

**NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD**

OPEN CHANNEL

(Ft.)

CODE 582

DEFINITION

Constructing or improving a channel, either natural or artificial, in which water flows with a free surface.

PURPOSE

To provide discharge capacity required for flood prevention, drainage, other authorized water management purposes, or any combination of these purposes.

CONDITIONS WHERE PRACTICE APPLIES

This standard applies to construction of new open channels or modification of existing streams or ditches. Design criteria for channel stability and maintenance of surface drainage, main or lateral (608), having a drainage area in excess of 1 mi² will be in accord with this standard for open channels. It does not apply to diversions (362), grassed waterways or outlets (412), or surface drainage, field ditches (607).

This standard applies to all earth channel construction or modification except as noted above. It also applies where stability requirements can be met, where the impact of the proposed construction on water quality, fish and wildlife habitat, forest resources, and quality of the landscape is evaluated and the techniques and measures necessary to overcome the undesirable effects are made part of any planned work, where an adequate outlet for the modified channel reach is available for discharge by gravity flow or pumping, and where excavation or other channel work does not cause significant erosion, flooding, or sedimentation.

CRITERIA

During initial planning, existing channels will be “use” classified, and the classification documented in the design folder, as listed under Ohio’s Water Body Use Designation (Ohio Administrative Code §3745-1-07 through §3745-1-30). Channel modifications under this standard under are limited as follows:

- Streams classified as “Modified Warmwater Habitat” or “Limited Resource Waters”
- Streams classified as “Warmwater Habitat” or better must also include improvements under Conservation Practice Standard 395- Stream Habitat Improvement and Management. The design folder will include consultation between the NRCS Wildlife Biologist and Ohio EPA. Ohio EPA will advise the project sponsor regarding precautions to avoid the possible loss of existing beneficial stream uses listed in OAC 3745-1

Measures shall be designed and installed according to a site-specific plan.

Measures to be applied shall be compatible with improvements planned or being carried out by others.

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Sufficient depth shall be maintained to provide adequate outlets for subsurface drains, tributary streams or ditches, or other channels.

Effect of channel work on existing structures such as culverts, bridges, buried cables, pipelines, shall be evaluated to determine impact on their intended functions.

Measures shall be designed for flow duration, depth of inundation, buoyancy, uplift, scour, angle of attack, and stream velocity and be sustainable for higher flow conditions, based on acceptable risk.

Measures shall be compatible with the bank or shoreline materials, water chemistry, channel hydraulics, and slope characteristics, both above and below the water line.

Measures shall be designed for anticipated ice action, debris impact, and fluctuating water levels.

Spoil material from clearing, grubbing, and channel excavation shall be disposed of in a manner that will not interfere with the function of the channel and in accordance with all local, State, Tribal, and Federal laws and regulations.

All disturbed areas around measures shall be protected from erosion. Vegetation shall be selected that is best suited for the anticipated site conditions.

Measures shall be designed to avoid adverse effects on endangered, threatened, proposed, and candidate species and their habitats.

Measures shall be designed to avoid adverse effects on archaeological, historic, structural, and traditional cultural properties.

Measures will not impede the upstream or downstream passage of aquatic organisms.

Channel clearing to remove stumps, fallen trees, debris, and sediment bars shall only be done when they are causing or could cause detrimental bank erosion or structural failure. Habitat-forming elements that provide cover, food, pools, and water turbulence shall be retained or replaced to the extent possible.

Measures shall be designed to maintain the appropriate sediment transport regime in order to avoid detrimental erosion or sedimentation upstream and downstream.

Measures shall not impair the floodway or floodplain functions.

Measures shall not result in adverse effects on the function of the stream or the stream corridor. These adverse effects include destruction of instream habitat, sediment transport imbalances, passage barriers, or unexpected changes in channel plan, pattern, or profile.

When water surface elevations are a concern, the effects of protective measures shall not cause detrimental changes in water surface elevations.

The quantity and character of the sediments entering the reach of channel under consideration shall be analyzed on the basis of both present conditions and projected conditions caused by changes in land use or land treatment and upstream improvements or structural measures.

Plan

Channel construction or modification is to be in accordance with an approved plan developed for the site. Technical Release No. 25, Design of Open Channels, shall be used in the surveys, planning and site investigations for channel work. Those portions of TR 25 relating to design criteria shall be followed, using the procedure best adapted to site

conditions. All Ohio drainage and water laws shall be adhered to in the planning and construction of this practice. Any and all required permits shall be obtained.

