

USDA  
NATURAL RESOURCES  
CONSERVATION SERVICE

DELAWARE CONSERVATION  
PRACTICE STANDARD

**LINED WATERWAY OR  
OUTLET**

CODE 468  
(Reported by Ft.)

wetness, prolonged base flow, seepage, or piping is such that a lining is needed to control erosion.

- Use by people or animals precludes vegetation as suitable cover.
- Limited space is available for design width, which requires higher velocities and lining.
- Soils are highly erosive or other soil or climatic conditions preclude using vegetation only.

**CONSIDERATIONS**

Consider adding widths of appropriate vegetation to the sides of the waterway for wildlife habitat.

Important wildlife habitat, such as woody cover or wetlands, should be avoided or protected if possible when siting the lined waterway. If trees and shrubs are incorporated, they should be retained or planted in the periphery of the grassed portion of the lined waterways so they do not interfere with hydraulic functions and roots do not damage the lined portion of the waterway. Mid- or tall bunch grasses and perennial forbs may also be planted along waterway margins to improve wildlife habitat. Waterways with these wildlife features are more beneficial when connecting other habitat types; e.g., riparian areas, wooded tracts and wetlands

Provide livestock and vehicular crossings as necessary to prevent damage to the waterway. Crossing design shall not interfere with design flow capacity.

Establish filter strips on each side of the waterway to improve water quality.

When designing riprap linings and specifying rock gradations, consider that rock delivered to the site is often segregated by size or does not conform exactly to the specified gradation. Adequate safety factor should be incorporated.

This practice has the potential to affect National

**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:

- Concentrated runoff, steep grades,

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

Register listed cultural resources or eligible (significant) cultural resources. These may include archeological, historic, or traditional cultural properties. Care should be taken to avoid adverse impacts to these resources. Follow NRCS state policy for considering cultural resources during planning.

**CRITERIA**

**Criteria Applicable to All Purposes**

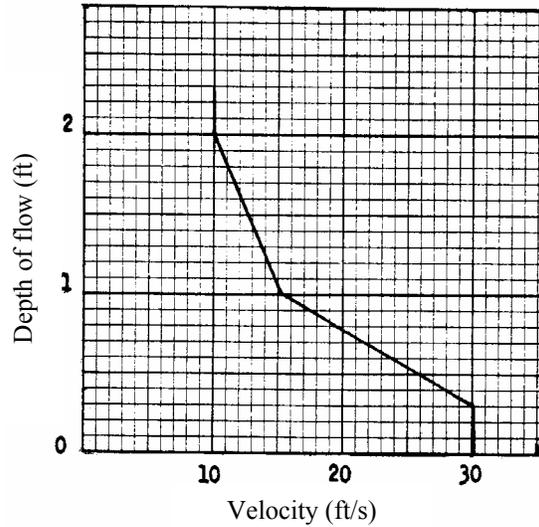
**Capacity.** The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft<sup>3</sup>/s. The minimum capacity shall be adequate to carry the peak rate of runoff from a 10-year, 24-hour frequency storm. Velocity shall be computed by using Manning's Formula with a coefficient of roughness "n" as follows:

Lining	"n" Value
Concrete	
Trowel finish.....	0.012 - 0.014
Float finish.....	0.013 - 0.017
Shotcrete.....	0.016 - 0.022
Flagstone.....	0.020 - 0.025
<sup>1/</sup> Riprap - (Angular Rock)	$n = 0.047(D_{50} S)^{0.147}$
Synthetic Turf Reinforcement Fabrics and Grid Pavers	Manufacturer's Recommendations

<sup>1/</sup> Applies on slopes between 2 and 40% with a rock mantle thickness of 2 x D<sub>50</sub> where:

D<sub>50</sub> = median rock diameter (in.),  
 S = lined section slope (ft./ft.) (.02 ≤ S ≤ .4)

**Velocity.** Maximum design velocity and rock gradation limits for rock riprap-lined channel sections shall be determined using Appendix 16A, Engineering Field Handbook unless a detailed design analysis appropriate to the specific slope, flow depth and hydraulic conditions indicate that a higher velocity is acceptable.



Maximum design velocity for concrete-lined sections should not exceed those using Figure 2.

**Figure 2. Maximum Velocity Versus Depth of Flow for Concrete-lined Channels.** Maximum design velocity for synthetic turf reinforcement fabrics and grid pavers shall not exceed manufacturer's recommendations.

Stable rock sizes and flow depths for rock-lined channels having gradients between 2 percent and 40 percent may be determined using the following detailed design process. This design process is from **Design of Rock Chutes** by Robinson, Rice, and Kadavy.

For channel slopes between 2% and 10%:

$$D_{50} = [q(S)^{1.5}/4.75(10)^{-3}]^{1/1.89}$$

For channel slopes between 10% and 40%:

$$D_{50} = [q(S)^{0.58}/3.93(10)^{-2}]^{1/1.89}$$

$$z = [n(q)/1.486(S)^{0.50}]^{3/5}$$

D<sub>50</sub> = Particle size for which 50% of the sample is finer, in.

S = Bed slope, ft./ft.

z = Flow depth, ft.

q = Unit discharge, ft.<sup>3</sup>/s/ft  
 (Total discharge ÷ Bottom width)

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 velocity shall be restricted to straight reaches.

