Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

CODE 410

(no)

DEFINITION

A structure used to control the grade in natural or constructed channels.

PURPOSE

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

- Reduce erosion
- Improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies where channels require a structure to stabilize the grade or to control gully erosion.

CRITERIA

General Criteria Applicable to All Purposes

Plan, design, and construct this practice to comply with all Federal, State, and local regulations.

Set the crest of the inlet at an elevation that will stabilize the channel and prevent upstream head cutting. Guidelines for selection of the type of structure are contained in Title 210, National Engineering Handbook (NEH), Part 650 (Engineering Field Handbook), Chapter 6, “Structures” (210-NEH-650-6).

The landowner is responsible for acquiring land rights from adjoining landowners for any permanent or temporary storage created by the planned structure. The landowner is also responsible for obtaining permits to comply with applicable federal and state laws and regulations. See Iowa Administrative Code, Section 567, Chapter 73.3 (IAC 567 – Chapter 73.3) for Iowa Department of Natural Resources (IDNR) water storage and construction permit thresholds and criteria.

The designer must complete Form IA-ENG-40 for inventory dams. Submit the form to the State Conservation Engineer upon completion of construction. The thresholds that have been established for dam and reservoir sizes to be included in the inventory of NRCS assisted dams may be found in the table titled “National Inventory of Dams Criteria” in Iowa NRCS Conservation Practice Standard Pond (Code 378).

Design earthen embankments and auxiliary spillways to handle the total capacity flowwithout overtopping any embankment. The foundation preparation, compaction, top width, and side slopes must ensure a stable earthen embankment for anticipated flow conditions.

Perform soils investigations of the structure site and borrow areas to determine the suitability of the foundation area and potential earthfill for construction and structure stability. Soils must also be investigated in the permanent pool area to determine water holding potential when relevant to the purpose

of, or impact to, the structure. Site investigations will be made in accordance with Title 210, National Engineering Manual (NEM), Part 531, “Geology.”

The principal spillway must be in alignment with the downstream channel.

Determine stability of grades below structures by velocity calculations or by inspection. If the existing grade below the spillway is unstable, take steps to incorporate stabilizing features in the design of the spillway outlet and the outlet channel to avoid failure due to undercutting of the structure at the outlet. Generally, existing grades will be considered stable when:

- The gully profile downstream has a uniform, non-eroding gradient.
- Signs of scour on the channel bottom or sides are negligible or not apparent.
- The channel banks are vegetated with stable benching.
- Runoff is reduced substantially by detention structures or terraces.

Unobstructed flow to the inlets of principal and auxiliary spillways is essential to the hydraulic operation of these features. Closed conduit structures may require trash racks and regular debris removal. For open structures and auxiliary spillways, the design of the approach channel to the inlet shall be such that no channel restrictions or obstacles will interfere with the design flow. Refer to 210-NEH- 628, Chapter 50, “Earth Spillway Design” for design considerations and processes involved with earth spillway design.

If the area is used by livestock, fence the structures, earthfill, vegetated spillways, and other areas as necessary to protect the structure. Near urban areas, fencing may be necessary to control access to prevent serious injury or death. It may also be necessary to exclude traffic to avoid damage to the vegetative cover.

Clear and grub all trees and shrubs at least 25 feet from the toes of the dam and edges of the auxiliary spillway. Grubbing is not required below the normal waterline except on that portion of the area used as borrow or for placement of fill material.

Provide a minimum sediment storage capacity equal to the expected life of the structure, or provide for periodic cleanout.

Provide measures necessary to prevent serious injury or loss of life such as protective guardrails, warning signs, fences, or lifesaving equipment.

Seed or sod the exposed surfaces of earthen embankments, earth spillways, borrow areas, and other areas disturbed during construction in accordance with Iowa NRCS Conservation Practice Standard (CPS) Critical Area Planting (Code 342). If climatic conditions preclude the use of seed or sod, use Iowa NRCS CPS Mulching (Code 484) to install inorganic cover material such as gravel.

