

**SOIL CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD**

**LINED WATERWAY OR OUTLET
(Feet)
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.

Scope

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 ft³/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 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 *or other provisions have been made to remove soil restrictions.*

Design 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
Concrete block	.025-.035
Gabion mattress	.025-.030
Flagstone	.020-.025
Riprap	Determine from figure 1

_____ Field Office

Sec. IV

SCS, OK
April, 1994

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

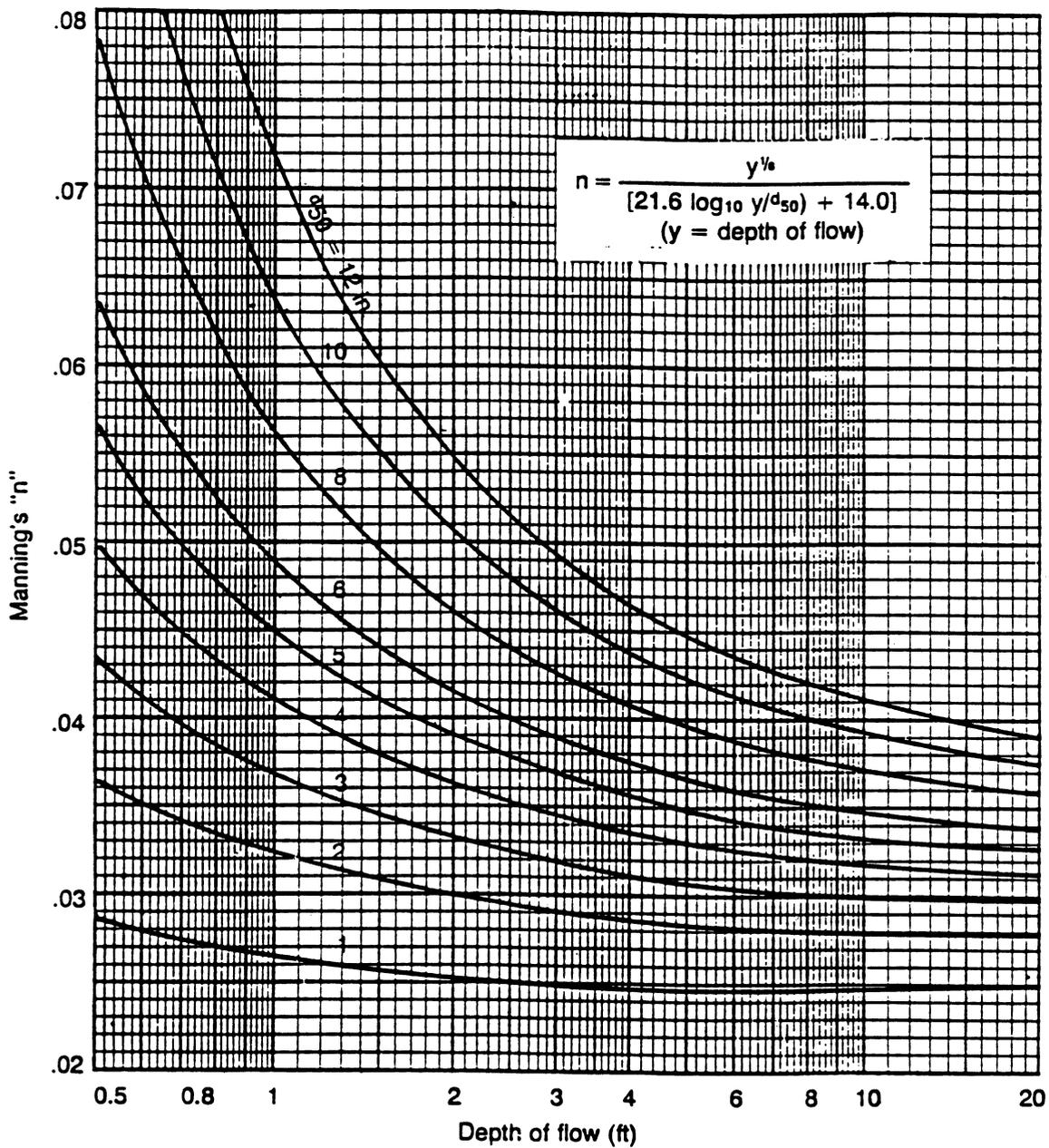


Figure 1.—Values of n for riprap-lined channels, d₅₀ size vs depth of flow.

Lined waterways or outlets shall be dimensioned according to approved standard drawings unless special designs are prepared.

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.