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

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

Nonreinforced concrete:

Hand-placed, formed concrete

Height of lining, 1.5 ft or less.....Vertical

Hand-placed screeded concrete or mortared

In place flagstone

Height of lining, less than 2 ft.....1 to 1

Height of lining, more than 2 ft... 2 to 1

Slip form concrete:

Height of lining, less than 3 ft.....1 to 1

Rock riprap.....2 to 1

Synthetic Turf Reinforcement Fabrics...2 to 1

Grid Pavers.....1 to 1

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

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

**Lining Thickness.** Minimum lining thickness shall be:

Concrete.....4 in. (In most problem areas, minimum thickness shall be 5 in. with welded wire fabric reinforcing.)

Rock riprap.....Maximum stone size plus thickness of filter or bedding

Flagstone.....4 in., including mortar bed

Synthetic Turf

Reinforcement Fabrics and

Grid Pavers...Manufacturer's Recommendations

**Lining Durability.** Use of non-reinforced concrete or mortared flagstone linings shall be made only on low shrink-swell soils that are well drained or where subgrade drainage facilities are installed.

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

**Outlets.** All lined waterways and outlets shall have a stable outlet with adequate capacity to 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 where appropriate 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 3,000 pounds per square inch.

**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 welded wire fabric or other uniform support to the joint to prevent unequal settlement.

**SPECIFICATIONS**

Plans and specifications for establishment of this practice shall be prepared in accordance with the previously listed criteria. Plans and specifications shall contain sufficient detail to ensure success of the practice. Documentation shall be in accordance with the section "Supporting Data and Documentation" in this standard.

### **OPERATION AND MAINTENANCE**

An operation and maintenance (O&M) plan shall be prepared for each management unit. The plan shall provide specific instructions for operating and maintaining the system to insure that it functions properly. Appropriate job sheet(s), fact sheets, or other information sheets may be used to serve as the management plan as well as supporting documentation and shall be provided to the client. These sheets shall be referenced in the conservation plan narrative.

The plan shall include the following items and others as appropriate.

A maintenance program shall be established to maintain waterway capacity and outlet stability. Lining damaged by machinery or erosion must be repaired promptly.

Inspect lined waterways regularly, especially following heavy rains. Damaged areas shall be repaired immediately. Remove sediment deposits to maintain capacity of lined waterways.

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. Prescribed burning and mowing may be appropriate to enhance wildlife values, but must be conducted to avoid peak nesting seasons and reduced winter cover. Control noxious weeds. Do not use as a field road. Avoid crossing with heavy equipment.

### **SUPPORTING DATA AND DOCUMENTATION**

The following is a list of the minimum data and documentation to be recorded in the case file:

1. Extent of planting in acres, field number, and the location of the practice marked on the conservation plan map;
2. Assistance notes shall include dates of site visits, name or initials of the person who made the visit, specifics as to alternatives discussed, decisions made, and by whom;
3. Completed copy of the appropriate job sheet(s) or other specifications and operation and management plan.

### **Field Data and Survey Notes**

The following is a list of the minimum data needed:

1. Plan view sketch.
2. Soils investigation that includes rock content and depth to seasonal high water table.
3. Profile of the lined waterway showing channel grade and ground lines.
4. Cross-sections of the existing ground.
5. Profile and cross-section of outlet and, special precautions if needed.

### **Design Data**

Record on appropriate engineering paper. For guidance on the preparation of engineering plans see Chapter 5 of the Engineering Field Handbook - Part 650. The following is a list of the minimum required design data:

1. Locate the practice on the farm plan map in the case file.
2. Determine soil type and any special restrictions.
3. Determine peak runoff from the contributing drainage area for the required design storm in accordance with Chapter 2, EFH, Part 650 or by other approved method.
4. Design each reach in accordance with this standard.

5. Lining requirements (size, thickness, geotextile, etc.)
  6. Plan view sketch, profile of the lined waterway and cross-sections of each design reach showing shape, width, depth, and lining thickness.
  7. Lengths of each reach and total length.
  8. Details of outlet protection or other structural components needed.
  9. Seeding, fertilizing, and mulching requirements, if required.
  10. Show job class on the plan.
  11. Estimated Quantities.
- meets or exceeds plans and NRCS practice standards.

#### **REFERENCES**

1. Robinson, K.M., C.E. Rice, and K.C. Kadavy. 1998. Design of Rock Chutes. Transactions of ASAE, Vol. 41(3): 621-626.
2. USDA, Natural Resources Conservation Service. National Engineering Handbook, Part 650.
3. USDA, Natural Resources Conservation Service. Engineering Field Handbook: Chapter 16, Streambank and Shoreline Protection.

#### **Construction Check Data/As-Built Plans**

Record on survey notepaper, NRCS-ENG-28, or other appropriate engineering paper. Survey data will be plotted in red on the as-built plans. The following is a list of minimum data needed for As-built documentation:

1. Documentation of site visits on CPA-6. The documentation shall include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom.
2. Check notes recorded during or after completion of construction showing grade and cross section of constructed reaches and outlets including length, width, and depth.
3. Statement as to the lining size and thickness is to be placed on the as-built plans.
4. Measure and record the constructed length of the lined waterway or outlet.
5. Statement on seeding.
6. Final quantities and documentation for quantity changes. Materials certifications as appropriate.
7. Sign and date check-notes and plans by someone with appropriate approval authority. Include statement that practice