to the main with a center-to-center or higher connection. A minimum difference in elevation of 0.3 foot between the flow lines of the main and of the lateral is desirable. Flowline-to-flowline connection is permissible when unavoidable.

For computation of maximum allowable loads on subsurface drains, use the trench and bedding conditions specified and the crushing strength of the kind and class of drain. The design load on the conduit shall be based on a combination of equipment loads and trench loads. Equipment loads are based on the maximum expected wheel loads for the equipment to be used, the minimum height of cover over the conduit, and the trench width. Equipment loads on the conduit are not a concern when the depth of cover exceeds 6 feet. Trench loads are based on the type of backfill over the conduit, the width of the trench, and the unit weight of the backfill material. A safety factor of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

Criteria for depth, spacing, and location are provided in the Drainage and Wet Soil Management, Drainage Recommendations for Indiana Soils, AY-300, Purdue Extension, June 2001 and Chapter 14, Water Management (Drainage), Subchapter C, Subsurface Drainage of the EFH.

Minimum Velocity and Grade. In areas where sedimentation is not a hazard, the minimum grades shall be based on site conditions and a velocity of not less than 0.5 ft/s (feet per second). If a hazard exists, a velocity of not less than 1.4 ft/s shall be used to establish the minimum grades if site conditions permit. Otherwise, provisions shall be made for preventing sedimentation by use of filters or by collecting and periodically removing sediment from installed traps, or by periodically cleaning the lines with high-pressure jetting systems or acceptable cleaning solutions.

Velocities based upon drain material sizes and grades are shown on the applicable nomographs in both the Indiana Drainage Guide and Chapter 14 of the EFH.

Maximum Velocity Without Protection. Excessive flow velocity in the drain may induce piping of soil material into the drain line.

Soil Texture	Velocity, ft/s
Sand and sandy loam	3.5
Silt and silt loam	5.0
Silty clay loam	6.0
Clay and clay loam	7.0
Coarse sand or gravel	9.0

TABLE 1 Maximum Velocities by Soil Texture

Maximum Grade and Protection. On sites where topographic conditions require that drain lines be placed on steep grades and design velocities will be greater than indicated in Table 1 special measures shall be used to protect the conduit or surrounding soil. These measures shall be specified for each job according to the particular conditions of the job site.

The protective measure shall include one or more of the following:

1. Enclose continuous perforated pipe or tubing with fabric-type filter material or properly graded sand and gravel.
2. Use nonperforated continuous tubing, a watertight pipe, or seal joints.
3. Place the conduit in a sand and gravel envelope or blinding with the least erodible soil available.
4. Select rigid butt end pipe or tile with straight, smooth sections and square ends to obtain tight fitting joints.
5. Wrap open joints of the pipe or tile with tar impregnated paper, burlap, or special fabric-type filter material.
6. Install open-air risers for air release or entry.

Iron Ochre Control. If drains are to be installed in sites where iron ochre and manganese dioxide problems are likely to occur, provisions shall be made to provide access for cleaning the lines. Each drain line shall outlet directly into an open ditch and/or shall have entry ports as needed to provide access for cleaning equipment. Drain cleaning provisions shall be installed in such a way that the drains can be cleaned in an upstream or rising grade direction. If possible, drains in ochre-prone areas shall be installed during the dry season when the water table is low and the iron and manganese dioxide is in its insoluble form.

Where possible, in areas where the potential for such problems is high, protection against their development shall be provided by designing an outlet facility to ensure permanent submergence of the drain line.

Protection Against Root Clogging. Problems may occur where it is necessary to place drains in close proximity to perennial vegetation. Roots of water-loving vegatation near subsurface drains may enter and obstruct the flow.

The first consideration is to use nonperforated tubing or closed joints through the root zone area. Where this is not possible, water-loving trees should be removed from a distance of at least 100 feet on each side of the drain. A distance of 50

feet should be maintained from other species of trees except for fruit trees. Orchards can often be drained by drain lines located close to the fruit trees.

Where crops and grasses may cause trouble on drain lines, facilities shall be installed to provide a means for submerging the line to terminate the root growth as desired or to maintain a water table above the drain lines to prevent growth into the system.

Materials. Subsurface drains include conduits of plastic, clay, concrete, bituminized fiber, metal, or other materials of acceptable quality.

The conduit shall meet strength and durability requirements for the site. All conduits shall meet or exceed the minimum requirements of the appropriate specifications published by the American Society for Testing and Materials (ASTM), American Association of State Highway and Transportation Officials (AASHTO), and the American Water Works Association (AWWA).

Foundation. If soft or yielding foundations are encountered, the lines shall be stabilized and protected from settlement by adding gravel or other suitable materials to the trench, by placing the conduit on a treated plank that will not readily decompose or on other rigid supports, or by using long sections of perforated or watertight pipe having adequate strength to ensure satisfactory subsurface drain performance. A flat treated plank shall not be used for corrugated plastic tubing.

Filters and Filter Material. Filters will be used around conduits, as needed, to prevent movement of the surrounding soil material into the conduit. The need for a filter will be determined by the characteristics of the surrounding soil material, site conditions, and the velocity of flow in the conduit. A suitable filter shall be specified if:

1. Local experience indicated a need.
2. Soil materials surrounding the conduit are dispersed clays, silts with a plasticity index less than 7, or fine sands with a plasticity index less than 7.
3. Deep soil cracking is expected, or
4. The method of installation may result in voids between the conduit and backfill material.

If a sand-gravel filter is specified, the filter gradation shall be designed in accordance with National Engineering Handbook (NEH) Part 633, Chapter 26, Gradation Design of Sand and Gravel Filters.

Specified filter material must completely encase the conduit so that all openings are covered with at least 3 inches of filter material except that the top of the conduit and side filter material shall be covered by a sheet of plastic or similar impervious material to reduce the quantity of filter material required.