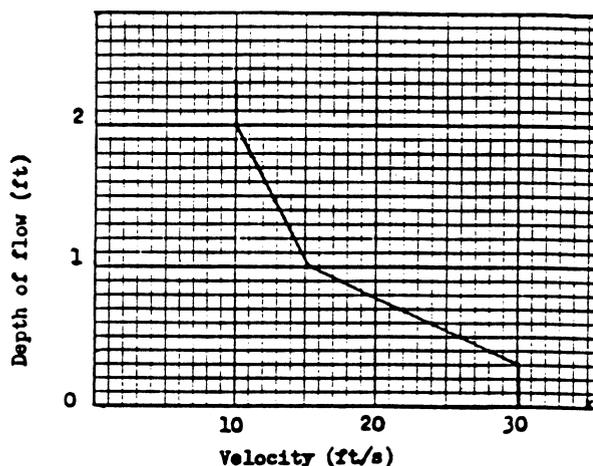


Figure 2.—Maximum velocity vs depth of flow.

Rock size for riprap lined waterways or outlets shall be determined by procedures contained in TR-59, Hydraulic Design of Riprap Gradient Control Structures.

Flagstone lined waterways or outlets shall be limited to a maximum velocity of 10 ft./sec.

Gabion mattress lined outlets shall be limited to the following entrance head (D) and fall (F), where D is equal to the depth of flow (He) plus 0.25 ft of freeboard:

<u>Maximum D (ft.)</u>	<u>F (ft.)</u>
2.5	8
2.3	10
2.1	12
1.9	14
1.5	18

Concrete lined outlets shall be limited to the following entrance head (D) and fall (F), where D is equal to the depth of flow (He) plus 0.25 ft of freeboard:

<u>Maximum D (ft.)</u>	<u>F (ft.)</u>
2.75	10
2.25	16
1.75	22
1.25	24

For concrete lined outlets with a slope of 10 horizontal to 1 vertical or flatter, there is no limit on the total amount of fall.

Concrete block lined outlets shall be limited to a maximum fall of 10 ft.

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.

A vegetated earth freeboard of a minimum of 0.5 ft. shall be provided to prevent overtopping adjacent to the liner.

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

Nonreinforced concrete:

- Hand-placed, formed concrete*.....2 to 1
- 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
- Gabion mattress*.....2.5 to 1
- Concrete block*.....2 to 1

Exit slope. *The steepest permissible exit slope for gabion mattress and concrete block lined outlets shall be 3 horizontal to 1 vertical. The steepest permissible exit slope for concrete lined outlets shall be 2 horizontal to 1 vertical.*

Lining Thickness. Minimum lining thickness shall be:

Concrete	5 in. with welded wire fabric reinforcing
Rock riprap.....	Maximum stone size plus thickness of filter or bedding
Flagstone.....	4 in. including mortar bed

For concrete lined outlets with exit slopes of 10 horizontal to 1 vertical or flatter, the lining thickness may be 4 in. without reinforcement.

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 SCS standards. Weep holes may be used with drains if needed.

Bedding for gabion mattress and concrete block lined outlets shall consist of a 3 inch layer of sand and nonwoven geotextile.

Upper Toewall. *The upper toewall for gabion mattress and concrete block lined outlets shall consist of an impervious geomembrane (10-mil PE or PVC plastic) strip extended two feet wider than the sidewalls and extended downward so that the bottom edge is brought to the same elevation (2' to 3' below floor subgrade) end to end. An impervious cutoff of geotextile sealed with asphalt or bentonite slurry may be approved so long as it provides equivalent protection and serviceability as the 10-mil plastic geomembrane.*

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 on 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.

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

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.

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. Overexcavated areas shall be backfilled with moist soil compacted to the density of the surrounding material.

No abrupt deviations from design grade or horizontal alinement 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 insure 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.

Concrete. Concrete shall be placed to the lines and grades as shown on the plans or as staked in the field. The concrete shall be delivered to the site and discharged into the forms within 1-1/2 hours after the introduction of the cement to the aggregates unless a mix design with a set retarder is approved for use by the technician. Concrete 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 and kept from drying out for at least 7 days or by coating the surface with an approved white-pigmented curing compound.

Sand Bedding. Sand bedding shall consist of a maximum 3 inch layer of concrete sand meeting ASTM C-33.

Nonwoven Geotextile. Nonwoven geotextile shall be a minimum 8 ounces per square yard. The nonwoven geotextile shall meet the following requirements:

<u>Property</u>	<u>Test Method</u>	<u>Requirement</u>
Tensile Strength	ASTM D 4632	180 lb. min.
Bursting Strength	ASTM D 3786	320 lb. min.
Elongation at Failure	ASTM D 4632	50% min.
Puncture	ASTM D 4833	80 lb min.
Ultraviolet Light (percent residual tensile strength)	ASTM D 4355	70% min.
Apparent Opening Size	ASTM D 4751	# 40 max.
Permittivity	ASTM D 4491	0.70/sec. min.

