NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE, (NUMBER)

Code 410

DEFINITION

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

PURPOSE

To stabilize grade, reduce gully erosion, and/or improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

In areas where the concentration and flow velocity of water require structures to stabilize the grade in channels or to control gully erosion. Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable.

CRITERIA

General Criteria. Planned work shall comply with all federal, state, and local laws and regulations. The landowner or operator must be advised that it is the responsibility of the landowner or operator to secure easements from adjoining landowners for any permanent or temporary storage and permits to comply with applicable federal and state laws and regulations, as necessary.

A permit must be obtained from the Iowa Department of Natural Resources (IDNR) for construction, operation, and maintenance of dams and impounding structures in the following instances:

1. Any dam designed to provide a sum of permanent and temporary storage exceeding 50 acre-feet at the top of dam elevation or 25 acre-feet if the dam does not have an auxiliary spillway and which has a height of 5 feet or more. Height of dam means the vertical distance from the top of the dam to the natural bed of the stream or watercourse measured at the downstream toe of the dam or to the lowest elevation of the outside limit of the dam if it is not across a watercourse.
2. Any dam designed to provide permanent storage in excess of 18 acre-feet.
3. Any dam across a stream draining more than 10 square miles.
4. Any dam located within 1 mile of an incorporated municipality, if the dam has a height of 10 feet or more, stores 10 acre-feet or more at the top of dam elevation, and is situated such that the discharge from the dam will flow through the incorporated area.

Inventory. The following ponds are to be included in the national inventory of NRCS assisted dams and are considered as NRCS inventory dams:

1. Dams with more than 6 feet in overall embankment height and with a storage capacity of 50 acre-feet or more.
2. Dams with an overall embankment height of 25 feet or more and a storage capacity of more than 15 acre-feet.

The inventory is in accordance with §520.21(f), National Engineering Manual (NEM). The dams shall be recorded on Form IA-ENG-40.

Guidelines for selection of the type of structure are contained in Chapter 6 of Engineering Field Handbook (EFH) (Part 650 of the National Engineering Handbook

Series). The structure must be designed for stability after installation. The crest of the inlet must be set at an elevation that will stabilize the channel and prevent upstream head cutting. Stability of grades below structures shall be determined by velocity calculations or by inspection.

If the existing grade below the spillway is unstable, steps shall be taken to incorporate stabilizing features in the design of the spillway outlet and the discharge channel to avoid failure due to undercutting of the outlet. Generally, existing grades will be considered stable when:

1. The gully profile downstream has a uniform gradient.
2. Signs of scour on the channel bottom or sides are negligible or not apparent.
3. Grass and trees growing on the channel banks and bottom indicate that erosion has not been serious for a number of years.
4. Runoff is reduced substantially by detention structures and terraces.

The approach channel shall be designed so that no channel restrictions or obstacles will interfere with the design flow entering the principal or auxiliary spillway inlet. The principal spillway shall be in alignment with the downstream channel. The downstream channel should be straight and cleared of all obstructions which cause turbulence, backeddying, and meandering for a distance of approximately 50 feet downstream from the spillway outlet.

Earth embankments and auxiliary spillways of structures for which criteria are not provided under the standard for ponds, NRCS Conservation Practice Standard Code 378, or floodwater retarding dam, NRCS Conservation Practice Standard Code 402, must be stable for all anticipated conditions. If earth spillways are used they must be designed to handle the total capacity flow indicated in Tables 2 or 4 without overtopping the embankment. The foundation preparation, compaction, top width, and side slopes must ensure a stable embankment for anticipated flow conditions. Discharge from the structure shall be controlled to minimize crop damage resulting from flow detention.

Sediment storage capacity must equal the expected life of the structure unless a provision is made for periodic cleanout. The drainage area above the structure must be protected against erosion to the extent that expected sedimentation will not shorten its planned effective life.

Earth embankment structures are potentially hazardous and precautions must be taken to prevent serious injury or loss of life. Protective guardrails, warning signs, fences, or lifesaving equipment shall be added as needed.

If the structure area is used for livestock, the structures, earthfill, vegetated spillways, and other areas should be fenced as necessary to protect the structure. Near urban areas, fencing may be necessary to control access and exclude traffic that may damage the structure or to prevent serious injury or death.

The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded, sodded, or otherwise protected as necessary to prevent erosion. If climatic conditions preclude the use of vegetation, nonvegetative coverings such as gravel or other mulches may be used.

All trees and shrubs shall be cleared and grubbed within a minimum distance of thirty (30) feet from an earth fill or any spillway. New plantings shall not be made within these limitations. Clearing and grubbing will not be required below the normal waterline except on that portion of the area used as borrow or for placement of fill material. Clearing will be done where necessary to prevent accumulation of trash at the spillway inlet.

Sufficient soil investigations shall be made of the structure site and borrow areas to determine the suitability of the site and materials for construction, structure stability, and water holding ability. Site investigations will be made in accordance with Part 531, National Engineering Manual.

Embankment Dams. Detention storage is the volume between the normal pool elevation and the crest of the auxiliary spillway. 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.

