



Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

STREAM CROSSING

CODE 578

(no)

DEFINITION

A stabilized area or structure constructed across a stream to provide controlled access for people, livestock, equipment, or vehicles.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Improve water quality by reducing sediment, nutrient, or organic loading to a stream
- Reduce streambank and streambed erosion

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all land uses where—

- An intermittent or perennial watercourse (stream) exists.
- Controlled access from one side of the stream to the other side is necessary to reduce or eliminate environmental degradation.
- Soils, geology, fluvial geomorphology, and topography are suitable for construction of a stream crossing.

CRITERIA

General Criteria Applicable to All Purposes

The following requirements are applicable regardless of the purpose or type of crossing.

- Apply this standard in accordance with all Federal, State, Tribal, and local regulations, including floodplain regulations and flowage easements.
- The landowner/contractor is responsible for locating all aboveground and buried utilities, and buried structures in the project area, including drainage tile.
- Provide signage and guidance to caution against use *if dangerous flow levels might exist*. Place staff gage and warning sign in a location that is clearly visible to the user before traveling across structure.
- Do not create a passage barrier where aquatic species are present and using the stream. Where aquatic organism passage is an issue, use additional criteria in NRCS Conservation Practice Standard (CPS) Aquatic Organism Passage (Code 396).

Location

Locate the stream crossing in an area where the streambed is stable or where the streambed can be stabilized. See NRCS CPS Channel Bed Stabilization (Code 584) and NRCS National Engineering

Handbook (NEH Title 210), Part 654, Stream Restoration Handbook, Chapter 3, Site Investigation and Assessment. *Avoid wetland areas where possible.* Do not place a crossing where—

- The channel grade or alignment changes abruptly.
- Excessive seepage or instability is evident.
- Evidence of incision and bed instability exists.
- Large tributaries enter the stream.
- Water velocity and depth are excessive.

Meet guidelines identified by State or Federal agencies responsible for aquatic species resources spawning habitat. Where such guidelines do not exist, locate crossings at least 300 feet from listed species spawning areas.

To the extent possible, locate the crossing on straight and riffle sections. Avoid locating in bends. Install the stream crossing perpendicular to the direction of stream flow where possible. Account for potential future lateral migration of the stream in developing the design.

Minimize the number of stream crossings planned and installed through evaluation of alternative trail or travel-way locations and land user operations. Where feasible, use existing roads. Discourage livestock loafing in the stream by locating crossings, where possible, out of shady riparian areas or by including gates in the design. Where appropriate, use NRCS CPSs Fence (Code 382) and Access Control (Code 472) in conjunction with management strategies to restrict access to the stream crossing.

Where a stream crossing is installed to remove an existing barrier to the passage of aquatic organisms, refer to Aquatic Organism Passage (Code 396).

If a stream crossing is installed higher than the channel bed, it can initiate sediment deposition in the upstream channel and bury habitat features such as deep pools, riffles, and overhead cover. Refer to the criteria and considerations in Channel Bed Stabilization (Code 584), if the stream crossing has the potential to affect the upstream channel gradient for a distance of more than 5 times the bankfull width.

Example: *If the crossing is set 2 feet above the channel bed and the gradient is 0.004 ft/ft, sediment deposition can extend 500 feet upstream. $2 \text{ ft} \div 0.004 \text{ ft/ft} = 500 \text{ ft}$. If 500 ft is greater than 5 x bankfull width, refer to Channel Bed Stabilization (Code 584).*

Access road crossings

Where the stream crossing is installed as part of an access road, design the crossing in accordance with the location, alignment, width, and surfacing criteria of NRCS CPS Access Road (Code 560).

Width

Provide an adequate travel-way width for the intended use. Provide a travel-way no less than 10 feet wide for a multiuse stream crossing. Make a “livestock only” crossing no less than 6 feet wide and no more than 20 feet wide. Measure widths from the upstream end to the downstream end of the stream crossing, not including the side slopes.

Side slopes

Make all side slope cuts and fills stable for the channel materials involved. Make the side slopes of cuts or fills in soil materials no steeper than 2 horizontal to 1 vertical (2:1). Make rock cuts or fills no steeper than 1.5 horizontal to 1 vertical (1.5:1).