Nonwoven geotextile shall be placed with the length perpendicular to the direction of flow. All laps shall be a minimum of 18 inches. Nonwoven geotextile shall be placed so that good uniform contact is maintained with the sand bedding.

Except as provided below, the rock for loose rock and gabion lined outlets shall have the following properties determined by ASTM method C127.

- a. Bulk specific gravity > 2.5 determined by ASTM C127
- b. Absorption < 2% determined by ASTM C127
- c. Soundness: Weight loss in 5 cycles < 10% in sodium sulfate.
Weight loss in 5 cycles < 15% in magnesium sulfate.
As determined by ASTM C88 coarse aggregate and modified by Material Specification 523.

SCS, OK
April, 1994

Rock that fails to meet the above criteria may be accepted if similar rock from the same source has been demonstrated to be sound after 5 years or more of service under conditions of weather, wetting and drying, and erosive forces similar to those anticipated for the rock to be installed.

Gabion Mattress Lined Outlet. *Gabion mattress units shall consist of compartmented rectangular basket containers 6 feet wide, 9 inches thick and divided into 3 feet compartments lengthwise. Twisted or welded wire mesh shall be used. All steel wire used shall be galvanized or aluminized prior to fabrication into mesh. The galvanized wire shall have a Finish 5 Class 3 zinc coating, indicated in ASTM A 641. The surface of coating shall be smooth and show no visible loose flakes and scratch marks due to manufacturing and fabricating process or in handling. Baskets may also be further protected by PVC coatings.*

Twisted wire mesh gabion units shall be of nonraveling construction and fabricated from a double twisted hexagonal wire mesh with opening size of approximately 2-1/2 inches by 3-1/4 inches. The gabion mesh wires shall be wrapped around the selvage wire no less than 1-1/2 times and shall interconnect with adjacent mesh wires.

Welded wire gabion units shall be of nonraveling construction and fabricated from welded wire mesh of approximately 3 inches x 3 inches square opening size. All aluminized steel wire shall be welded and fabricated into mesh prior to fabrication. All gabion and frame wire shall equal or exceed Federal Specification QQ-W-461H and possess soft tensile strength of 60,000 psi with a tolerance of minus 2,000 psi.

All perimeter edges of gabions shall be securely selvaged or bound so that the joints

formed by tying the selvages have approximately the same strength as the body of the mesh. Prior approval must be obtained before use of wire fasteners in lieu of lacing wire. As a minimum, a fastener shall be installed at each mesh opening at the location where mesh wire meets selvage or edge wire. Galvanized wire fasteners shall be used with galvanized gabions. Aluminum wire fasteners shall be used with aluminized gabions. Stainless steel fasteners shall be used with PVC-coated gabions.

All adjoining empty gabion units shall be connected by lacing wire or approved wire fasteners along the perimeter of their contact surfaces. Lacing of adjoining basket units shall be accomplished by continuous stitching with alternating single and double loops at intervals of not more than 5 inches, and a half hitch shall be included at every double loop. All lacing wire terminals shall be securely fastened. Approved wire fasteners may be used in lieu of lacing wire for forming individual baskets and joining empty baskets together prior to stone filling. All joining shall be made through selvage-to-selvage or selvage-to-edge wire connection.

Stone filling operations shall proceed with placement by hand or machine so as not to damage the wire coating, to assure a minimum of voids between the stones, and the maintenance of alignment throughout the filling process. Undue deformation and bulging of the mesh shall be corrected prior to further stone filling. The maximum height from which the stone may be dropped into the basket units shall be 36 inches.

The mattresses shall be placed with the 3' cell dimension in the direction of flow to better control the movement of rock within the cell. Otherwise, the gabion mattresses shall be placed, filled, and tied in accordance with the manufacturer's recommendations.

The gabion mattresses shall be filled with rock meeting the following gradation:

<i>Size of Rock</i>	<i>% Smaller By Weight</i>
<i>8 Inches</i>	<i>100</i>
<i>6 Inches</i>	<i>60-80</i>
<i>5 Inches</i>	<i>25-50</i>
<i>4 Inches</i>	<i>5-20</i>
<i># 4</i>	<i>0-5</i>

Rock for filling the gabions shall meet the following requirements:

Individual rock fragments shall be dense, sound and free from cracks, seams and other defects conducive to accelerated weathering. The rock fragments shall be angular to subrounded in shape. The least dimension of an individual rock fragment shall be not less than one-third the greatest dimension of the fragment.

Concrete Block Lined Outlets. *Concrete blocks shall be standard modular 8" x 8" x 16" concrete blocks with a minimum weight of 37 lb. each.*