Grade Stabilization Structure (No.) 410

DEFINITION

A structure used to control the grade and head cutting in natural or artificial channels.

PURPOSES

To stabilize the grade and control erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to enhance environmental quality and reduce pollution hazards.

This standard applies to all types of grade stabilization structures, including a combination of earth embankments and mechanical spillways and full-flow or detention-type structures. This standard also applies to channel side-inlet structures.

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.

Side-inlet structures are pipe or full flow open structures used to lower the water from a field elevation, a surface drain, or a waterway to a deeper outlet channel.

Full flow open structures include drop, chute, box inlet spillways, toe wall spillways and drop boxes to road culverts constructed in natural or constructed drainage ways.

Island-type structures are used where outlet channel capacity is less than design peak flows.

Embankment dams used as grade stabilization structures are those designed to provide detention and release of excess flows using a combination of principal and emergency spillways.

DESIGN CRITERIA

General Criteria

Grade stabilization structures shall be planned, designed, and installed to meet all federal, state, local and tribal laws and regulations.

Structures shall be designed for stability after installation. The crest of the inlet shall be set at an elevation that stabilizes upstream head cutting.

Earth embankment and emergency spillways of structures for which criteria are not provided under the standard for Ponds (378) or in TR-60 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 4 or 5 without overtopping the fill.

The foundation preparation, compaction, top width, and side slopes must ensure a stable dam for anticipated conditions.

Necessary sediment storage capacity must equal the expected life of the structure, unless a provision is made for periodic cleanout.

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

Grade stabilization structures shall be constructed of materials such as earth, concrete, plastic, geosynthetics, rock, masonry, steel, aluminum and treated wood. They shall be designed in accordance with the principles outlined in the Engineering Field Handbook, Chapter 6.

The earth embankment pond 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.

Embankments

The minimum sum of the upstream and downstream side slopes of the settled embankment shall not be less than five horizontal to one vertical with neither slope steeper than 2:1. Slopes shall be designed to be stable in all cases.

The fill height shall be increased by a minimum of 5 % for mineral foundation soil and 33% for organic foundation soil to allow for settlement, except where detailed soil testing and laboratory analysis shows a lesser amount is adequate.

The minimum top width for embankments is shown in table 1.

TABLE 1

Minimum Top Width Requirements for Embankments

Fill Height	Effective Top Width
m (ft.).	*m (ft.)*
0-1.5 (0-5)	0.9 (3)
1.5-3 (5-10)	1.8 (6)
3-4.5 (10-15)	2.4 (8)

Pipe Conduits

The diameter of the pipe shall not be less than 20 cm (8 inches).

The following pipe materials are acceptable: cast-iron, steel, corrugated steel or aluminum, asbestos-cement, concrete, plastic, vitrified clay with rubber gaskets and cast-in-place reinforced concrete. Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet resistant materials or protected by coating or shielding.

Inlets and outlets shall be structurally sound and made from materials compatible with the pipe.

Antiseep collars or sand and gravel filters shall be used to prevent piping unless all of the following conditions exist:

1. The conduit is corrugated pipe and has a diameter of 46 cm (18 inches) or less.
2. The maximum hydraulic head on the pipe is 1.8 m (6 feet) or less.
3. The soils used for backfilling have good to excellent piping resistance. (Ref. EFH, Chapter 4)
4. The designer has evidence that pipes in similar soil and site conditions have functioned satisfactorily without anti-seep collars or sand and gravel filters.

Watertight coupling bands are required for all pipes designed for pressure flow. Closed conduit spillways designed for pressure flow are to have an antivortex device. Pressure flow occurs in pipe control or outlet control conditions.

An appropriate trash guard shall be installed at the inlet or riser as necessary to prevent clogging of the conduit.

Pipe strength shall not be less than that of the grades indicated in Table 2 for plastic pipe and Table 3 for corrugated aluminum and steel pipe.

TABLE 2

Acceptable PVC and PE Pipe for use in Grade Stabilization Structures

Nominal Pipe Size	Material and Schedule or Wall Type	Maximum Depth of Fill Over Pipe
cm (in.)		*m (ft.)*
20 (8) - 30 (12)	PVC 40	3 (10)
20 (8) - 30 (12)	PVC 80	4.5 (15)
20 (8) - 61 (24)	PE single	6 (20)
20 (8) - 153 (60)	PE double	6 (20)

Polyvinyl chloride (PVC) pipe, PVC 1120 or PVC 1220, conforming to ASTM D 1785

Polyethylene (PE) pipe will conform to one or more of the following standards. ASTM F 405, ASTM F 667, AASHTO M 252, and AASHTO M 294.