Stream approaches

Where possible, blend approaches to the stream crossing with existing site topography. Use streambank soil bioengineering practices and other streambank stabilization measures such as NRCS CPS Streambank and Shoreline Protection (Code 580) as appropriate and feasible. Design stable approaches with gradual ascent and descent grades that are no steeper than 5 horizontal to 1 vertical (5:1). Construct approaches with suitable material to withstand repeated and long-term use. Design the minimum width of

the approaches equal to the width of the crossing surface. Use NRCS CPSs Access Road (Code 560) or Trails and Walkways (Code 575) as needed.

Divert surface runoff around the approaches to prevent erosion. Use NRCS CPSs Diversion (Code 362), Structure for Water Control (Code 587), Lined Waterway or Outlet (Code 468), or Grade Stabilization Structure (Code 410) as needed.

Rock

Use only rock that is sound, durable, and able to withstand exposure to air, water, and freezing and thawing. Use rock of sufficient size and density to resist mobilization by design flood flows. Use appropriate rock sizes that will accommodate the intended traffic without causing injury to livestock or people, or damage to vehicles using the crossing. For a rock livestock crossing, use a hoof contact zone or alternative surfacing method over the rock.

Use rock materials that meet Wisconsin Construction Specification 11, Small Rock Aggregate.

Fencing

Exclude livestock access to the crossing using fence and gates, as needed. Install cross-stream fencing at fords with breakaway wire, swinging floodgates, hanging electrified chain, or other devices to allow the passage of floodwater and large woody material during high flows. Design and construct all fencing in accordance with Fence (Code 382).

Vegetation

As soon as practical after construction, vegetate highly disturbed areas in accordance with Critical Area Planting (Code 342), Riparian Herbaceous Cover (Code 390), and/or Riparian Forest Buffer (Code 391). In areas where the vegetation may not survive use Heavy Use Area Protection (Code 561).

Criteria Applicable to Bridge Crossings

Design the bridge in a manner that is consistent with sound engineering principles and adequate for its intended use. Utilize appropriate bridge materials and necessary safety measures (including bridge rail and guardrail). Refer to NRCS 210-NEM-536 and the current edition of the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) "Bridge Design Specifications."

Design the bridge to fully span the stream, passing at least the bankfull flow where the design flow is not dictated by regulations. At design flow capacity, the structure must convey stream flow, sediment, and other materials without appreciably altering stream flow characteristics and pass the design flow without causing erosion or overtopping of the structure. Adequately protect the bridge so that flows exceeding the bridge's flow capacity can safely bypass without damaging the bridge or eroding the streambanks.

For all bridge crossings, perform a geologic subsurface investigation that is in enough detail and analysis to support the design. Refer to NRCS 210-NEM, Part 531, "Geology."

Bridges must meet the requirements for capacity as required by state statutes or local ordinances. Use Table 1 when no statutory or ordinance requirements apply.

On public roads, the minimum design storm runoff capacity shall be conveyed without causing erosion or road overtopping.

On non-public use roads, an erosion-resistant low point or overflow area may be constructed across the road to supplement the capacity. Flow depths and velocities must allow safe passage of private and emergency vehicles.

Evaluate the need for safety measures such as guardrails and reflectors at bridge crossings. Acceptable bridge materials include concrete, steel, and wood.

Table 1

Road Type	Storm Frequency (24-hour duration)
Forest, Farm Field	2-year*
Farm Driveways, Non-Public	10-year
Public	25-year
<i>*Full bank flow may be used if the 2-year storm produces out-of- bank flow.</i>	

Criteria Applicable to Culvert Crossings

Design the culvert in a manner that is consistent with sound engineering principles and adequate for its intended use. Evaluate the need for safety measures such as guardrails at the culvert crossing. Refer to NRCS 210-NEM-536 and the current edition of AASHTO LRFD “Bridge Design Specifications.”