In selecting the location and design of channels, careful consideration is to be given to minimizing water pollution, damaging fish and wildlife habitat and protecting forest resources and the landscape. Considering requirements for construction and operation and maintenance, selected woody plants must be preserved. Selection is to consider the overall landscape character, prominent views and the fish and wildlife habitat requirements.

Planned measures necessary to mitigate unavoidable losses to fish or wildlife habitat are to be included in the project. Quality of the landscape shall be maintained by both location of channel works and plantings as appropriate.

The alignment of channels undergoing modification shall not be changed to the extent that the stability of the channel or laterals is endangered.

Geological Investigation

Geological investigations are to be performed according to the requirements set forth in National Engineering Manual, Subpart 531A. Sampling and associated lab testing must be adequate to determine soil properties necessary to document stable channel design.

Capacity

The capacity for open channels shall be determined by procedures applicable to the purposes to be served and in accord with related engineering standards, guidelines, and handbooks. The water surface profile or hydraulic grade line for design flow shall be determined in accord with guidelines for hydraulic design in TR 25. The “n” value for aged channels shall be based on the expected vegetation, along with other retardant factors, considering the level of maintenance prescribed in the operation and maintenance plan developed with the owners or sponsors. The required capacity maybe established by consideration of volume-duration removal rates, peak flow, or a combination of the two as determined by the topography, purpose of the channel, desired level of protection, and economic feasibility.

Cross Section

The required channel cross section and grade are determined by the plan objectives, the design capacity, the materials in which the channel is to be constructed, the vegetative establishment program and the requirements for operations and maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. Urban and other high value developments through which the channel is to be constructed must be considered in design of the channel section.

Side slopes will be 2:1 or flatter, stable, and be designed based on site conditions. Side slopes steeper than 2:1 will be approved by the State Conservation Engineer.

Channel Stability

Characteristics of a stable channel are:

- The channel neither aggrades nor degrades beyond tolerable limits.
- The channel banks do not erode to the extent that the channel cross section is changed appreciably.
- Excessive sediment bars do not develop.

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- Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.
- Channel modifications do not cause excessive erosion or deposition upstream or downstream of the modified channel section

All channel construction and modification (including clearing and snagging shall be in accord with a design which can be expected to result in a stable channel and can be maintained at reasonable cost. Vegetation, riprap, revetments, linings, structures or other measures are to be used where necessary to ensure stability.

The method applicable to site conditions in TR-25 shall be used in determining the stability of proposed channel improvements.

Bankfull flow is the flow in the channel that creates a water surface at or near the normal ground elevation, or the tops of dikes or continuous spoil banks that confine the flow for a significant length of a channel reach.

Channels must be stable under conditions existing immediately after construction (as-built-condition) and under conditions existing during effective design life (aged condition). Channel stability shall be determined for discharge under these conditions as follows:

1. **As-Built Condition** – Bankfull flow, design discharge, or 10-year-frequency flow, whichever is smallest, but not less than 50 percent of design discharge.

The allowable as-built velocity (regardless of type of stability analysis) in the newly constructed channel may be increased by a maximum of 20 percent if all the following provisions are met:

- a) The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion-controlling vegetation.
- b) Species of erosion-controlling vegetation adapted to the area and proven methods of establishment are known.
- c) The channel design includes detailed plans for establishing vegetation on the channel side slopes.
- d) Provisions are made with the owner, operator or contractor to seed the channel sideslopes during construction. Also channel excavation and seeding operations will be limited to that time of year when seedings are within the growing season for the type of vegetation specified.

2. **Aged Condition** – Bankfull flow or design discharge, whichever is larger, except that it is not necessary to check stability for discharge greater than the 100-year frequency.

Stability checks that are flow related are not required if the velocity is 2 ft/s or less.

For newly constructed channels in fine-grained soils and sands, the “n” values shall be determined in accordance with Chapter 6 of TR 25, and shall not exceed 0.025. The “n” value for channels to be modified by clearing and snagging only shall be determined by reaches according to the expected channel condition upon completion of the work.

Appurtenant Structures

The channel design shall include all structures required for the proper functioning of the channel and its laterals as well as travelways for operation and maintenance. Inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the channel design. The design also is to

provide for necessary flood gates, water level control devices, bays used in connection with pumping plants and any other appurtenances essential to the functioning of channels and contributing to the attainment of the purposes for which they are built. Critical sections such as junctions of channels shall have protective structures or treatment to ensure stability.

The effect of channel work on existing culverts, bridges, buried cables, pipelines, irrigation flumes and inlet structures for surface and subsurface drainage on the channel and laterals thereto shall be evaluated to determine the need for modification or replacement.