Class (a) dams that have a product of storage times the effective height of the dam of 3,000 acre-feet^2 or more, those more than 35 feet in effective height, and all class (b) and class (c) dams shall meet or exceed the requirements specified in Technical Release (TR) 60. See §520.21, National Engineering Manual for definition of dam classes.

Class (a) dams that have a product of storage times the effective height of the dam of less than 3,000 acre-feet^2 and an effective height of 35 feet or less shall meet or exceed the requirements specified for ponds, NRCS Conservation Practice Standard Code 378, except for the principal spillway criteria shown in Table 1.

Pond Size Dams. If principal spillways are required the minimum capacity of the principal and auxiliary spillways shall be that required to pass the peak flow expected from a 24-hour duration design storm of the frequency shown in Table 1, less any reduction attributed to detention storage. The principal spillway flow, regardless of size and detention storage, may be considered in design of the auxiliary spillway. Included are full-flow, closed conduit structures with no reduction of peak flow because of detention storage.

If criteria values exceed those shown in Table 1 or the storage capacity is more than 50 acre-feet, the 25-year frequency, 24-hour duration storm must be used as the minimum principal spillway design storm.

Grade stabilization structures with a settled fill height of less than 15 feet and 10-year frequency, 24-hour storm runoff less than 10 acre-feet, shall be designed to control the 10-year frequency storm without overtopping. The embankment can be designed to meet the requirements for water and sediment control basins, NRCS Conservation Practice Standard Code 638, rather than the requirements for ponds, NRCS Conservation Practice Standard Code 378. An auxiliary spillway is not required if the combination of storage and principal spillway discharge will safely handle the design storm.

Grade stabilization structures in deep gullies may be designed as water and sediment control basins to control the advancement of deep gullies if all of the following conditions are met:

1. Uncontrolled drainage area is 20 acres or less and total drainage area is 50 acres or less.
2. Maximum settled fill height is 20 feet measured from the natural ground at the centerline of the embankment.
3. Overall height from top of constructed fill to the point where the toe of fill intersects the exiting gully bottom is not more than 50 feet.
4. The need for embankment and abutment drainage is carefully evaluated.
5. A resource management system is in place for the entire drainage area.
6. One foot of freeboard is added to the required ridge and an auxiliary spillway is provided on one or both ends of the basin.

An auxiliary spillway must be provided for all dams unless the principal spillway is large enough to pass the routed design hydrograph peak discharge and the trash that comes to it without overtopping the dam.

A closed conduit principal spillway with a cross-sectional area of 3 square feet or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash is the minimum design that may be used without an auxiliary spillway.

If an auxiliary spillway cannot be provided, design the principal spillway and any associated temporary storage for Q_{50} – 24-hour runoff and provide at least 2.0 feet of freeboard. This requires approval of the State Conservation Engineer.

Table 1. Minimum Spillway Capacity For Ponds And Other Storage Type Structures.

				Minimum Design Frequency (24-Hour Duration Storm)[2]	
Drainage Area (Acres)	Minimum Pipe Diameter (Inches)	Effective Fill Height[1] (Feet)	Storage[1] (Acre-feet)	Principal Spillway Year	Auxiliary Spillway Year
0 – 20	4	0 – 20	Less than 50	- -	10
0 – 20	4	20 – 35	Less than 50	2	25
20 – 80	6	0 – 20	Less than 50	5	25
20 – 80	6	20 – 35	Less than 50	5	50
80 – 250	10	0 – 20	Less than 50	10	25
80 – 250	10	20 – 35	Less than 50	10	50
All Others	15	0 – 35	- - -	25	50

[1] As defined under “Embankment Dams”.

[2] If structure requires an IDNR permit more restrictive criteria may apply. See IDNR Technical Bulletin 16.

Table 2. Criteria For Determining Minimum Capacity Of Full Flow Open Structures.

Maximum Drainage Area		Minimum Design Frequency (24-Hour Duration Storm)	
(Acres)	Vertical Drop (Feet)	Principal Spillway Capacity Year	Total Capacity Year
450	5 or less	5	10
900	10 or less	10	25
All Others		25	100

Full-Flow Open Structures. Full-flow open structures are those which must pass the design storm through the principal and auxiliary spillways without creating storage above the design flow’s normal depth. Examples are straight drop spillways, chute spillways, and box inlet spillways. These structures shall be designed according to the principles set forth in the Engineering Field Handbook (EFH) for Conservation Practices (Part 650 of the National Engineering Handbook (NEH) Series), and other applicable NRCS publications and reports. The minimum capacity shall be that required to pass the routed design hydrograph expected from the 24-hour duration design storm of the frequency shown in Table 2. If site conditions exceed those shown in Table 2, the minimum design 24-hour storm frequency is 25 years for the principal spillway and 100 years for the total capacity. Structures must not create unstable conditions upstream or downstream. Provisions must be made to ensure reentry of bypassed storm flows. Peak discharge rates shall be determined using procedures in Chapter 2, Engineering Field Handbook (EFH), TR-55, or by developing an inflow hydrograph.