Artificial fabric or mat-type filter materials shall be used, provided that the effective opening size, strength, durability, and permeability are adequate to prevent soil movement into the drain throughout the expected life of the system.

Envelopes and Envelope Material. Envelopes shall be used around subsurface drains if they are needed for proper bedding of the conduit or to improve the characteristics of flow of ground water into the conduit.

Materials used for envelopes do not need to meet the gradation requirements of filters, but they must not contain materials that will cause an accumulation of sediment in the conduit or that will render the envelope unsuitable for bedding of the conduit.

Envelope materials shall consist of sand-gravel, organic, or similar material. Sand-gravel envelope materials shall all pass a 1.5-inch sieve; not more than 30 percent shall pass a No. 60 sieve; and not more than 5 percent shall pass the No. 200 sieve. ASTM-C-33 fine aggregate for concrete has been satisfactorily used and is readily available.

Where organic or other compressible materials are used, they shall be used only around a rigid wall conduit and above the centerline of flexible tubing. All organic or other compressible material shall be of a type that will not readily decompose.

Placement and Bedding. The conduit shall not be placed on exposed rock or stones more than 1.5 inches in diameter for 6 inch or larger tile and stones no more than ¾ inch diameter for tile less than 6 inches. Where such conditions are present the trench must be over-excavated, a minimum of 6 inches and refilled to grade with a suitable bedding material.

The conduit shall be placed on a firm foundation to ensure proper alignment. Prevent runoff and surface water from entering the trench.

If installation will be below a water table or where unstable soils are present, special equipment, installation procedures, or bedding materials may be needed. These special requirements may also be necessary to prevent soil movement into the drain or plugging of the envelope if installation will be made in such materials as quicksand or a silt slurry.

For trench installations of corrugated plastic tubing 8 inches or less in diameter, one of the following bedding methods will be specified:

1. A shaped groove or 90° V-notch in the bottom of the trench for tubing support and alignment.
2. A sand-gravel envelope, at least 3 inches thick, to provide support.
3. Compacted soil bedding material beside

and to 3 inches above the tubing

For trench installations of corrugated plastic tubing larger than 8 inches, the same bedding requirements will be met except that a semi-circular or trapezoidal groove shaped to fit the conduit will be used rather than a V-shaped groove.

For rigid conduits installed in a trench, the same requirements will be met except that a groove or notch is not required.

All trench installations shall be made when the soil profile is in its driest possible condition in order to minimize problems of trench stability, conduit alignment, and soil movement into the drain.

For trench installations where a sand-gravel or compacted bedding is not specified, the conduit shall be covered with selected material containing no hard objects larger than 1.5 inches in diameter. Conduit shall be covered to a minimum of 3 inches above the top of the conduit.

All installations shall meet the minimum requirements of the appropriate ASTM specification.

Auxiliary Structures and Protection. Structures installed in drain lines must not unduly impede the flow of water in the system. Their capacity must be no less than that of the line or lines feeding into or through them. The use of internal couplers for corrugated plastic tubing will be allowed.

If the drain system is to carry surface water flow, the capacity of the surface water inlet shall not be greater than the maximum design flow in the drain line or lines. Covers or trash racks shall be used to ensure that no foreign materials are allowed in the drain lines.

The capacity of a relief well system will be based on the flow from the aquifer, the well spacing, and other site conditions and will be adequate to lower the artesian waterhead to the desired level.

The size of relief wells is generally based on the available materials rather than on hydraulic considerations. Such wells will not be less than 4 inches in diameter.

Junction boxes, manholes, catch basins, and sand traps shall be accessible for maintenance. A clear opening of not less than 2 feet will be provided in either circular or rectangular structures.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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The drain system shall be protected against velocities exceeding those provided in Table 1 and against turbulence created near outlets, surface inlets, or similar structures. Continuous or closed-joint pipe shall be used in drain lines adjoining the structure where excessive velocities will occur.

Junction boxes shall be installed where three or more lines join or if two lines join at different elevations. In some locations it may be desirable to bury junction boxes. A solid cover shall be used, and the junction box shall have a minimum of 1 ½ feet of soil cover.

If not connected to a structure, the upper end of each subsurface drain line will be capped with a tight-fitting external cap of the same material as the conduit or other durable materials.

Outlet

The outlet must be protected against erosion and undermining of the conduit, entry of tree roots, damaging periods of submergence, and entry of rodents or other animals into the subsurface drain. A continuous section of rigid pipe without open joints or perforations will be used at the outlet end of the line and must discharge above the normal elevation of low flow in the outlet ditch. Standard corrugated plastic tubing is not suitable for the outlet section. Minimize the visual impact of projecting outlets.

Continuously submerged outlets will be permitted for water table control systems if planned and designed according to the Natural Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG) Standard (554) Drainage Water Management.

The outlet pipe and its installation will conform to the NRCS FOTG Standard (620) Underground Outlet.

Watertight conduits strong enough to withstand the expected loads will be used if subsurface drains cross under irrigation canals, ditches, or other structures.

CONSIDERATIONS

When designing subsurface drainage systems, consider the effects the system will have on water quantity and quality.

Effects on quantity to consider include: water budget, base flow and runoff to water uses and users, groundwater recharge, and volume of soil water needed to improve plant growth.

Water quality effects that should be considered include: delivery of sediment, changes in the delivery of dissolved salts, such as nitrates, on downstream water uses and users, changes in delivery of dissolved substances to the aquifer, downstream water temperatures, and the effects on the visual quality of downstream water.

If a concern exists of tile lines picking up polluted water from manure spreading, consider installing tile blocks, stoppable catch basins, or other temporary flow blocking devices.