Culverts and bridges which are modified or added as part of channel projects shall meet reasonable standards for the type of structure, and shall have a minimum capacity equal to the design discharge or state agency design requirements, whichever is greater. Low-water ford type crossings will be in accordance with the requirements set in Standard 378, Stream Crossing.

Stable outlets for all existing concentrated surface and subsurface flow entering the channel will be provided.

Disposition of Spoil

Spoil material resulting from clearing, grubbing and channel excavation is to be disposed of in a manner which will:

- Not confine or direct flows so as to cause instability when the discharge is greater than bankfull flow.
- Provide for the free flow of water between the channel and flood plain unless the valley routing and water surface profile are based on continuous dikes being installed.
- Not hinder the development of travelways for maintenance.
- Leave the right-of-way in the best condition feasible, consistent with the project purposes and adjacent land uses.
- Direct water accumulating on or behind spoil areas to protected outlets.
- Maintain or improve the visual quality of the site to the extent feasible.

Erosion Control During Construction

Provisions will be made to include temporary measures for control of erosion during construction. Mechanical measures in addition to vegetative measures will be specified as needed.

Vegetation of Channel

Vegetation will be established on all channel slopes, berms, spoil and other disturbed areas except where the slopes are permanently covered with water or where bank material, and land use are such that vegetation is impractical. Vegetation will be established according to NRCS Conservation Practice Standard 342, Critical Area Planting.

1. Channel side slopes are to be seeded as soon as possible after excavation. Use daily seeding.
2. Correct acidity, alkalinity and fertility problems as necessary to ensure a viable vegetative growth.
3. Except for channel sideslopes, annual species may be used for daily seeding if necessary to provide a quick ground cover. Permanent vegetation is to include plants adapted to the area and should be seeded as soon as possible after excavation.

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4. Anchored mulch or soil stabilizers are to be used if needed to achieve an adequate vegetative cover.

CONSIDERATIONS

When planning this practice, consider:

- Conservation planning measures to protect the contributing watershed, and land immediate adjacent to the channel, from excessive sediment and nutrient/pesticide transport into the channel are necessary for the channel to function as planned without excessive maintenance.
- Conservation measures to preserve and/ or to establish riparian buffers immediately adjacent to the channel will provide additional bank stability and wildlife habitat
- Possible damages above or below the point of discharge that might involve legal actions or other off-site impacts.
- Potential impacts on wetlands or other water-related wildlife habitat.
- Impact on cultural resources.
- Fencing and other livestock exclusion measures; do not place fence across navigable streams
- Potential water quality impacts for soluble pollutants and attached sediment pollutants.
- Potential changes in soil moisture that will affect the growth of desirable vegetation.
- Effect on ground water recharge and quality of ground water.

Additional Considerations for Two-Stage and Self Forming (over-wide) Channels

Two-stage ditches, and self-forming channels, may have environmental benefit because floodplain benches support plant life that can reduce downstream nutrient and sediment transport. See Two-Stage Channel (Figure 1) and Self-Forming Channel (Figure 2).

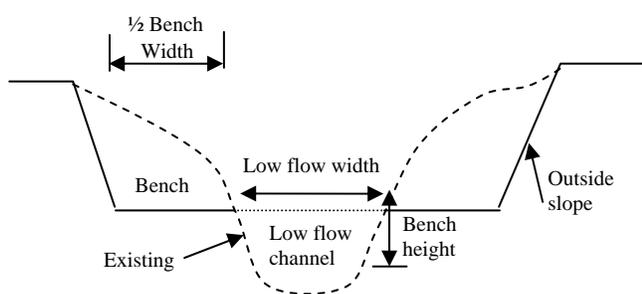


Figure 1. Typical Two-stage Channel

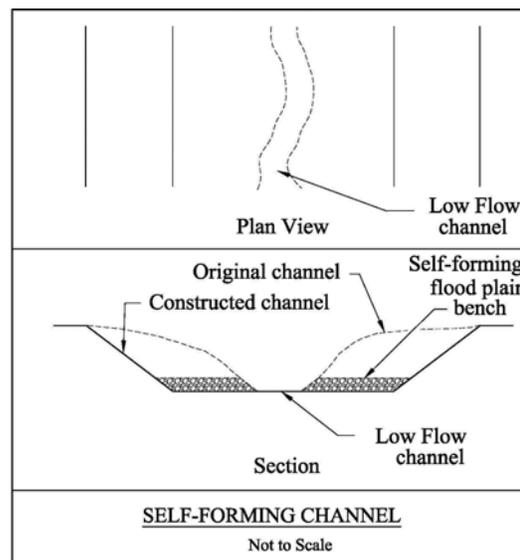


Figure 2. Typical Self-forming Channel

A stream system assessment must be performed to determine that the stream is not degrading before it can be considered. Stream assessment and classification tools are available from:

- NRCS, National Engineering Handbook Part 654, Stream Restoration, Chapter 3
- Spreadsheet Tools for River Evaluation, Assessment and Monitoring (STREAM modules) developed by ODNR and Ohio State University

Bench height shall be determined by the appropriate regional curve method or other accepted runoff method to size the low flow channel to carry between 0.5 and 1-year, 24 hour storms or by approximating elevation of natural bench formations.