Design the culvert to have sufficient capacity to pass storm flow in Table 1. Adequately protect the culvert crossing so that flows in excess of culvert capacity can safely bypass the structure without damaging it or eroding the streambanks or crossing fill material. Do not use culverts in locations where large flows of sediment or large woody material are expected, or where the channel gradient exceeds 6 percent (100 horizontal to 6 vertical).

On non-public use roads, an erosion-resistant low point or overflow area may be constructed across the road to supplement the capacity. Ensure flow depths and velocities allow safe passage of private and emergency vehicles.

If needed, use additional culverts at various elevations to maintain terrace or floodplain hydraulics and water surface elevations. The length of the culvert system must be adequate to extend the full width of the crossing, including side slopes and inlet or outlet extensions.

Acceptable culvert materials include concrete, corrugated metal, corrugated plastic, or steel. Select pipe material based on height of cover, soil type (corrosivity of the backfill material), and hydraulics.

For open bottom culverts or large culverts, perform a geologic investigation that is in enough detail and analysis to support the design. Refer to 210-NEM-531.

Criteria Applicable to Ford Crossings

Ford crossings have the least detrimental impact on water quality when their use is infrequent. Ford crossings are adapted for crossing wide, shallow watercourses with firm streambeds. The following requirements are applicable to ford crossings regardless of the type of ford crossing:

- Do not place ford crossings immediately downstream from a pipe or culvert because of potential damage from localized high-velocity flows.
- Avoid placement of fords in areas where bank heights exceed 5 feet.
- Stream crossings used frequently or daily by livestock must use a culvert crossing or curbed bridge unless exclusion gates are included in the design to prevent livestock loafing on the crossing.
- To the extent possible, design the top surface of the ford crossing to follow contours of the streambed. Slope the crossing to match the existing thalweg (low-flow) channel.
- Provide cutoff walls at the upstream and downstream edges of the ford when needed to protect against undercutting.
- Evaluate the need for advance warning signage and water depth signage. Refer to Clarkin et al. (2006) for signage recommendations.

Concrete fords

Use a concrete ford crossing only where the foundation of the stream crossing has enough detail and analysis to support the design. Refer to NRCS 210-NEM-531.

Recess the subgrade of the stream crossing so the upstream edge of the constructed (finished) surface of the crossing is at or below the original surface of the streambed. *Use Wisconsin Construction Specification 4 - Concrete for the design and installation of concrete fords.*

Dewatering of the site and toe walls is required during placement of concrete to lessen the potential for segregation and to maintain the proper water to cement ratio. Flowing water erodes concrete that is not sufficiently hardened. The stream must be diverted or prevented from flowing over the concrete until the concrete makes its final set, at a minimum of 12 hours after placement of the concrete.

Use a minimum thickness of 5 inches of placed concrete. Construct the concrete slab on a minimum 4-inch thick gravel base, unless the foundation is otherwise acceptable. Refer to NRCS 210-NEM-536 for design criteria.

Construct toe walls at the upstream and downstream ends of the crossing. Make the toe walls a minimum of 6 inches thick and 18 inches deep. Extend the toe walls in the stream approaches to the bankfull flow elevation.

Precast panels meeting the above criteria may be used in place of cast-in-place concrete slabs. *To the extent possible, the panels shall follow the contours of the stream bottom in order to avoid potential problems with sediment accumulation. Use concrete units that have adequate reinforcement for transportation and placement.* As with the cast-in-place concrete, install a gravel base and toe walls.

Rock fords and the use of geosynthetic materials

When the site has a soft or unstable subgrade, use geotextiles to improve the foundation bearing capacity in the design of rock ford crossings. *Use geotextiles that meet the requirements of Table I or II, Class IV, in WI Construction Specification 13, Geotextiles.*

Recess the subgrade of the stream crossing so the upstream edge of the constructed (finished) surface of the crossing is at or below the original surface of the streambed.

Dewater and excavate the bed of the channel to the necessary depth and width and cover with geotextile material. Install the geotextile material to extend across the bottom of the stream and up the side slopes to at least the bankfull flow elevation.