Consider adding collector mains to minimize the visual impact, potential fear from ice or debris damage, and to facilitate maintenance of the grassed ditch bank.

Consideration shall be given to possible damages above or below the point of discharge that might involve legal actions.

Consideration shall be given to maintaining or enhancing environmental values.

Considerations must be given to preventing adverse impacts to delineated wetlands regulated by State and Federal regulations.

PLANS AND SPECIFICATIONS

Plans and specifications for installing subsurface drains shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

A maintenance program shall be established by the landowner/user to maintain the

functional capacity of the subsurface drain. Items to consider are:

1. Keep inlets, trash guards, collection boxes and structures clean and free of materials that can reduce the flow.

2. Repair all broken or crushed lines to insure proper functioning of the drain.

3. Repair or replace broken or damaged inlets and breathers damaged by livestock or machinery.

4. Periodically, or at a minimum of annually, inspect the outlet conduit and animal guards for proper functioning.

REFERENCES

NEH Part 650, Engineering Field Handbook, Chapter 14, Water Management (Drainage)

NEH Part 633, Soil Engineering, Chapter 26, Gradation Design of Sand and Gravel Filters

Drainage and Wet Soil Management, Drainage Recommendations for Indiana Soils, AY-300, Purdue Extension, June 2001

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

Tree/Shrub Establishment

(Acre)

Code 612

DEFINITION

Establishing woody plants by planting seedlings or cuttings, direct seeding, or natural regeneration.

PURPOSES

- To establish woody plants for forest products.
- To establish wildlife habitat.
- To provide long-term erosion control and improve water quality
- To treat waste.
- To reduction air pollution.
- To sequester carbon.
- To conserve energy.
- To enhance aesthetics.

CONDITIONS WHERE PRACTICE APPLIES

On any areas where woody plants can be grown.

CRITERIA

General Criteria Applicable to All Purposes

- Plans and application of tree/shrub establishment shall comply with all applicable federal, state, and local laws and regulations.
- The species, type of plant material, location, layout and density of the planting shall accomplish the intended purposes.
- Species shall be adapted to the soils, climate and site conditions.
- The planting design shall consider the cultural and management practices likely to occur in the future e.g. thinnings etc.
- Native plant species shall be used whenever possible. Known non-native invasive species shall not be used.
- Woody plants shall be established without compromising the integrity of:
  1. Property Lines
  2. Fences
  3. Utilities
  4. Roads
  5. Legal Drains
  6. Other Easement Areas or Right of Ways

  Where a right-of-way easement exists, written permission from the landowner will be needed.
- Where subsurface drains (tile lines) cross through a tree/shrub planting, and where these drains will remain functional. Sealed conduit shall be installed through the planting and extend a minimum of 50 feet on either side of the planting, or trees/shrubs shall not be planted within 50 feet on either side of the tile line.

Site Preparation/Weed Control for Establishment

1. Eliminate competing vegetation prior to planting or seeding (see Table 1). Before direct seeding or installing weed barrier material heavy grass and/or weed cover shall be eliminated to prevent damage to plants
from mice and voles.

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

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2. If fabric weed barrier is used the following shall apply:

- The minimum width of weed barrier material shall be 3 feet wide.
- The weed barrier shall contain UV inhibitor, be permeable to water movement, and have a manufacturer's guarantee not to deteriorate for a minimum of 3 years when exposed to sunlight.
- Weed barrier shall be capable of preventing underlying plant growth.
- Weed barrier shall be installed according to the manufacture specifications.

3. Hay or straw mulch shall not be used for weed and grass control around trees and shrubs.

Planting Dates

- Barerooted stock shall be planted in early spring as soon as the ground thaws until June 1.
- Balled and burlapped or container grown stock shall be planted September 15 to June 1 as local soil and weather conditions permit.
- Direct seeding shall be completed as local soil and weather conditions allow as follows:

  September 15 – December 1 or using stratified seed in the spring after the ground thaws before May 15th except White Oak, Swamp Chestnut Oak, and Chinquapin Oak. These species should be seeded within 10 days after seed drop because they are difficult to store.
- Extension of planting dates is appropriate if approved by the NRCS State Forester.

Planting Stock Size

- Bare rooted stock

Conifers:

Tree Height	Caliper[1]	Minimum Root Length
9"	1/8"	8"
12"	3/16"	10"
15"	3/16"	10"

Hardwoods:

Tree Height	Caliper[1]	Minimum Root Length
8"	3/16"	8"
10'	¼"	10"
12"	¼"	10"

- Balled and Burlapped Stock

Conifers:

Tree Height	Minimum Diameter Ball
18-24"	10"
2-3'	12"
3-5'	14"
5-6'	20"

Hardwoods:

Tree Height	Minimum Diameter Ball	Caliper[1]
5-6'	12"	1/2"
6-8'	14"	3/4"
8-10'	16"	1"

- Container stock (all species)

Container Size	Tree Height	Caliper[1]
1 gallon	2 – 4'	3/8 – 5/8"
3 gallon	2 – 6'	3/8 – 5/8"

[1] Caliper (diameter at ground level) shall be measured at the root collar.

Planting and Storage Guidelines for Woody Stock

- Care and Handling Requirements for Woody Planting Stock

1. Plant material will be protected from desiccation during temporary storage and delivery to the planting site. Stock will be kept in a cool environment out of direct sunlight and wind.
2. If seedling planting is delayed more than 5 days, keep seedlings in shipping container and place in cold storage at 35º to 45º F. If cold storage in not feasible, seedlings will be heeled-in. To heel-in, dig a trench in a shady area, deeper than the root system and spread the roots against the back of the trench. Cover roots completely with soil, tamped to eliminate air pockets. Water as needed to keep the roots moist.
3. Roots of bareroot stock shall be kept moist during planting operations by placing in a water-soil (mud) slurry, peat moss,

sphagnum moss, super-absorbent (e.g. polyacrylamide) slurry or other equivalent material. (Note: Do not soak trees in water for more than 2 hours.)