The two-stage bench or self-forming bottom width should typically be between 3 to 5 times the anticipated low flow channel width unless otherwise shown to be required and stable

The design of two stage and self-forming channels shall follow NRCS, National Engineering Handbook Part 654, Stream Restoration, Chapter 10, or the “Enhanced Ditch Design Spreadsheet Tool” and “Design Manual” developed by ODNR and Ohio State University

Consider re-routing tile drainage outlets entering a two-stage ditch to outlet them top of the bench and onto a riprap pad.

Divide the proposed bottom width equally across the existing average centerline. Unequal construction shall only be permitted to avoid important infrastructure or resources.

Channels designed under these conditions will have generally have higher in-bank capacity than before. The channel reaches both upstream and downstream of the planned two-stage

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construction must be analyzed for stability and transition sections designed accordingly. To minimize these impacts, the termination of two stage construction should occur at a control point such as a road culvert.

The low flow channel and vegetation below the bench elevation shall not be disturbed unless determined needed by the NRCS engineer to outlet an upstream component.

The benches should be seeded to cool season grasses; refer to Appendix A for specific recommendations

PLANS AND SPECIFICATIONS

Plans and specifications for construction of Open Channels shall be in keeping with this standard and shall describe the requirements for proper installation of the practice to achieve its intended purpose.

Plans and specifications will be prepared for the practice site. Plans will include at a minimum:

- Location map including roadways
- Watershed boundary
- Plan view of channel layout and inlet structures
- Profile (including existing gradeline, planned gradeline, low bank, and hydraulic gradeline @ design flow)
- Cross section (including maintenance berm & spoil deposition)
- Soil borings (location & profile)
- Location of spoil (including spoil gaps when applicable)
- Seeding rates, dates and establishment procedure in conformance with NRCS Conservation Practice Standard 342, Critical Area Planting

OPERATION AND MAINTENANCE

An operation and maintenance plan must be developed for each channel system. Minimum requirements for operation, maintenance and replacement shall be consistent with the design objectives. This includes consideration of fish and wildlife habitat, quality of the landscape, water quality, mitigation features, methods, equipment, costs, stability, function for design life, frequency, and time of year for accomplishing the work. Detailed provisions for operation and maintenance must be made where complex features such as water level control structures and pumping plants are required. A maintenance program will be established by the landowner/user to maintain capacity and vegetative cover. Items to consider are:

- Do not graze protected area during vegetative establishment and when soil conditions are wet.
- Fertilize to maintain a vigorous vegetative cover. Caution should be used with fertilization to maintain water quality.
- Promptly remove accumulated debris following storm events
- Promptly repair eroded areas.
- Remove silt and sediment accumulations in the channel cross-section as soon as practical to prevent buildup and growth of undesirable vegetation.

- Reestablish vegetative cover immediately where scour erosion has removed established seeding.
- Keep inlets to side drainage structures open.
- Keep subsurface drain outlet pipes open and protected. Maintain animal guards in proper operation.
- Periodically inspect area for signs of undermining or instability and, if any are observed, take immediate action to protect from further damage.

Maintenance Access

Travelways for maintenance will normally be provided as a part of all channel work. This requirement may be met by providing ready access points to sections of channel where this will permit adequate maintenance in conformance with the operation and maintenance plan.

A travelway shall be provided on each side of large channels if necessary for use of maintenance equipment. Travelways must be adequate for movement and operation of equipment required for maintenance of the channel. The travelway may be located adjacent to the channel on a berm or on the spread spoil. The travelway, including access points, must blend into the topography, landscape, and adjacent land uses.

Safety

Open channels can create a safety hazard. Appropriate safety features and devices should be installed to protect people and animals from accidents such as falling or drowning. Fencing shall not be placed across navigable streams.

