NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

LINED WATERWAY OR OUTLET

(Ft)

CODE 468

DEFINITION

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

PURPOSE

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

- Provide 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, steep grades, wetness, prolonged base flow, seepage, or piping is such that a lining is needed to control erosion.
2. Use by people or animals precludes vegetation as suitable cover.
3. Limited space is available for design width, which requires higher velocities and lining.
4. Soils are highly erosive or other soil or climatic conditions preclude using vegetation only.

CRITERIA

General Criteria Applicable To All Purposes

Capacity. The maximum capacity of the waterway flowing at designed depth is not to exceed 200 ft^3/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 Equation, 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
1/ Riprap - (Angular Rock)	$n = 0.047(D_{50}\,S)^{0.147}$
Synthetic Turf Reinforcement Fabrics and Grid Pavers	Manufacturer's recommendations

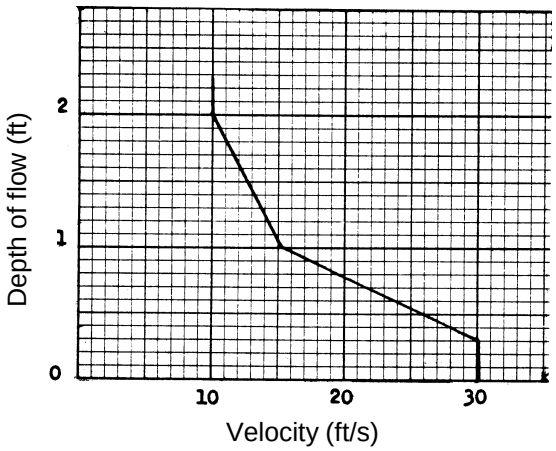
1/ Applies on slopes between 2 and 40% with a rock mantle thickness of 2 x D_{50} where:
D_{50} = median rock diameter (in.),
S = lined section slope (ft. /ft.) ($.02 \leq S \leq 0.4$)

Velocity. Use a given design velocity to determine rock gradation limits for rock riprap-lined channel sections using the National Engineering Handbook, Part 650, Streambank and Shoreline Protection, Appendix 16A . Use a detailed design analysis appropriate to the specific slope, flow depth and hydraulic conditions to determine when a higher velocity is acceptable.

Design maximum velocities for concrete-lined sections not to exceed those represented by the figure below.

Figure 1. Maximum velocity versus depth of flow for concrete-lined channels

Do not exceed manufacturer's



recommendations for maximum design velocity for synthetic turf reinforcement fabrics and grid pavers.

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_{50} = Particle size for which 50% of the sample is finer, in.

S = Bed slope, ft./ft.

z = Flow depth, ft.

q = Unit discharge, $ft^3/s/ft$

(Total discharge÷Bottom width)

Except for short transition sections, avoid flow in the range of 0.7 to 1.3 of the critical slope 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 that 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 will be triangular, parabolic, or trapezoidal. Monolithic concrete cross sections will be rectangular.

Freeboard. The minimum freeboard for lined waterways or outlets will 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 established and maintained.

Lining Thickness. Minimum lining thickness will 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 dissipaters must meet the hydraulic and structural requirements for the site.

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

Geotextiles. Use geotextiles 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. Design geotextiles according to AASHTO M288, Section 7.3.

Permanent Turf Reinforcement. Use turf reinforcement materials in areas where flow conditions exceed the limits of natural vegetation. Turf reinforcement material must be machine produced mat capable of withstanding a minimum shear stress of 3.0 lbs./sq. ft. for unvegetated, and 8 lbs./ sq.ft. for vegetated channels subject to long term flows. The turf reinforcement material must be a three dimensional matrix commercially produced for this purpose made of heavyweight UV stabilized polypropylene. The turf reinforcement blanket must be placed and anchored following manufacturer's recommendations.

A mulch blanket with a weight of 0.5 lb. per sq. yard or greater must be integral with the turf reinforcement or placed separately over the turf reinforcement prior to stapling. If a separate mulch blanket is to be used, place the commercial erosion control blanket on photodegradable poly mesh netting.

Install turf reinforcement within 48 hours after seeding. Smooth, hand-seed, and rake areas disturbed during the installation of the turf reinforcement.

Waterways shall be vegetated according to Rhode Island NRCS Conservation Practice Standard Critical Area Planting, code 342. Species selection must suit current site conditions and intended uses. Selected species must have the capacity to achieve adequate density, height, and vigor within an appropriate time frame to stabilize the waterway.

Filters or bedding. Use filters or bedding where appropriate to prevent piping. Use drains to reduce uplift pressure and collect water, as required. Design filters, bedding, and drains according to NRCS standards. Use weep holes with drains,where needed.

Concrete. Proportion concrete used for lining so that it is plastic enough for thorough consolidation and stiff enough to stay in place on side slopes. A dense durable product is 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, must 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.

CONSIDERATIONS

Consider cultural resources when planning this practice. Where appropriate, the local cultural values will be incorporated into the design in a technically sound manner.

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

Avoid or protect important wildlife habitat, such as woody cover or wetlands, when siting the lined waterway. If trees and shrubs must be retained or planted in the periphery of the grassed portion of the lined waterways so they do not interfere with hydraulic functions. Tree roots must 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 can 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. Incorporate an adequate safety factor.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for lined waterways or outlets that describe the requirements for applying the practice according to this standard. As a minimum the plans and specifications shall include:

- A plan view of the lined waterway or outlet.
- Typical cross sections of the lined waterway.
- Profile(s) of the lined waterway(s) with descriptions of required material, for the given reach of the lined waterway. Show existing channel grades on drawing.
- Stabilized outlet or planned method for stabilizing outlet.
- Disposal requirements for excess soil material.
- Site specific construction specifications that describe the installation of the lined waterway or outlet.

OPERATION AND MAINTENANCE

Provide and review the operation and maintenance plan with the landowner. Include the following items and others as appropriate.

Establish a maintenance program for waterway capacity and outlet stability. Promptly repair lining damaged by machinery or erosion .

Inspect lined waterways regularly, especially following heavy rains. Repair damaged areas immediately. Remove sediment deposits to maintain capacity of lined waterways.

Advise landowners to avoid areas where forbs have been established when applying herbicides. Do not use 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.

REFERENCES

National Engineering Handbook, Part 650, Engineering Field Handbook: Chapter 16, Appendix 16A, Streambank and Shoreline Protection.

Robinson, K.M., C.E. Rice, and K.C. Kadavy. 1998. Design of Rock Chutes. Transactions of ASAE, Vol. 41(3): 621-626.

2002 Connecticut Guidelines for Soil Erosion and Sediment Control, Connecticut Department of Environmental Protection (CTDEP) Bulletin 34, May, 2002 by the Connecticut Council on Soil and Water Conservation in Cooperation with CTDEP

AASHTO M288, Section 7.3.