4. Rooting medium of container and balled and burlapped stock shall be kept moist at all times by periodic watering.

- Planting Requirements for Woody Planting Stock

1. Stock shall not be planted when the soil is frozen or dry. All stock will be planted in a vertical position. Bare root and container stock shall be planted with the root collars approximately at or slightly below the existing ground line. Balled and burlapped stock will be planted with the root collars at or slightly above the existing ground line.
2. Seedlings: The planting trench or hole shall be deep and wide enough to permit roots to spread out and down without J-rooting or L-rooting. If the roots are too long for the planting equipment modestly prune them to the correct length before planting. Never prune back beyond the main root system or more than 25% of the root length. After planting pack soil around each plant firmly to eliminate air pockets.
3. Container trees: Dig a hole slightly larger than the container diameter. Remove plants from containers before placing in the ground and firmly pack soil around roots to eliminate air pockets. Before planting loosen any spiraling roots and prune if needed.
4. Balled and burlapped trees: When handling stock never pick up a tree at the stem or trunk, handle stock at the root ball. Dig a hole 11/2 times as wide as the root ball and about the same depth as the root ball. Remove any rope, wire, or plastic twine from the tree. Pull back burlap around trunk and fold once in the hole. Carefully place the tree in the hole and firmly pack soil around roots to eliminate air pockets. After planting water as needed.

Criteria for Forest Products, Erosion Control, Improve Water Quality, Reduce Air Pollution, And to Sequestrate Carbon

A minimum of 300 trees/acre shall be established using one or a combination of the following methods:

- planting bare root seedlings
- direct seeding
- natural regeneration
- planting container stock

1. Criteria for bare root seedlings

- Planting bare root seedlings is applicable on a wide range of soil types, hydrologic conditions, aspects and slopes. Bare root seedlings can be used in reforestation projects, supplemental plantings and wildlife projects.
- A minimum of 436 trees/acre shall be planted (10 foot by 10-foot spacing or equivalent).

Number of plants required per acre for various spacing

Spacing (feet)	Plants per acre
5 x 5	1742
6 x 6	1210
6 x 8	907
6 x 10	726
7 x 10	622
7 x 7	889
8 x 8	681
9 x 9	538
8 X 10	544
9 x 10	484
10 x 10	436
10 x 12	363
10 x 13	335
12 x 12	302
14 x 14	222
16 x 16	170
18 x 18	134
20 x 20	109

2. Criteria for direct seeding

Seed Inspection

Inspect seed by species selecting at least 10 randomly selected seeds/bushel. Crack or cut seeds open to be sure all seed is filled, moist, normal colored and not damaged by insects. If seed appears to be non-viable increase the seeding rate by the percentage of non-viable seed from the tested seed.

Floating in water can separate walnut seed that has not filled, as the unfilled nuts will float, while the filled nuts will sink. Discard floating walnut seed.

Seed Care, and Storage

Field collected seed shall be placed in porous bags e.g. onion bags, burlap bags, or standard feed sacks and placed in storage no more than 50º F and preferably 35-40º F to prevent heat buildup.

All species except oaks should be kept dry. Oak acorns should be re-hydrated, by soaking in cold water for 4- 24 hours as soon as possible after collection or delivery, maintain moisture content at greater than 25%.

If planting is delayed for more than 2 weeks or planted after February, store seed at 35-40º F in sealed containers as described by species in the "Illinois Direct Seeding Handbook".

Species that need stratification to germinate, shall be stratified as described in the "Illinois Direct Seeding Handbook". Stratification is a pregermination treatment to break seed dormancy. Stratification methods vary by species.

Seeding Rates and Methods

- Shall consist of at least 75%, of a combination of Black Walnut, Oak and/or Hickory species.
- To improve seed germination and to prevent rodent depredation the site (planting rows or entire area) shall be kept bare and free of grass and weed cover before and 2 years after direct seeding is completed.
- Seed shall be sown at 2 times the seed diameter.
- To overcome seed predation double the seeding rate for the first 300 feet on sites adjacent to woodlands.

Seeding rates[1] (minimum):

Seeding Method	**Seeds Per Acre** (heavy seeded species)
Row Planting	3000
Broadcast Planting	4500

[1]See direct seeding rate table on page 5 for seeding rates by species.

Species suitable for direct seeding:

Heavy Seeded Species	**Light Seeded Species**
Black Walnut (*Juglans nigra*)	Ash (*Fraxinus spp.*)
Oak (*Quercus spp.*)	Yellow Poplar or Tulip Tree (*Liriodendron tulipifera*)
Hickory (*Carya spp.*)	Black Cherry (*Prunus serotina*)
Persimmon (*Diospyros virginiana*)	Maple (*Acer spp.*)
Kentucky Coffeetree (*Gymnocladus dioica*)	Basswood (*Tilia americana*)
	Sycamore (*Platanus occidentalis*)
	Hackberry (*Celtis occidentalis*)
	Blackgum (*Nyssa sylvatica*)
	Sweetgum (*Liquidambar styraciflua)*
	Bald Cypress (*Taxodium distichum*)

Row/Seed Spacing for 3000 seeds/acre

Row Spacing (feet)	Seed Spacing (feet)
3	4.8
4	3.6
5	2.9
6	2.4
7	2.0
8	1.8
9	1.6
10	1.5
11	1.3
12	1.2
14	1.0
16	0.9
18	0.8

Direct Seeding Rates Table (Note: walnut and all hickory species are husked)

