

**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.

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 standard applies to waterways or outlets having linings of non-reinforced, 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 ft³/s.

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 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.

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

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

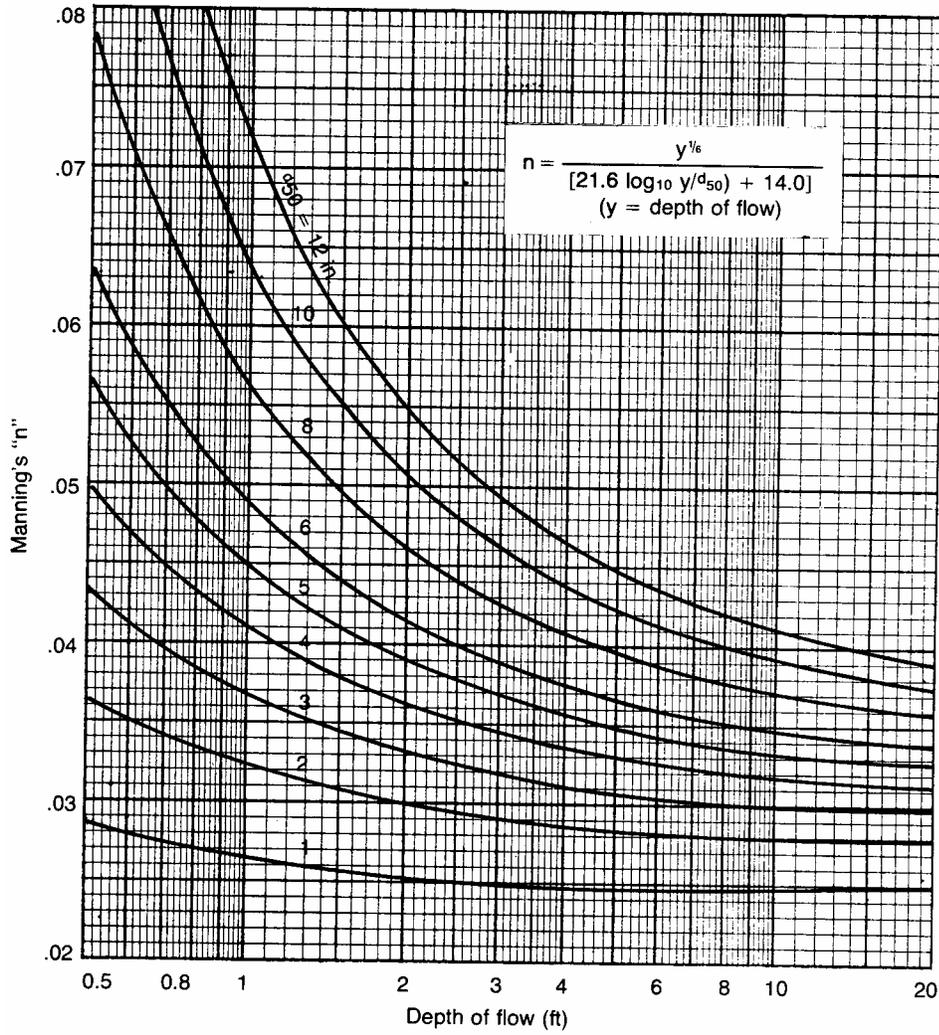


Figure 1.—Values of n for riprap-lined channels, d₅₀ size vs depth of flow.

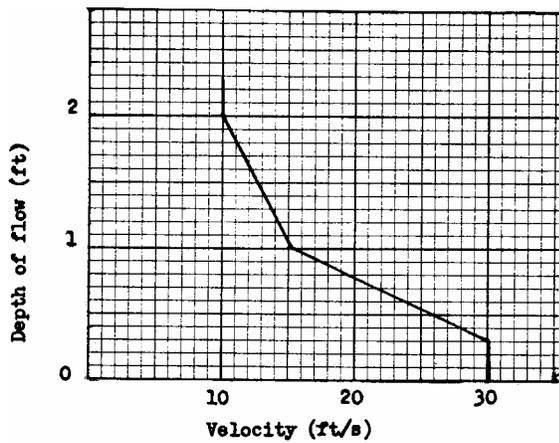


Figure 2.—Maximum velocity vs depth of flow.

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 dissipator 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 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 lessVertical
- 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

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 dissipators 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. 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 1-1/2 in.

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 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.

CONSIDERATIONS

Water quantity

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

Water quality

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

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.

Specifications for construction and installation of a lined waterway or outlet shall use or be in conformance with the requirements of the attached "Construction Specification." An engineer shall approve any variation from these specifications.

OPERATION AND MAINTENANCE

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

**Natural Resources Conservation Service
Construction Specification**

LINED WATERWAY OR OUTLET

1. SCOPE

Work shall consist of constructing the lined waterway or outlet and will include all clearing, shaping, excavation, fill placement, installation of concrete, filter material, stone and mortar, and other features to the lines, grades, and elevations as specified on the drawings and staked in the field.

2. SITE PREPARATION

The structure foundation area shall be cleared of all trees, stumps, roots, sod, loose rock, or other objectionable material that could interfere with construction activities or cause the structure to be undermined.

Cleared material and other debris shall be disposed of by burning or burying at designated location or removal from the site.

3. EXCAVATION AND SHAPING

The structure cross section, inlet, and outlet 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 deviation from design grade or horizontal alignment shall be permitted. Final ground line shall be shaped to blend with the structure slopes for hydraulic efficiency, ease of maintenance, and pleasing appearance.

4. WATERWAY LINING

Concrete linings shall be placed to the thickness and slopes shown on the plans and shall be finished in a workmanlike manner. Provisions shall be made to protect the freshly placed concrete and mortar to ensure proper curing.

Concrete or mortar shall not be placed when the outside temperature is below 40 degrees or above 90 degrees Fahrenheit. Concrete placed during cold weather shall be protected from freezing during the curing period. The concrete shall be cured by covering with burlap, canvas or other suitable material or coated with an approved, white pigmented curing compound and kept from drying out for at least seven days.

Waterway lining weep holes, drains, and filter material shall be placed to the design dimensions at the locations shown on the plans.

Structural lining tolerances shall be as follows:

1. Concrete lining thickness or mortar depth shall not be more than 0.5 inch less than design thickness measured perpendicular to the concrete or stone surface.
2. Inlet crest shall be within ± 0.1 foot of design elevation.
3. Outlet floor shall not be more than 0.1 foot above design elevation.
4. All other width and length dimensions shall equal or exceed design requirements.

5. PROTECTION

A protective cover of vegetation shall be established around the structure entrance, exit sides, and other disturbed soil areas. Temporary vegetation may be used until permanent vegetation can be established. The structure area shall be fenced to protect vegetation when livestock are present.

6. MEASUREMENT

No specific quantity calculations will be made for site preparation and for excavation and shaping. Compensation for this work shall be made in a single, lump sum payment.

Concrete volumes shall be computed to the neat lines of the design dimensions. Wire mesh, filter material, and any forming required will be included in payment for concrete. Concrete will be calculated to the nearest 0.1 cubic yard.

Stone placement surface area shall be computed to the neat lines of the design dimensions. Stone placement, mortar, and filter material shall be included in payment for the stone. Measurement shall be to the nearest 1.0 square foot.

Measurement for vegetative planting area shall cover all disturbed areas (structure entrance, exit, sides, and disposal area, etc). Areas shall be measured to the nearest 0.1 acre.