Embankment dams
Low-hazard dams that have a product of storage times the effective height of the dam of 3,000 ac-ft^2 or more, those more than 35 feet in effective height, and all significant and high-hazard dams must meet or exceed the criteria specified in NRCS Engineering Technical Release (Title 210), 60, “Earth Dams and Reservoirs.”

Low-hazard dams that have a product of storage times the effective height of the dam of less than 3,000 ac-ft^2 and an effective height of 35 feet or less must meet or exceed the requirements specified in Iowa NRCS CPS Pond (Code 378).

The effective height of the dam is the difference in elevation, in feet, between the auxiliary spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no auxiliary spillway, the top of the dam is the upper limit.

Storage is the capacity of the reservoir in acre-feet below the elevation of the crest of the lowest auxiliary spillway or the elevation of the top of the dam if there is no open channel auxiliary spillway.

Closed Conduit Structures
Design detention and full flow closed conduit structures in accordance with criteria in Pond (378).

The following additional criteria applies to closed conduit full flow structures:

- For dry structures with no storage below the principal spillway crest, granular bedding material may be placed under the entire length of the conduit in lieu of a compacted soil bedding.
- The 35-year sediment storage requirement in Pond (378), is not required as long asif sediment accumulation is accounted for in the hydraulic design and periodic sediment removal is included in the O&M Plan.

Small pond-sized dams
For dams with an effective height of less than 15 feet and 10-year frequency, 24-hour storm runoff volume less than 10 acre-feet, the designer may use the requirements of Iowa NRCS CPS Water and Sediment Control Basin (Code 638). Design the grade control structure to control the peak flow from the 10-year frequency, 24-hour duration storm without overtopping. If the combination of storage and mechanical spillway discharge will handle the design storm, an auxiliary spillway is not required.

Full-flow open structures
Design drop, chute, and box inlet drop spillways to the guidance in the 210-NEH-650 (EFH) and other applicable NRCS publications and reports. Provide a minimum capacity to pass the peak flow expected from a design storm of the frequency and duration shown in table 1, less any reduction from detention storage. Structures must not create unstable conditions upstream or downstream. Install provisions for reentry of bypassed storm flows.

A freeboard providing headwalls or sidewalls a minimum of 6 inches higher than the water surface attained by the principal spillway design discharge must be used. For chute structures lined with erosion resistant materials such as loose rock, gabions, grouted riprap, or concrete blocks, the top of the erosion resistant material must be a minimum of 6 inches higher than the water surface attained by the principal spillway design discharge.

The maximum water surface attained by the total capacity design discharge must be at or below the elevation of the structure sidewalls or headwalls, or the erosion resistant material lining of chutes.

When freeboard is included in the formula for a specific type of structure, such as may be found in the 210- NEH, Section 11, “Drop Spillways,” (210-NEH-11), the formula must govern minimum freeboard requirements. Provide a minimum of 1.0 foot between the top of the sidewalls and the top of the settled embankment. When the structure is a lined chute, provide a minimum of 1.0 foot between the top of the erosion resistant material and the settled embankment.

Additional specific criteria apply to each type of full flow drop spillway as follows:

Reinforced Concrete Chute Spillway:

Use 210-NEH, Section 14, “Chute Spillways,” for hydraulic design of reinforced concrete chute spillways and Saint Anthony Falls (SAF) outlets. The use of propped outlets is limited to spillways having a maximum discharge of 600 cfs or 50 cfs per foot of width, whichever governs.

Straight Drop Spillway:

Use 210-NEH-11 for hydraulic design of straight drop spillways. Design with freeboard as given by Equation 3.5 in Chapter 3. Maximum over fall “F” will be 10 feet with a maximum weir depth “h” of 6 feet. Earth fill immediately adjacent to the weir opening will be scoured out by flows that approach design

discharge unless adequate protection is provided. Since vegetation may not provide this protection, riprap is preferred. See Chapter 2, “Layout,” of 210-NEH-11 for proper design and placement of riprap.