Common Name	Scientific Name	Range of Seeds/Lb.	Ave. Seeds/Lb.	Lbs/Ac. For 3000 Seeds/Ac	Lbs/Ac. For 4500 Seeds/Ac
Common Persimmon	*Diospyros virginiana*	665-1764	1200	2.5	4
Black Walnut	*Juglans nigra*	11-100	40	75	112
Hickories (Carya Species)					
Bitternut Hickory	*Carya cordiformis*	125-185	156	20	30
Mockernut Hickory	*Carya tomentosa*	34-113	90	34	51
Pecan	*Carya illinoensis*	151-174	162	19	28.5
Pignut Hickory	*Carya glabra*	175-225	200	15	22.5
Shagbark Hickory	*Carya ovata*	80-150	100	30	45
Shellbark Hickory	*Carya laciniosa*	25-35	30	100	150
Oaks (Quercus species)					
White Oak	*Quercus alba*	70-210	120	25	37.5
Chinquapin Oak	*Quercus muhlenbergii*	263-520	395	8	12
Swamp White Oak	*Quercus bicolor*	90-175	85	35	52.5
Shingle Oak	*Quercus imbricaria*	315-795	415	8	12
Overcup Oak	*Quercus lyrata*	139-154	140	22	33
Bur Oak	*Quercus macrocarpa*	40-145	75	40	60
Swamp Chestnut Oak	*Quercus michauxii*	35-195	85	35	52.5
Cherrybark Oak	*Quercus pagoda*	420-745	580	5	7.5
Pin Oak	*Quercus palustris*	320-540	410	8	12
Northern Red Oak	*Quercus rubra*	75-256	125	24	36
Shumard Oak	*Quercus shumardii*	78-128	100	30	45
Black Oak	*Quercus velutina*	125-400	245	13	20

3. Criteria for Natural Regeneration

Natural regeneration is generally used to supplement direct seeding, container stock, and bare root seedling plantings.

Natural regeneration is not always successful even next to a forested seed wall. A forested seed wall is a site dominated by woody vegetation adjacent to the site. Failure may result from poor site preparation practices, adverse soil conditions or seed predators.

Successful natural regeneration shall establish (>300 stems/acre, including seeded or planted stock if applicable) woody vegetation within 3 years. If natural regeneration has not established woody vegetation after 3 years additional planting will be completed if it is determined that additional natural regeneration will not be sufficient to colonize the site within an acceptable time frame (usually 5 years).

Section 1. (floodplain sites)

Natural regeneration may be considered likely to establish woody vegetation on sites that are frequently flooded (see flooding parameter table) with an upstream floodplain that is dominated by woody vegetation. Flooding frequency can be obtained from the NRCS FOTG, Section II and local observation. If the site is not frequently flooded or if the upstream watershed is not dominated by woody vegetation proceed to Section 2.

Section 2. (non floodplain sites)

This section applies to sites that are not frequently flooded or on flood plain sites that are not downstream from a floodplain dominated by woody vegetation.

In this section natural regeneration may only be considered likely if the site is adjacent to a forested seed wall. A distance of 150 feet for natural regeneration may be used in these instances. If a forested seed wall is not present or is greater than 150 feet from the site natural regeneration is not considered likely.

- **If natural regeneration is not considered likely from Section 1 or 2. Trees and/or shrubs shall planted or seeded.**

Flooding Parameter Table[1]

Flooding Frequency	**Chance of Flooding Each Year**
Frequently	>50%
Occasional	5-50%
Rare	0-5%
Flooding Duration	**Days of Flooding**
Very long	>30
Long	7-30
Brief	2-7
Very Brief	<2

[1]Data can be obtained from the NRCS, FOTG, Section II, Water Features Table. An on-site investigation is recommended to verify flooding or ponding parameters.

4. Criteria for Container Stock

Container stock (potted stock) may be a satisfactory method to establish trees on sites where spring planting of bare root stock is not feasible due to spring and summer flooding or excessive wetness. Container stock may also be appropriate in other situations, e.g. supplemental plantings, windbreaks, environmental plantings etc.

In areas not prone to flooding or ponding, potted stock is generally, not the most efficient or cost effective way to establish woody plants. In most situations bare root seedlings are proven to be more reliable and economical method to establish woody plants.

- **Container stock when natural regeneration is likely**

  If natural regeneration is determined likely from **Criteria for Natural Regeneration** then container stock shall be planted at a minimum rate of 27 plants/acre (40’ x 40’ spacing or equivalent). However, clump planting of trees shall be used when potted stock is likely to fail over large portions of the area due to flooding, wetness, water flow, sand deposition, or debris deposit. The minimum number of trees to plant in a clump shall be 109 trees per acre (20’ x 20’ spacing or equivalent). The minimum clump size shall be ¼ acre unless site conditions suggest otherwise.

- **Container stock when natural regeneration is not likely**

  When natural regeneration is considered not likely from **Criteria for Natural Regeneration** then container stock shall be planted at a minimum rate of 300 plants/acre (12' x 12' foot spacing or equivalent).

Additional Criteria to Reduce Soil Erosion

To control sheet and rill erosion on critical slopes:

- plant trees and shrubs on the contour
- apply mulches as needed, see FOTG (484) Mulching
- seed a cover crop between the planted rows

Cover Crop Seeding Table (using pure live seed)

Species	Seeding Rate Lbs/Ac
Annual Ryegrass	8
Spring Oats	16
Winter Wheat	30

Additional Criteria for Forest Products

Christmas trees
Use a 6' spacing in the rows and a row width to accommodate maintenance equipment. Allow for adequate service roads in the plantation.

Supplemental planting (species enrichment)
Planting additional trees in an area that is already stocked with trees. Supplemental planting is done to improve the stocking and composition of an existing stand. The existing stand is managed for the protection and early development of planted trees.

