

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, 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.

This standard applies to waterways or outlets having linings of nonreinforced, cast in-place concrete; flagstone mortared in place; rock riprap; or similar permanent linings. It does not apply to irrigation water conveyance, grassed waterways with stone centers or small lined sections to carry prolonged low flows. The maximum capacity of the waterway flowing at designed depth shall not exceed 200 ft<sup>3</sup>/s.

**PURPOSE**

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**

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. 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.

**CRITERIA**

**Capacity.** 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 - .014
Float finish.....	.013 - .017
Gunite.....	.016 - .022
Flagstone.....	.020 - .025
Riprap.....	Determine from Figure 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 exceed critical shall be restricted to straight reaches.

Waterways or outlets with velocities exceeding

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critical shall discharge into an energy dissipater to reduce velocity to less than critical.

**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 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 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 form concrete:

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

Rock riprap.....2 to 1

Concrete grouted rock riprap..... 1 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

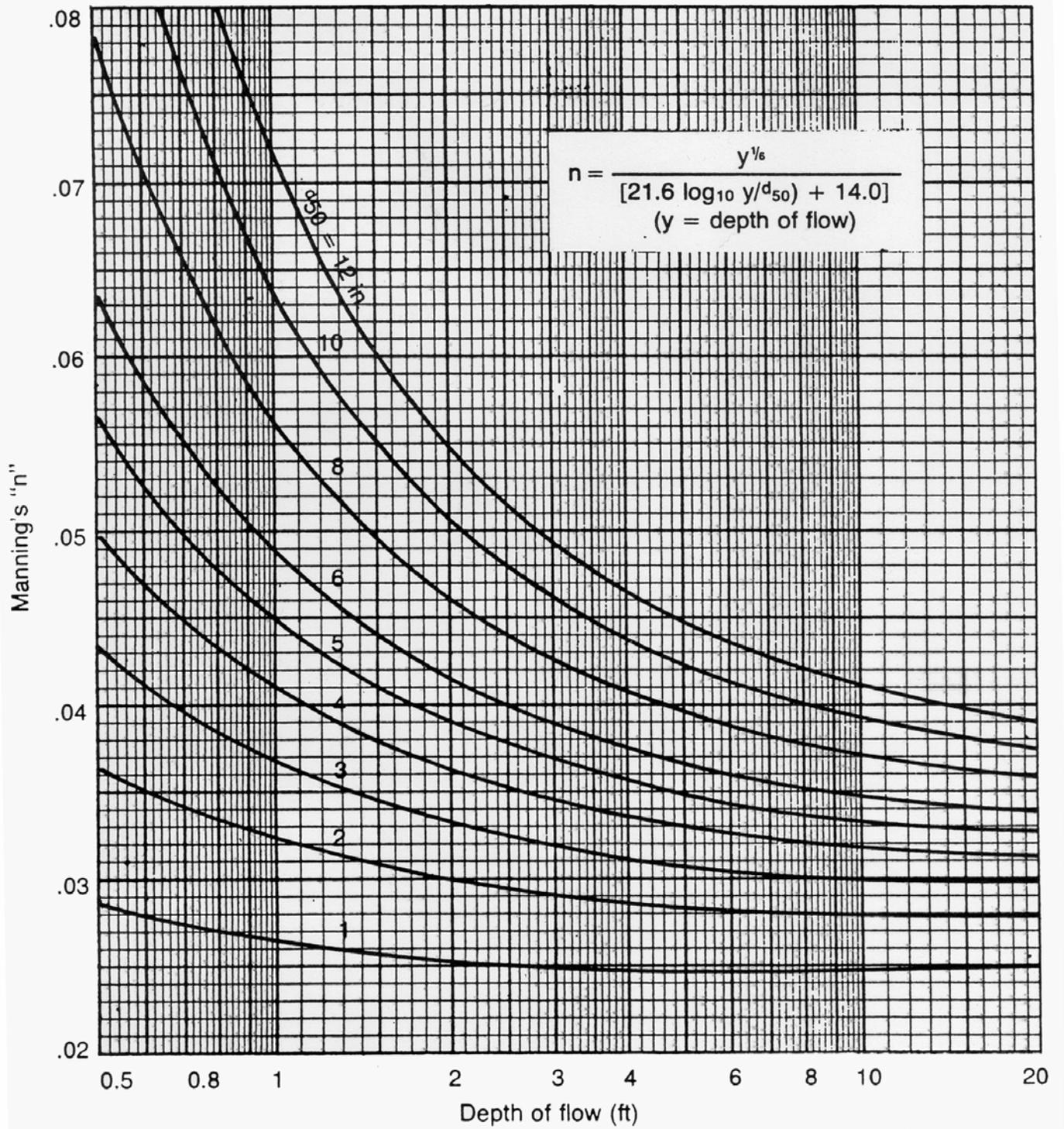


Figure 1 – Values of  $n$  for riprap-lined channels,  $d_{50}$  size vs depth of flow.

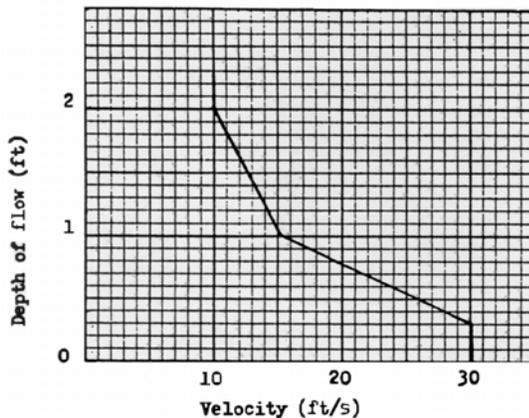


Figure 2 – Maximum velocity vs depth of flow.

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

**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. Non-woven geotextile used as an underliner shall have a minimum tensile strength of 120 pounds, puncture strength of 90 pounds, permeability coefficient of 0.2cm/sec. and accelerated weathering strength retained of 70 percent. 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.<sup>2</sup>. Cement used shall be Portland cement, Types I, II, or if required, Types IV and V. Aggregate used shall have a maximum size of 1 ½ 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.

**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 the effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and groundwater recharge.

Variability of the practice's effect caused by seasonal and climatic changes should be assessed.

Filtering effects of vegetation on the movement of sediment and dissolved and sediment-attached substances will be evaluated.

Effects on the visual quality of the water resources should be considered.

Short-term and construction-related effects on the quality of water resources should be assessed.

## PLANS AND SPECIFICATIONS

Plans and specifications for constructing a lined waterway or outlet shall be in keeping with this standard and shall adequately describe the requirements for properly installing this practice to achieve its' intended purpose.

**Lined Waterway or Outlet Specifications.** The foundation area 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. Over-excavated 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 a workmanlike manner. Provisions shall be made to protect freshly placed concrete and to ensure proper curing.

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 and water pollution are minimized and held within reasonable and legal limits. The completed job shall be workmanlike and present a good appearance. All disturbed areas shall be vegetated or otherwise provided with a cover to protect the areas against soil erosion.

## OPERATION AND MAINTENANCE

The applied practice shall be inspected after all significant runoff events. Any discovered damage shall be repaired as soon as practical, vegetal scour or rock displacement, etc.

## REFERENCES

NRCS National Engineering Handbook Part 650, Engineering Field Handbook, Chapter 7

Appropriate Technical Releases and Design Notes, USDA, NRCS.