Use durable geosynthetic materials and install them according to the manufacturer's recommendations, including the use of staples, clips, and anchor pins. Cover the geotextile material with at least 6 inches of crushed compacted rock. Use minimum 6-inch deep geocells if geocells are installed. *Cover the geotextile material or excavated bed with graded rock base as shown in Table 2.*

Table 2

Foundation Consistency and Use	Minimum Base Course Thickness
<i>Soft foundations for equipment crossing</i>	<i>18 inches or 8 inches underlain with geotextile</i>
<i>Firm foundations for equipment crossings and ALL cattle crossings</i>	<i>8 inches</i>

Design the rock ford stream crossing to remain stable for *the full bank design flow or 10-year, 24-hour duration storm flow, whichever is less.* Compute channel velocities and choose rock size using procedures and guidelines set forth in NRCS 210-NEH, Part 654, Technical Supplement (TS) 14N, "Fish Passage and Screening Design," and 210-NEH-650-16, Appendix 16A, "Size Determination for Rock Riprap," or other procedures approved by the State conservation engineer.

Crushed stone surfaces shall be stable for design velocities computed for the 10-year, 24-hour duration storm or full bank flow, whichever is less, unless provisions for replacement are included in the Operation and Maintenance Plan.

Allowable velocities for various sizes of rock material are shown in Table 3.

Table 3

<i>D50 (inches)</i>	<i>Allowable Velocity (fps)</i>
0.5	2.7
1	3.2
2	4.3
3	5
4	5.6
5	6
6	6.5
7	7.2
10	8

Base course options include quarry-run (angular) or field stone (rounded) graded rock (see Table 3). Surfacing treatment options include either:

1. *4 inches of crushed stone.*
2. *4 inches of additional base course thickness.*

If a 2-inch thick hoof contact zone is used, the thickness of the stone surface layer may be reduced by 2 inches. The material to be used for hoof contact will be decided upon by the landowner and could include sand, ground limestone, rock screenings, or similar materials.

Manufactured products such as articulated concrete blocks (ACBs) can be used to construct a low-flow ford. Properly designed ACB surfaces provide stable driving surfaces in a variety of conditions. Refer to 210-NEH-654, Technical Supplement (TS) 14L for guidance for planning, design, and uses of such materials.

Vented fords

Use a vented ford where relatively frequent overtopping is expected during high flow events to have a driving surface above normal flows and remain functional and stable for the design flow and sustainable for high flow conditions. Unlike conventional bridges, the deck is depressed relative to the approach and generally has only a curb stop (no rails). The 'vent' can be a culvert or an arch culvert; align either to work with the stream planform (contour). Design the crossing—

- With one or more open structures (vents) that approximates or exceeds the size of the normal channel area, allowing low flows and average daily flows to pass beneath the roadbed.
- To remain functional and stable for the design flow and sustainable for high flow conditions.
- To protect the channel, the structure, and its foundation against scour and erosion and to mitigate downstream energy dissipation for high flow events.

CONSIDERATIONS

For bridge, culvert, and vented ford crossings, consider incorporating natural streambed substrates through the impacted reach (including through the structure) for passage of aquatic organisms. See Bunte and Abt (2001) for sampling procedures. Natural streambeds provide passage and habitat benefits to many life stage requirements for aquatic organisms and may reduce maintenance costs. Consider all life

stages of aquatic organisms in the stream crossing design to accommodate their passage, in accordance with the species' requirements. Consider the habitat requirements of other aquatic or terrestrial species that may be affected by construction of a stream crossing. For example, a crossing may be designed with features that also promote safe crossing by terrestrial vertebrates.

Consider including a well-graded rock riprap apron on the downstream edge of concrete crossings to dissipate flow energy.