- Trees shall not be planted in locations where they will be overtopped by other trees left in the stand. Overstory trees shall be killed or removed within 2-5 years after plant establishment. The following table provides a list of species suitable for supplemental planting.

Species Suitable for Supplemental Planting

Scientific Name	Common Name
Fraxinus americana	White Ash
Fraxinus pennsylvanica	Green Ash
Juglans nigra	Black Walnut
Liquidambar styraciflua	Sweetgum
Liriodendron tulipifera	Yellow Poplar or Tulip Tree
Prunus serotina	Black Cherry
Quercus alba	White Oak
Quercus rubra	Red Oak

Fine Hardwood Products

Fine hardwoods are tree species that can be used for furniture, veneer products, etc. In Indiana fine hardwood species include:

Fine Hardwood Species

Scientific Name	Common Name
Acer saccharum	Sugar Maple
Carya illinoensis	Pecan
Juglans nigra	Black Walnut
Liriodendron tulipifera	Yellow Poplar or Tulip Tree
Prunus serotina	Black Cherry
Quercus spp.	Some Oak Species

To promote rapid canopy closure and to produce a forest containing well-formed trees a minimum of 544 trees/acre shall be planted (8' X 10' spacing or equivalent) or established using direct seeding methods.

Criteria to Enhance Aesthetics

Trees or shrubs shall not be planted within 10 feet of fire hydrants, water meters, or utility structures.

Trees and shrubs shall be planted so that the crowns will not infringe on adjoining property unless permission is obtained from the landowner.

Plant Spacing:

- Large trees (mature height greater than 60 feet) shall be planted no closer than 40 feet apart.
- Medium trees (mature height 30-60 feet) shall be planted no closer than 35 feet apart.

- Small trees (mature height less than 30 feet) shall be planted no closer than 25 feet apart.
- Shrubs shall be planted no closer than 3 feet apart.

Use evergreen and/or deciduous species, species with showy flowers, brilliant fall foliage, persistent colorful fruits, and noteworthy growth forms and shapes. Use a mixture of small and/or large trees, and shrubs.

Use curvilinear designs and/or small group plantings to increase visual sight diversity.

CONSIDERATIONS

General

Consider landowners objectives for tree/shrub establishment so that the planned objective for the planting is achievable.

Bare root seedlings should be considered as the standard method to establish trees and shrubs. Planting bare root seedlings has proven to be the most economical and successful method to establish trees and shrubs. However, other methods to establish trees and shrubs may be applicable in some circumstances.

Seed sources for direct seeding and woody planting stock should be locally adapted and come from no more than 200 miles north or south of the planting site.

Consider selecting species from Conservation Tree/Shrub Suitability Groups (CTSG), species to plant, Section II (FOTG). Trees to plant from CTSG's can be viewed at the NRCS Indiana web site.

Monocultures and off site species are discouraged in hardwood reforestation projects.

Consider planting 2-3 rows of conifers along all open plantation edges and planting periodic rows of conifers within large plantings to serve as a woodland border and/or wind barrier.

Consider using a support stake when planting container trees and balled and burlapped stock.

Consider planting a mixture of species (5-10 species) adapted to the site (including conifers, hardwoods, and shrubs) to improve plant diversity.

Seek technical assistance from a professional forester for reforestation or other conservation tree planting projects.

Weed Control

To improve plant growth, consider 2 additional years of chemical weed control after plants are established. Weed control should be performed using narrow bands (2'-3' wide) on each side of a plant row unless the entire site is treated.

Erosion

To control sheet and rill erosion consider the establishing permanent cover between tree rows To treat gully erosion consider closer tree spacing and establishing permanent cover. See FOTG Conservation Cover (327) for additional information.

Forest Products

Fine hardwood species should be mixed with other trees (hardwood and softwood) and shrubs to promote diversity, facilitate thinning operations and encourage straight boles.

Direct Seeding

For direct seedings, if there is not a source of light seeded species within 500 feet of any portion of the site, consider seeding an additional 1000 seeds/acre of heavy or light seeded species.

When using direct seeding consider that spring seeding can reduce rodent and insect damage. Fall seeding can eliminate the need for seed storage.

Natural Regeneration

Sites that are frequently flooded or ponded for long or very long duration may be difficult and unpractical for tree/shrub establishment. Consider using natural regeneration on these sites to establish woody plants and allow the site to revegetate to herbaceous and/or woody plant cover.

Consider that natural regeneration is often likely to occur, but not guaranteed on sites that have a seed source from a forested floodplain system where seeds are deposited in sufficient quantity to establish woody vegetation. On these sites, natural regeneration of light seeded species (e.g.

green ash, silver maple, cottonwood , etc.) may establish large numbers of tree seedlings.

Wildlife

Consider selecting species from FOTG Wildlife Upland Habitat Management (645) and/or FOTG Wetland Wildlife Habitat Management (644) to enhance wildlife benefits.

Shrub species may be direct seeded to provide wildlife habitat. Refer to Direct Seeding of Shrubs, IN-NRCS, Forestry Technical Note No. 16.

Soil Fertility

Consider soil testing to determine pH, Phosphorus (P), and Potassium (K) levels before establishment of woody vegetation. Soil pH should be checked by soil horizons, P and K should be checked in the Ap horizon or upper 8 inches. Species planted should be adapted to soil pH levels at the site. Apply lime only on sites that have been acidified through actions of man e.g. past cropping systems. Consider applying P and K to a medium level for forage production.

PLANS AND SPECIFICATIONS

Plans and specifications for tree/shrub establishment will be prepared for each site in accordance with the criteria for this practice. The plan will include planting dates, site preparation, weed control, plant spacing, species, type of stock used, and planting and storage guidelines.