Standard drawings are available for sheet pile structures in till soils where F ≤ 6 feet and depth to till is less than 4 feet below downstream channel bottom elevation. For sheet pile structures where F > 6 feet, or the foundation soils are not till, a structural analysis of the sheet pile wall is required. The structural analysis shall be completed using 210-NEH, Part 654, Technical Supplement 14R, “Design and Use of Sheet Pile Walls in Stream Restoration and Stabilization Projects,” or US Army Corps of Engineers Publication EM 1110-2-2504, Design of Sheet Pile Walls. Other methods of analysis that maintain the same degree of safety and economy as structures designed by the methods outlined in EM 1110-2-2504 will be accepted.

Toe Wall Drop Spillway:

Use 210-NEH-650-6 for toe wall drop spillways with a vertical drop of up to and including 6 feet.

A toe wall drop spillway is used to provide a stable outlet for a grassed waterway and serves as a dividing point between a wet channel and a dry waterway. It may be used to provide an outlet for subsurface drains.

Toe wall drop spillways can be used if the vertical drop is 6 feet or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is equal to or greater than one-third of the height of the over fall. These limits may be exceeded if a site specific design is prepared.The weir and headwalls of toe wall drop spillways may be fabricated from corrugated steel, aluminum sheets, fused glass, or fused plastic coated steel sheets. The toe wall and floor are composed of concrete. A vertical drop (F) of 6.0 feet and a notch depth (H) of 3.0 feet are the maximum for this type of structure. Dimensions, assembly, and installation must be in accordance with manufacturer’s instructions.

Box-Inlet Drop Spillway:

Design guidance is found in Agriculture Handbook No. 301, “Hydraulic Design of the Box-Inlet Drop Spillway”. The maximum height “D” for the box is 10 feet.

Table 1. Design Criteria for Establishing Minimum Capacity of Full-flow Open Structures

Maximum drainage area (Acres)	Vertical Drop (Feet)	Frequency of minimum design,24-hour duration storm	
		Principal Spillway Capacity(Year)	Total Capacity(Year)
450	0-5	5	10
900	0-10	10	25
All Others		25	100

Box Inlets on Existing Road Culverts

The capacity of the drop box must meet the requirements of the responsible road authority or as specified in table 1 or 2, whichever is greater.

The dimensions of the box must be sufficient to prevent submergence of the existing culvert headwall at minimum design capacity unless the headwall is raised and designed to act as an anti-vortex device.

Scour protection must be provided in accordance with NEH Section 11, Drop Spillways. If the culvert wings are flared out from the headwall so as to cause restriction of weir flow into the box, remove them to the elevation of the inlet or increase the box dimensions to compensate for the restriction. The minimum unrestricted horizontal area of the top of the box inlet must be 1.5 times the cross-sectional area of the

culvert to which it is attached. The maximum design water surface elevation must not be higher than 1 foot below the low point of the roadway.

Table 2. Design Capacity for Box Inlets of Existing Culverts

Culvert Capacity	Minimum Design Weir Capacity
$Q_c < Q_{50}$	$1.25Q_c$
$Q_{50} < Q_c < 1.50Q_{50}$	$1.25Q_{50}$ or Q_c (whichever is greater)
$> 1.50Q_{50}$	$1.50Q_{50}$

Island-type structures
Island-type structures are a special case of the full-flow structure. For island-type structures, out of bank flooding can be tolerated.

Design the minimum capacity equal to the capacity of the downstream channel. Design the minimum auxiliary spillway capacity equal to that required to pass the peak flow expected from a 24-hour duration storm of the frequency shown in table 1 for total capacity without overtopping the headwall extensions of the mechanical spillway. Make provision for safe reentry of bypassed flow as necessary.

Side-inlet, open weir, or pipe-drop drainage structures
Side-inlet drainage structure applications are intended where the hydrology is dominated by relatively flat landforms such as flood plains or the prairie pothole region, and land management includes surface drainage. Drainage areas may not be well defined. Surface water may accumulate from uplands or from the backwater of a river system. These structures are used to lower surface water from field elevations or lateral channels into deeper open channels where gully erosion is the main resource concern.