A freeboard providing sidewalls 6 inches higher than the water surface attained by the principal spillway design discharge shall be used. When freeboard is considered in the formula as given in the National Engineering Handbook (NEH), the formula shall govern freeboard requirements. An additional 1 foot shall be provided between the top of the sidewalls and the top of the settled embankment.

Use Section 14, National Engineering Handbook (NEH), for hydraulic design of the chute spillway and SAF outlet. 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.

Use Section 11, National Engineering Handbook (NEH), for hydraulic design of straight drop spillways. Maximum overfall “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 NEH-11 for proper design and placement of riprap.

The 4100 series standard drop spillways may be used only if the h/F ratio is no greater than 0.5. (See Index Drawing 3-L-4100, Chapter 6, National Engineering Handbook (NEH) Part 650, Engineering Field Handbook (EFH)).

Toe wall drop structures can be used if the vertical drop is 4 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 overfall. Toe wall drop structures may be fabricated from corrugated steel, aluminum sheets, fused glass, or fused plastic coated steel sheets. Cutoff walls and floors are of concrete. F = 4.0 feet and h = 2.5 feet are the maximum for this type of structure. These limits may be exceeded if a site specific design is prepared. Dimensions, assembly, and installation must be in accordance with manufacturer’s instructions.

Use National Engineering Handbook (NEH) 11, National Engineering Handbook (NEH) 14, and Agriculture Handbook No. 301 for hydraulic design of box inlet drop spillways. Maximum height “D” for the box is 10 feet.

For risers on existing road culverts the ratio of the capacity of drop boxes to road culvert shall be as required by the responsible road authority but not less than that required to pass the routed design hydrograph for the maximum culvert capacity. Box inlets on culverts shall be designed with weir capacity in excess of the design storm or the culvert capacity Q_C, as shown in Table 3. Q_C shall be determined using procedures in Chapter 2, Engineering Field Handbook (EFH).

The dimensions of the box shall 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 antivortex device. If the culvert wings are flared out from the headwall so as to cause restriction of weir flow into the box, they shall be removed to the elevation of the inlet or the box dimensions increased to compensate for the restriction. The minimum unrestricted horizontal area of the top of the box inlet shall be 1.5 times the cross-sectional area of the culvert to which it is attached. The maximum design water surface elevation shall not be higher than 1 foot below the low point of the roadway.

Table 3. Design Capacity For Culvert Box Inlets.

Culvert Capacity	Minimum Design Capacity
$< Q_{50}$	$1.25Q_C$
$> Q_{50}$ but $< 1.50Q_{50}$	$1.25Q_{50}$ 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. The minimum capacity of the principal spillway of an island-type structure shall equal the capacity of the downstream channel. In no case shall it be less than the 2-year - 24-hour storm or the design drainage curve runoff.

The minimum auxiliary spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2 for total capacity without overtopping the headwall extensions of the principal spillway. Provision must be made for safe re-entry of bypassed flow as necessary.

Table 4. Design Criteria For Establishing Minimum Capacity Of Side-Inlet, Open Weir, Or Pipe-Drop Drainage Structure.

Maximum Drainage Area	Frequency Of Minimum Design (24-Hour Duration Storm)			
(Acres)	Vertical Drop (Feet)	Receiving Channel Depth (Feet)	Principal Spillway Capacity	Total Capacity Year
450	0 - 5	0 - 10	*	*
450	5 - 10	10 - 20	*	10
900	0 - 10	0 - 20	*	25
All Others			*	50

* Design Drainage Curve

Side-Inlet Drainage Structures. 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 are shown in Table 4. The minimum principal spillway capacity shall equal the design drainage curve runoff for all conditions. If site condition values exceed those shown in Table 4, the 50-year frequency storm shall be used for minimum design of total capacity.

PLANNING CONSIDERATIONS

In highly visible, public areas and those associated with recreation, careful considerations should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Shorelines can be shaped and islands created to add visual interest and valuable wildlife habitat. Exposed concrete surfaces may be formed to add texture or finished to reduce reflection and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

Consider conservation and stabilization of archaeological and historic sites when designing this practice. This practice has the potential of positively and/or negatively affecting National Register listed or eligible (significant) cultural resources. Follow NRCS state policy for considering cultural resources during planning, construction, and maintenance.

Fencing should be utilized in areas when necessary to control access by animals or people.

Consideration should be given to the effect a structure will have on the aquatic habitat of a channel. If the channel supports fish, the effect of a structure on the passage of fish should be considered.

Structures installed in natural channels shall be compatible with the fluvial geomorphic conditions at the site to ensure the stability of the structure.

PLANS AND SPECIFICATIONS

Plans and specifications for installing grade stabilization structures shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

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-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

An operation and maintenance plan shall be prepared for use by the owner or others responsible for operating and maintaining the system. The plan shall provide specific instructions for operating and maintaining the system to ensure that it functions properly. It shall also provide for periodic inspections and prompt repair or replacement of damaged components.