United States Department of Agriculture

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 during dangerous flow levels. 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. 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 agenciesresponsible for aquatic species resources spawning habitat. Where such guidelines do not exist, locate crossings at least 300 feet from listedspecies 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.

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) and NRCS National Engineering Manual (NEM) (Title 210), Part 536, “Structural Engineering,” in addition to the criteria in this NRCS CPS.

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.

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 NRCS CPS Fence (Code 382).

Vegetation
As soon as practical after construction, vegetate highly disturbed areas in accordance with NRCS CPSs 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 NRCS CPS 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.”

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.”

If the culvert is not associated with an NRCS CPS Access Road (Code 560) crossing, designers must account for possible adverse effects to channel bed and bank stability resulting from installation of the crossing. The potential for adverse aggradation and degradation of the bed must be assessed and control measures taken if necessary. Use caution where large pulses of sediment or woody debris flows are expected.

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. Install the downstream edge with a low-flow hydraulic drop no greater than 0.5 feet above the original stream bottom. If possible, install the entire crossing with a finished grade about 4 inches lower than the natural grade of the channel.

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. Impacts to sediment needs to be evaluated to avoid potential problems with sediment accumulation. As with the cast-in-place concrete, install a gravel base and toe walls.

Rock fords and the use of geosynthetic materials

In steep areas subject to flash flooding and where normal flow is shallow or intermittent, use coarse aggregate or crushed rock at ford crossings. When the site has a soft or unstable subgrade, use geosynthetic materials to improve the foundation bearing capacity for the design of rock ford crossings. Geocells can be used for a low-flow ford as they provide economical surfaces in soft soils. Select geosynthetic material for separation and stabilization according to the current version of AASHTO M-288, “Standard Specification for Geosynthetic Specification for Highway Applications.”

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. Install the downstream edge with a low-flow hydraulic drop no greater than 0.5 feet above the original stream bottom. If possible, install the entire crossing with a finished grade about 4 inches lower than the natural grade of the channel.

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.

Design the rock ford stream crossing to remain stable for design flow. The typical minimum design flow is the 10-year 24-hour storm event. 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.

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 substainable 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/.