

USDA
NATURAL RESOURCES
CONSERVATION SERVICE
MARYLAND
CONSERVATION
PRACTICE STANDARD
LINED WATERWAY OR OUTLET
CODE 468
(Reported by Ft.)

DEFINITION

A waterway or outlet having an erosion-resistant lining of concrete, stone, or other permanent material. The lined section extends up the side slopes to a designed depth. The earth above the permanent lining may be vegetated or otherwise protected.

PURPOSES

To provide for safe disposal of runoff from other conservation structures or from natural concentrations of flow, without damage by erosion or flooding, where unlined or grassed waterways would be inadequate. Properly designed linings may also control seepage, piping, and sloughing or slides.

CONDITIONS WHERE PRACTICE APPLIES

The practice applies where one or more of the following exists:

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. People or animals preclude use of vegetated waterways or outlets.
4. High-value property or adjacent facilities warrant the extra cost to contain design

runoff in a limited space.

5. Soils are highly erosive or other soil or climatic conditions preclude using vegetation.
6. Installation of nonreinforced 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.

CONSIDERATIONS

Quantity

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of the practice's effect caused by seasonal and climatic changes.

Quality

1. Filtering effects of vegetation on the movement of sediment and dissolved and sediment attached substances will be evaluated.
2. Effects on the visual quality of the water resources.
3. Short-term and construction-related effects on the quality of water resources.

CRITERIA

General Criteria

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

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

Lining	“n” Value
Concrete	
Trowel finish	0.013
Float finish	0.015
Gunite	0.019
Flagstone	0.022
Gabion	0.030
Riprap	Determine from Fig. 1

Velocity - Maximum design velocity shall be as shown in Figure 2. 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 dissipater to reduce velocity to less than critical, or to a velocity the downstream soil and vegetative conditions will allow.

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 ft. 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 can be grown and maintained.

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 screened 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 from concrete:

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

Rock riprap..... 2 to 1

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

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

Filters or Bedding - Filter 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 inch.

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.