Table 3 provides the design criteria for minimum capacity of open-weir or pipe structures used to lower surface water from field elevations or lateral channels into deeper open channels. Design the minimum principal spillway capacity equal to the design drainage curve runoff for all conditions. If site condition values exceed those shown in table 3, use the 50-year frequency, 24-hour duration storm for minimum design of total capacity.

Table 3. Design Criteria for Establishing Minimum Capacity of Side-inlet, Open-weir, or Pipe-Drop Drainage Structure[1]

Maximum drainage area (Acres)	Vertical Drop (Feet)	Receiving Channel Depth (Feet)	Frequency of minimum design, 24-hour duration storm	
			Principal Spillway Capacity	Total Capacity (Year)
450	0-5	0-10	*	5
450	5-10	10-20	*	10
900	0-10	0-20	*	25
All Others			*	50

[1]Side-inlet structures includes either open weir or pipe-drop structures

*Design Drainage Curve

CONSIDERATIONS

Provide sufficient discharge to minimize crop-damaging water detention.

In highly visible public areas and those associated with recreation, give careful consideration to landscape resources. Landforms, structural materials, water elements, and plant materials should complement their

surroundings visually and functionally. Consider using a diverse mix of native vegetation that is adapted to the site to provide enhanced ecological, habitat, and pollinator benefits. Shape excavated material and cut slopes to blend with the natural topography. Shape shorelines and create islands to add visual interest and wildlife habitat. Form and finish exposed concrete surfaces to add texture, reduce reflection, and to alter color contrast. Select sites to reduce adverse impacts or create desirable focal points.

Consider the effect of the grade control structure on aquatic habitat. For channels supporting fish, consider the effect of the structure on fish passage.

In natural channels, consider the effect of the grade control structure on fluvial geomorphic conditions.

Provide fences to protect structures, earth embankments, and vegetated spillways from livestock. Near urban areas, provide fencing as appropriate to control access and exclude traffic.

PLANS AND SPECIFICATIONS

Prepare plans and specifications for installing grade stabilization structures that describe the requirements for applying the practice according to this standard. As a minimum, include—

- A plan view of the layout of the grade stabilization structure and appurtenant features.
- Typical profiles and cross sections of the grade stabilization structure and appurtenant features as needed.
- Structural drawings, as needed.
- Seeding requirements, as needed.
- Safety features.
- Site-specific construction requirements.

The following list of Construction Specifications is intended as a guide to selecting the appropriate specifications for each specific project. The list includes most but may not contain all of the specifications that are needed for a specific project:

- IA-1 Site Preparation
- IA-3 Structure Removal
- IA-5 Pollution Control
- IA-6 Seeding and Mulching for Protective Cover
- IA-9 Subsurface Drain Investigation, Removal, and Repair
- IA-11 Removal of Water
- IA-13 Sheet Piling
- IA-21 Excavation
- IA-23 Earthfill
- IA-24 Drainfill
- IA-26 Salvaging and Spreading Topsoil
- IA-31 Concrete
- IA-45 Plastic (PVC, PE) Pipe
- IA-51 Corrugated Metal Pipe Conduits
- IA-52 Steel Pipe Conduits
- IA-61 Loose Rock Riprap
- IA-62 Concrete Grout for Riprap
- IA-64 Wire Mesh Gabions
- IA-81 Metal Fabrication and Installation

- IA-83 Timber Fabrication and Installation
- IA-92 Fences
- IA-95 Geotextile
- IA-99 Cathodic Protection for Buried Metal Structures

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator. As a minimum, include—

- Periodic inspections of all structures, earthen embankments, spillways, and other significant appurtenances.
- Prompt repair or replacement of damaged components.
- Prompt removal of sediment when it reaches predetermined storage elevations.
- Periodic removal of trees, brush, and invasive species.
- Periodic inspection of safety components and immediate repair if necessary.

Require maintenance of vegetative protection and immediate seeding of bare areas as needed.

REFERENCES

Iowa Administrative Code. Approval, Construction, Use, Maintenance, Removal, Inspections, and Safety of Dams, 567 – Chapter 73. (2022). https://www.legis.iowa.gov/law/administrativeRules/agencies

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