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REFERENCES

Technical Release 25 (TR-25) – Design of Open Channels, Natural Resources Conservation Service, NRCS, 1977 <http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=18899>

National Engineering Handbook Part 654, Stream Restoration Design Handbook, Natural Resources Conservation Service, NRCS, August 2007
<http://directives.sc.egov.usda.gov/RollupViewer.aspx?hid=17092>

Ohio's Water Body Use Designation rules (OEPA):
http://www.epa.ohio.gov/dsw/rules/3745_1.aspx

Ohio's Water Body Use Designation, index to individually named waterbodies (OEPA):
http://www.epa.ohio.gov/portals/35/rules/water_body_index.pdf

Ohio Department of Natural Resources (ODNR), Division of Soil and Water Resources, Stream Restoration and Management (including STREAM modules spreadsheet tools):
<http://soilandwater.ohiodnr.gov/water-conservation/stream-restoration>

Ohio Department of Natural Resources (ODNR), "Rural Drainage Report", January 2008:
http://soilandwater.ohiodnr.gov/portals/soilwater/pdf/swcd/Drainage_Report.pdf

Ohio Department of Natural Resources (ODNR), "Rainwater and Land Development Manual" <http://soilandwater.ohiodnr.gov/water-conservation/stormwater-management>

Ohio Department of Natural Resources (ODNR), "A Functional Assessment of Stream Restoration in Ohio", <http://www.dnr.state.oh.us/tabid/21817/Default.aspx>

Ohio Stream Guide: <http://epa.ohio.gov/Portals/42/documents/OhioStreamGuide.pdf>

The Ohio State University, Agricultural Drainage Channels (including "Enhanced Ditch Design Spreadsheet Tool" and "Design Manual" for two stage ditches):
<http://agditches.osu.edu/node/60>

ASABE paper 12-13862, Ecological Services of Constructed Two-Stage Agricultural Ditches: <https://elibrary.asabe.org/azdez.asp?JID=1&AID=41414&CID=iwqe2012&T=2>

**NATURAL RESOURCES CONSERVATION SERVICE
CONSTRUCTION SPECIFICATION**

OPEN CHANNEL

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Site Preparation

All trees, snags, logs, brush and rubbish shall be cleared from the channel, berm, area for spoil placement and other areas necessary for construction. Cleared material will be burned, buried or piled at designated locations or otherwise removed from the construction site. All burning shall be performed outside the channel, and shall conform to burning regulations in effect in the area. Care must be taken to protect the trees marked to be saved.

Excavation

Channels shall be excavated to the lines and grades shown on the drawings. The excavated surfaces shall be reasonably smooth. All excavation operation shall be conducted in a manner that will not restrict flow from existing channels.

Material excavated from the channel shall be disposed of in the locations and in the manner shown on the drawings. Spoil will be piled or spread in a manner to maintain the stability of the channel banks and with consideration of the existing and future land use of the adjacent area. Spoil shall not block drainageways into the channel.

Environmental Features

The contractor is responsible to use all appropriate Best Management Practices to minimize the likelihood of site erosion and offsite sediment transport. When final site stabilization cannot be completed within 14 days of the commencement of construction, an Ohio EPA NPDES permit may be required (landowner is responsible for obtaining this if required) Best Management Practices include, but are not limited to:

- Placing spoil in a location to prevent its sloughing or washing into the channel or water course.
- Keeping chemicals, fuel, lubricants, sewage and waste materials out of channel and drainage ways.
- Limiting the use of excavating equipment to areas outside the channel and drainageways, except when no other alternative is possible.
- Install all bank protection, grade control structures, and other related protection devices as the work progresses to permit the proper functioning of the channel.
- Establish vegetation on all disturbed areas, especially the channel banks, as soon as possible after exposure or disturbance, as the work progresses.

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Measures and construction methods that enhance fish and wildlife values shall be incorporated as needed and practical. Special attention shall be given to protecting and maintaining key shade, food, and den trees. Where possible, limit construction to one side only.

In cases where the seed and/or mulch are washed away by high channel flows, provisions will be made for immediate reseeding and/or mulching. Seeding will be performed by one of the following methods:

1. Seed channel banks with tall fescue within 24 hours after the banks are excavated. Fertility and pH must be adequate to support vegetation.
2. State Conservation Engineer and State Resource Conservationist must jointly approve other vegetative methods.

All bench and bank areas shall be seeded according to FOTG Standard (342) Critical Area Planting and mulched or blanketed. All disturbed areas outside of top of bank shall be seeded to the appropriate NRCS standard, planted to crop within 30 days or temporary seeded if to be planted to a crop at a later time. The typical seeding mix for two-stage ditch areas is shown in Table 1. Use Appendix A, <http://efotg.sc.egov.usda.gov/treemenuFS.aspx> to determine alternative mixes.