OPERATION AND MAINTENANCE

Check survivability of planted species after 3 years to insure that at least 300 desirable stems/acre of woody plants are established. If less than 300 stems/acre are established additional planting will be completed if it is determined that additional natural regeneration will not be sufficient to colonize the site within an acceptable time frame (usually 5 years).

Control weed competition during establishment (3 years). Competing weeds, brush, and vines can adversely affect survival, form and rate of tree growth. Additional years of weed control may be needed in some instances e.g. to control johnsongrass, quackgrass, or other hard to control weed species.

Use the following or combination of methods as needed to control weed competition (see Table 1 for specific treatments):

- shallow cultivation
- mowing
- spraying approved herbicides
- cutting woody plants and applying approved pesticides

Shear and shape Christmas trees and correlatively prune hardwood species, as needed depending on species and growth form desired. Refer to FOTG Tree Shrub Pruning (660).

Protect the planting from fire. Plan access roads and firelanes prior to planting. See Indiana Field Office Technical Guide, Section IV for Access Road (560) and Firebreak (394).

Fence if necessary to protect the planting from excessive livestock browsing and trampling damage, refer to FOTG Standards, Use Exclusion (472) and Fence (382).

Protect from disease, rodents, deer, and insects using approved pesticides, hunting, fencing, or other appropriate methods. Additional information can be viewed from the “Illinois Direct Seeding Handbook”, Wildlife Damage Management.

SITE PREPARATION TREATMENT ALTERNATIVES, Table 1.

TILLABILITY /SOIL TEXTURE	SOD OR ALFALFA SITES	SMALL GRAIN OR ROW CROP SITES	HEAVY BRUSH & TREE GROWTH	HEAVY WEED GROWTH	BADLY COMPACTED
TILLABLE SITES WITH LOAMY/ CLAYEY SOILS	#1a or #3a	#1b, #2, or #7 depending on need for erosion protection	#5a, #5b, or #5c depending on equipment available	#1a, #3a, or #4 on slopes 0-2% #2, #3b, or #4 on steeper slopes	#6
TILLABLE SITES WITH SANDY SOILS	#1a or #3a	#1b, #2, or #7 depending on need for erosion protection	#5a, #5b, or #5c depending on equipment available	#1a, #3a, or #4 on slopes 0-2% #2, #3b, or #4 on steeper slopes	Normally not applicable
NON-TILLABLE SITES DUE TO STEEPNESS (>18%)	#3b, run strips on contour if practical	Normally not applicable	#5a, #5b, or #5c depending on equipment available	#3b, run strips on contour if practical	Normally not applicable
NON-TILLABLE SITES DUE TO ROCKINESS	#3a or #3b depending on slope	Normally not applicable	#5a, #5b, or #5c depending on equipment available	#3a, #3b, or #4 on slopes 0-2% #3b or #4 on steeper slopes	Normally not applicable

All options for site preparation should also include an approved herbicide application in conjunction with tree planting unless other effective weed control measures are planned and implemented.

1a - Plow entire area and disc down firm in late summer or early fall. If erosion control is a concern establish a temporary cover crop[1] prior to a spring planting.
1b – If needed for erosion control establish a temporary cover crop[1].
2 - Scalp or till in strips 3 to 4 feet wide in spring just before planting. On sloping ground consider running strips on the contour.
3a - Fall burn-down with approved herbicide over entire site. Best window of opportunity is September 1 to October 15 as long as it is applied at least one week before the first killing frost. Also use a pre-emergent herbicide before or during planting to control emerging seedlings.
3b - Fall burn-down in strips 3 to 4 feet wide with approved herbicide. Also use a pre-emergent herbicide before or during planting to control emerging seedlings.
4 - Mow in fall. Use appropriate herbicides in the spring prior to or during planting.
5a - Deaden the undesirable trees and shrubs and let them stand.
5b - Hand clear by cutting and removing undesirable trees and shrubs. Treat stumps with an approved herbicide.
5c - Use heavy equipment to clear and remove undesirable trees and shrubs. Where needed, follow-up with establishment of a temporary cover crop[1] prior to planting.
6 - Subsoil or rip compacted areas. If soil surface is rough use appropriate tillage tool to smooth. Where needed, follow-up with establishment of a temporary cover crop[1] prior to planting. On slopes over 6% subsoil or rip on contour.
7 - No site preparation needed.

[1]Temporary cover can be seeded August 15–September 30 or using a dormant seeding December 10-February 28, using 1/2 bushel/acre of wheat, rye, or spring oats.

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NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

WELL DECOMMISSIONING

(No.)

CODE 351

DEFINITION

The sealing and permanent closure of a water well no longer in use.

PURPOSE

This practice serves to:

- Prevent entry of animals, debris, or other foreign substances into well or well bore hole;
- Eliminate the physical hazard of an open hole to people, animals, and farm machinery;
- Prevent entry of contaminated surface water into well and migration of contaminants into unsaturated (vadose) zone or saturated zone;
- Prevent commingling of chemically or physically different ground waters between separate water bearing zones;
- Eliminate possibility of well being used for any other purpose;
- Conserve yield and hydrostatic head of aquifers;
- Restore, as far as feasible, hydrogeologic conditions that existed before well was constructed.

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to any drilled, dug, driven, bored, or otherwise constructed vertical water well determined to have no further beneficial use, is no longer used, or is in such a state of disrepair that using it to obtain ground water is impractical or a health hazard.

This practice does not apply to water wells that were used for waste disposal.

CRITERIA

Closure options shall be compatible with all applicable Federal, State, and Local requirements.

A water well abandoned prior to January 1, 1988, maybe plugged by the landowner. Water wells abandoned on or after January 1, 1988, must be plugged by an Indiana licensed water well driller.

Data collection. As-built construction documents, maintenance records and other available data for the abandoned water well shall be collected, reviewed and applied toward the development of a well decommissioning plan. Existing conditions shall be documented as defined in Plans and Specifications.