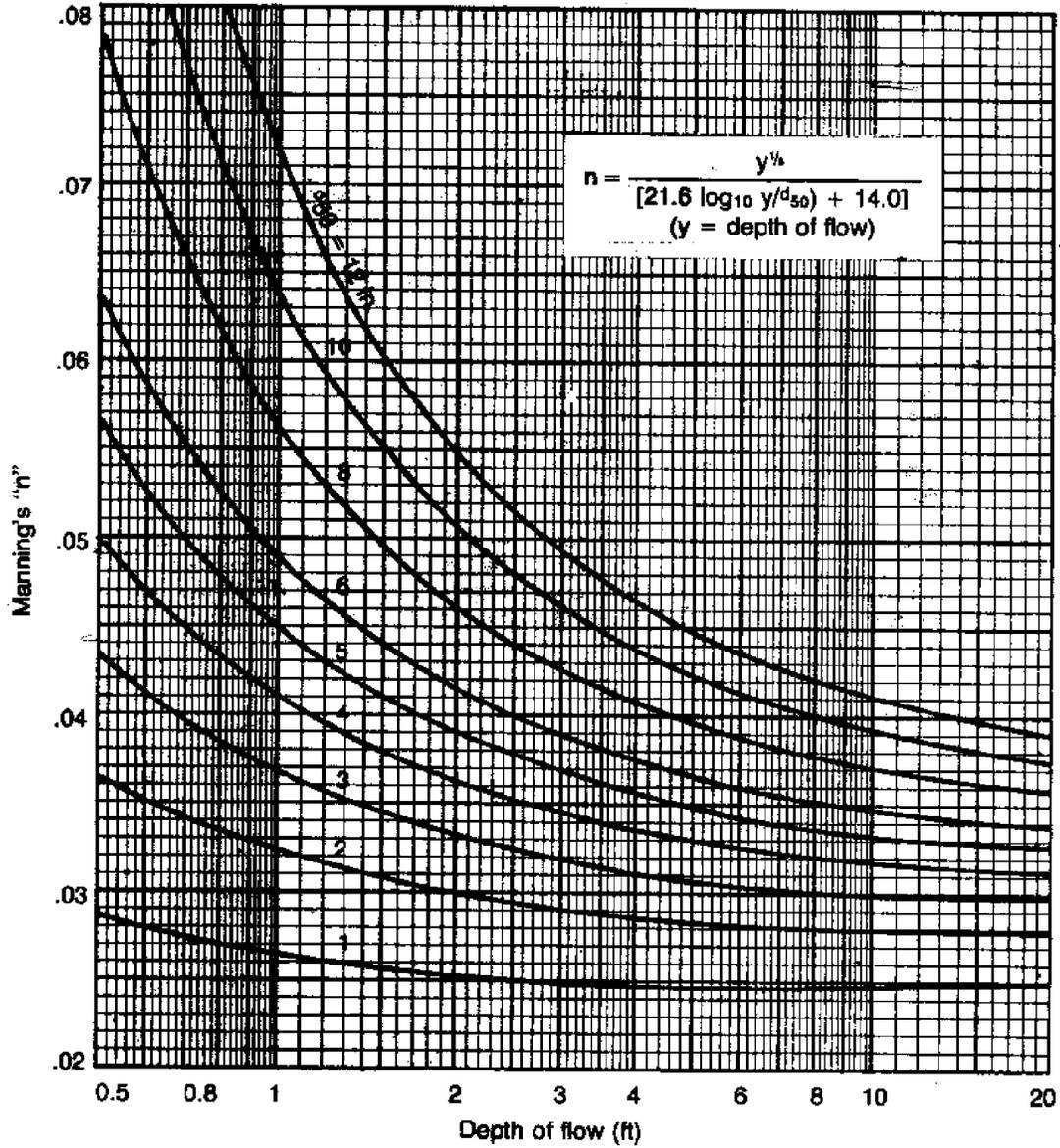


Figure 1.—Values of n for riprap-lined channels, d_{50} size vs depth of flow.

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 ft. 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.

Cutoff - Concrete walls shall be used at the beginning and ending of concrete lining, and rock riprap lining shall be keyed into the channel bottom at both ends of the lining. Depth of cutoff shall be determined by site needs.

Maintenance - Provisions must be made for timely maintenance to insure that lined waterways function properly.

- Pavement or lining should be maintained as built to prevent undermining and deterioration. Trees should be removed next to pavements, as roots can cause uplift damage.
- Vegetation next to the lining should be maintained in good condition to prevent scouring if the lining is overtopped. See Standards and Specifications for Critical Area Planning for vegetative details.

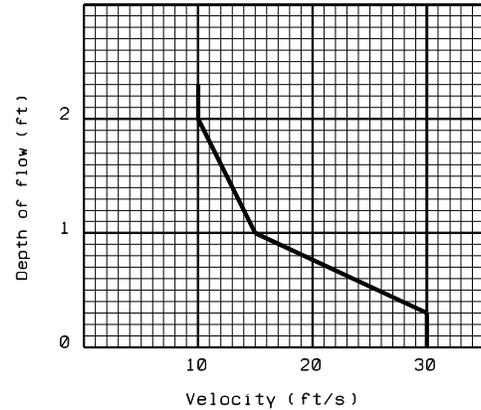


Figure 2. - Maximum velocity vs depth of flow

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.

The foundation shall be cleared of trees, stumps, roots, sod, loose rock, or other objectionable material.

The cross section shall be excavated to the neat lines and grades as shown on the plans. Overexcavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alignment shall be permitted.

Concrete linings shall be placed to the thickness shown on the plans and shall be finished in an appropriate manner. Provisions shall be made to protect freshly placed concrete and to insure proper curing.

Surfacing materials shall not be placed on a wet subgrade.

Filter, bedding, and rock riprap shall be placed to line and grade and in the manner specified. Riprap shall be placed so that it does not reduce the design section more than 10 percent.

Construction operations shall be done in such a manner that erosion and air pollution are minimized and held within reasonable and legal limits. The completed job shall present a good appearance.

All disturbed areas shall be vegetated or otherwise provided with a cover to protect the areas against soil erosion. Seedbed preparation; time of seeding; seeding mixture and rate; stabilizing crop, mulching, or mechanical means of stabilizing; and fertilizer and lime requirements shall be specified for each applicable area. Stabilization shall be in accordance with conservation practice standard Critical Area Planting (342).

SUPPORTING DATA AND DOCUMENTATION

Field and Design Data

Record on appropriate engineering paper. The following is a list of the minimum required design data:

- Plan view of lined waterway or outlet.
- Soils investigation that includes rock content and depth to seasonal high water table.
- Profile of the lined waterway showing channel grade, lining thickness, and ground lines.
- Cross section showing cross section shape, width and design depth.
- Lining requirements (size, thickness, geotextile, etc.) and installation details.
- Seeding, fertilizing and mulching requirements if required.
- Quantities.

Construction Check Data/As-Built

1. Installation and construction check notes are to be recorded in sufficient detail to show that the practice meets this standard and applicable specifications. Minimum requirements are:
 - a) Measurements to show length, and width; and grade of completed lined waterway or outlet marked in red on the "as-built" plans.
 - b) A statement as to the lining size and thickness is to be placed on the "as-built" plans.
 - c) The certification statement and signature on the "as-built" plans.
 - d) Measurements and computations for quantities will be recorded and filed to the extent that they

are required to determine the number of practice units performed, or as requested by the landuser.

2. Provide a statement on seeding.
3. Sign and date notes including statement that the practice meets or exceeds plans and specifications.

REFERENCES

1. *Maryland Technical Guide*, Section IV, Standards and Specifications.
2. *National Handbook of Conservation Practices*, USDA, Soil Conservation Service.
3. *Standard Specifications for Construction Materials*, Maryland Department of Transportation, State Highway Administration, Baltimore, Maryland, October 1993.
4. *Engineering Field Handbook*, Part 650, USDA, Soil Conservation Service.