Locate stream crossings to avoid adverse environmental impacts and consider—

- When riffles are not present, consider using a stable straight reach.
- Effects on upstream and downstream flow conditions that could result in increases in erosion, deposition, or flooding. Consider habitat upstream and downstream of the crossing to avoid fragmentation of aquatic and riparian habitats.
- Short-term and construction-related effects on water quality.
- Timing of construction and other potential impacts in relation to passage of aquatic species.
- Overall effect on erosion and sedimentation that will be caused by the installation of the crossing and any necessary stream diversion.
- Effects of large woody material on the operation and overall design of the crossing.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for stream crossings in accordance with this standard. Clearly describe the requirements for applying the practice to achieve its intended purpose. As a minimum, include—

- Location of stream crossing
- Stream crossing width and length with profile and typical cross sections
- Details for permanent surface water diversion, as applicable
- Thickness, gradation, quantities, and type of rock or stone
- Type, dimensions, and anchoring requirements of geotextile
- Thickness, compressive strength, reinforcement, and other special requirements for concrete, if used
- Applicable structural details of all components, including reinforcing steel, type of materials, thickness, anchorage requirements, lift thickness, and covering
- Load limits for bridges and culverts
- Vegetative requirements that include seed and plant materials to be used, establishment rates, and season of planting
- Location, type, and extent of fencing required
- Location and types of gates required
- Method of surface water diversion and dewatering during construction or a statement making the contractor responsible for selecting such
- Location of all aboveground and buried utilities and notification requirements
- Location of all buried structures adjacent to the stream, including drainage tile
- Additional site-specific considerations
- Material and construction specifications

OPERATION AND MAINTENANCE

Develop an operation and maintenance plan and implement it for the life of the practice.

As a minimum, include the following items in the operation and maintenance plan:

- State the appropriate conditions when the crossing can be safely used and when it should not be used by a predetermined depth. NOTE: If this restriction prevents the landowner from using a culvert or ford a significant amount of time, a bridge should be considered.
- Inspect the stream crossing, appurtenances, approaches, and associated fence and exclusion gates at least annually and after each major storm event. Make repairs, if needed.
- Remove accumulated organic material, woody material, or excess sediment.
- Replace surfacing stone for livestock crossing as needed.

REFERENCES

American Association of State Highway and Transportation Officials. 2017. LRFD Bridge Design Specifications, Customary U.S. Units, 8th Edition. ISBN-13: 978-1-56051-654-5, 2160.
https://bookstore.transportation.org/item_details.aspx?id=2211.

Bunte, K. and R. Abt. 2001. Sampling Surface and Subsurface Particle-size Distributions in Wadable Gravel-and Cobble-bed Streams for Analyses in Sediment Transport, Hydraulics, and Streambed Monitoring. General Technical Report RMRS-GTR-74. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. https://www.fs.fed.us/rm/pubs/rmrs_gtr074.pdf.

Clarkin, K., G. Keller, T. Warhol, and S. Hixson. 2006. Low-water Crossings: Geomorphic, Biological, and Engineering Design Considerations. National Technology and Development Program Publication 0625 1808-SDTDC. San Dimas, CA: USDA Forest Service. http://www.fs.fed.us/t-d/php/library_card.php?p_num=0625%201808P.

Higgins, S.F., C.T. Agouridis, and S.J. Wightman. 2011. Stream Crossings for Cattle. University of Kentucky Cooperative Extension Service: AEN-101.
<http://www2.ca.uky.edu/agcomm/pubs/aen/aen101/aen101.pdf>.

USDA Forest Service. 2008. Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings. Technology and Development Center Publication 0877 1801P. San Dimas, CA: USDA Forest Service, Stream-Simulation Working Group. http://www.fs.fed.us/t-d/php/library_card.php?p_num=0877%201801P.

USDA NRCS. 2007. National Engineering Handbook (Title 210), Part 654, Stream Restoration Handbook, Chapter 3, Site Investigation and Assessment. Washington, D.C. <https://directives.sc.egov.usda.gov/>

USDA NRCS. 2001. Livestock Water Access and Ford Stream Crossings. Montana Engineering Technical Note MT-13. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_052940.pdf.

USDA NRCS. 2008. National Engineering Handbook (Title 210), Part 654, Stream Restoration Design. Washington, D.C. <https://directives.sc.egov.usda.gov/>.

USDA NRCS. 2017. National Engineering Manual (Title 210), Part 536, Structural Engineering. Washington, D.C. <https://directives.sc.egov.usda.gov/>.

USDA NRCS. 2019. National Engineering Manual (Title 210), Part 531, Geology. Washington, D.C. <https://directives.sc.egov.usda.gov/>.