Well preparation. The well shall be cleared of all pumping equipment, valves, pipelines, casings, liners, screens, grease, oil, scum, debris, and other foreign material, to the extent possible.

Disinfection. Before sealing, the entire column of well water shall be brought to an available chlorine concentration of 100 ppm or greater, or other solution specified by local or state requirements. After being agitated in the well water, the chemical solution shall be left for no less than 24 hours to assure complete disinfection.

Plugging materials. Plugging materials do not require disinfection.

Water to be mixed with plugging materials shall be compatible with the material, and shall be of a quality that will not result in contamination of

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resources Conservation Service.

the well or water-bearing zones penetrated by the well.

Placement of plugging materials. Cement and bentonite slurries shall be pumped into place with a grout pipe from the bottom of the well and moving the pipe progressively upward as the well is filled. Pelletized, coarse grade or medium grade crushed bentonite shall be installed in the well by gravity methods in a manner to prevent bridging of the plugging material within the well.

Fill material. Fill material shall be clean and free of organic or other foreign matter. The gradation shall be such that bridging will not occur during placement.

Placement of fill material. When allowed by law, fill materials, such as sand, pea gravel, sand-gravel mix, crushed stone, or agricultural lime can be used to plug a portion of the well. Fill material shall be placed into the well only after the well water has been disinfected. All material shall be placed from the bottom of the well upward by methods that avoid segregation, dilution, or bridging of the material.

For wells greater than 30 inches in diameter, backfill shall be placed and compacted in a manner that minimizes segregation to prevent surface subsidence.

Surface seal. After completion of or during the process of well plugging, the well casing shall be severed at least two (2) feet below the ground surface, and a cement plug larger in diameter than the borehole shall be installed.

The interval between the ground surface and the top of the concrete plug shall be filled with soil material that achieves an in-place hydraulic conductivity equivalent to or less than the surface soil surrounding the well. The ground surface at the sealed well site shall be mounded and graded in a manner that prevents ponding of surface runoff.

Control of elevated formation pressure. If a well penetrates a formation that is under artesian head (confined conditions), or from which a gas is being released under pressure, the grout pressure must be maintained greater than the formation pressure until initial grout set occurs. Procedures for balancing formation pressures during grouting operations shall conform to ASTM D5299 (Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities).

Removal or grouting in place of well casing.

If required, the well casing shall be completely removed from the well by either pulling or overdrilling (overreaming) as explained in ASTM D5299.

If necessary, casing that cannot be removed completely shall be ripped, perforated, or cut off at a depth greater than the maximum potential for frost penetration or any other near surface soil fracturing hazard (such as desiccation), or three feet, whichever is greater. Perforated or ripped casing shall provide sufficient apportioned open area to assure passage of the grout into the space. The casing shall be perforated or ripped throughout the entire length of a confining layer. Casings to be grouted in place shall employ a pressurized grouting procedure that will completely fill and seal the open space around the casing.

Casings to be removed from a collapsing formation shall be grouted concurrently with removal such that the bottom of the casing remains submerged in the grout.

CONSIDERATIONS

This practice may be part of a ground water protection system that includes water and chemical management practices.

To the extent practicable, an abandoned well should be decommissioned in a manner that restores the original hydrogeologic conditions of the well site and does not preclude the use of the site from future land management practices.

All decommissioning procedures, fill and sealing materials need to be selected with due consideration of the site-specific geological, biological, physical, and climatic conditions; the chemical composition of the surrounding soil, rock, and ground water at the well site; and the well's construction practices. Water well drilling records may be available from the IDNR Division of Water.

PLANS AND SPECIFICATIONS

Plans and specifications for decommissioning abandoned water wells shall be consistent with this standard and shall describe the

requirements for applying the practice to achieve its intended purposes. A record of the installation of this practice shall be made and shall include the following information:

- Location of the decommissioned well by street address, latitude/longitude, township/range, or other georeference convention, of such precision that it can be readily located in the field, if required, in the future;
- Date of completion of well decommissioning;
- Name of landowner;
- Name, title, and address of person responsible for well decommissioning;
- Total depth of well;
- Age of well, if known;
- Installation method (i.e. drilled, driven, jetted, bucket, dug);
- Length of casing (if known);
- Length of well screen (if known);
- If applicable, length of casing removed or length of casing cut off below ground level;
- Inside diameter of well bore or casing;
- Type of casing material or schedule (e.g., standard weight steel, or PVC Sch-80);
- Static water level measured from ground surface prior to decommissioning;
- Types of materials used for filling and sealing, quantities used, depth intervals for emplacement of each type, and emplacement method used.

Notification requirements. The Indiana Department of Natural Resources, Division of Water shall be notified in writing of a well abandonment within thirty (30) days after plugging is completed. Indiana licensed water well drillers shall report well abandonment on forms provided by the Department.

OPERATION AND MAINTENANCE

The practice site shall be inspected periodically to ensure that the decommissioned well and the adjacent area have not settled or eroded, or are otherwise adversely disturbed. The well site and adjacent ground surfaces shall be maintained in a manner that prevents ponding of surface runoff on the site.

REFERENCES

Listed below are references helpful in planning this practice:

- Indiana Code 25-39
- Rule 312 IAC 13-10
- ASTM D5299, Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities.
- Purdue University Cooperative Extension Service Publication
  - Plugging Abandoned Water Wells: A Landowner's Guide, 1998 (WQ-21)
- Indiana Department of Natural Resources
  Division of Water
  402 W Washington St Rm W264
  Indianapolis, IN 46204
  (317) 232-4160
- Indiana Groundwater Association
  7829 Prairie View Drive
  Indianapolis IN 46256
  (317) 596-9760

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