TABLE 3

Gage or Thickness Required: Corrugated Metal Pipe for Fill Heights above Pipe not to Exceed 4.5 m (15 feet)

Pipe Diameter	Steel 1/	Aluminum 2/
cm (in.)	*minimum gage*	*minimum thickness mm (in.)*
30(12) to 65(24)	16	1.5 (0.06)
75 (30)	14	1.9 (0.075)
95 (36)	14	1.9 (0.075)
110 (42)	14	XXX
125 (48)	14	XXX

1/ For steel CMP:

a. Maximum pipe diam. is 125 cm (48 in.).

b. 2 2/3 X 1/2 corrugations except 3X1 corrugations for over 95 cm (36 in.) in diameter.

2/ For alum. CMP with 2 2/3X1/2 corrugations..

a. Pipe may be riveted or helical fabrication.

b. Pipe shall not be placed in soils having a pH less than 4 nor greater than 9.

c. Max. allowed pipe diam. is 91 cm (36 in).

Emergency Spillways

An emergency spillway must be provided for all closed conduit structures except as allowed for embankment dams and for drop boxes to road culverts. Full flow open structures such as chute or drop spillway structures do not require an emergency spillway if the principal spillway can safely pass the minimum total capacity design storm peak flow.

Constructed spillways shall be trapezoidal and will be located in undisturbed or compacted earth. The side slopes shall be 2 1/2:1 or flatter. The emergency spillway shall have a minimum bottom width of 2.4 m (8 ft.) and a minimum depth of 0.3 m (1.0 ft.). The minimum elevation of the settled fill shall be 0.15 m (0.5 ft.) above the water surface with the emergency spillway flowing at design depth.

The exit channel shall provide for passage of the design flow at a safe velocity to a point downstream of where the embankment will not be endangered. For further information see EFH pp. 11-17 through 11-22.

Protection

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

Use vegetation adapted to the site that will accomplish the desired purpose. Preference shall be given to native species in order to reduce the introduction of invasive plant species; provide management of existing invasive species; and minimize the economic, ecological, and human health impacts that invasive species may cause. If native plant materials are not adaptable or proven effective for the planned use, then non-native species may be used. Refer to the Field Office Technical Guide, Section II, Invasive Plant Species for plant materials identified as invasive species.

Side-inlet structures. The design criteria for minimum capacity of full flow open structures or pipe structures used to lower surface water from field elevations or lateral channels into deeper open channels are shown in table 4.

TABLE 4 1/ 2/ 3/ 4/

Side Inlet Structure Hydraulic Design Criteria

Maximum Drainage Area	Maximum Vertical Drop	Frequency of Minimum Design, 24-hour Duration Storm	
		Principal Spillway Capacity	Total Capacity
ha (acres)	*m (ft.)*	*year*	*year*
8 (20)	all	2	10
40 (100)	all	5	25
180 (450)	1.5 (5)	2	10
180 (450)	3 (10)	5	10
375 (900)	3 (10)	5	25

1/ If the entire structure watershed has an average slope of less than 0.5%, side inlet structures may be designed to pass a "B" curve drainage flow.

2/ Watersheds less than 20 acres in size may use, at the designers option, a 10 inch min. diameter

pipe with at least 1.5 ft. stage in lieu of designing for the 2-year frequency design storm.

3/ If site conditions exceed those shown in table 4, the minimum design for total capacity shall be for a 50 year frequency, 24 hour duration storm.

4/ For geosynthetic chutes with a maximum 10 year - 24 hour frequency design storm of 2.3 cubic meters per second (80 cfs) and a maximum drop of 4.5 m (15 ft.), the minimum design for total capacity shall be for a 10 year frequency, 24 hour duration storm.

Full-flow open structures. Drop, chute, and box inlet drop spillways shall be designed according to the principles set forth in the Engineering Field Handbook for Conservation Practices, the National Engineering Handbook, and other applicable NRCS publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table 5, less any reduction because of detention storage. Structures must not create unstable conditions upstream or downstream. Provisions must be made to insure reentry of bypassed storm flows.

Toe wall drop structures can be used if the vertical drop is 1.25 m (4 ft.) 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.

The ratio of the capacity of drop boxes to road culverts shall be 1.25 times the capacity required by the responsible road authority, the existing culvert capacity, or as specified in table 4 or 5, as applicable, less any reduction because of detention storage.

TABLE 5 1/, 2/

Full-flow Open Structure Design Criteria

Maximum Drainage Area	Maximum Vertical Drop	Frequency of Minimum Design, 24-hour Duration Storm	
		Principal Spillway Capacity	Total Capacity
ha (acres)	*m (ft.)*	*year*	*year*
8 (20)	all	2	10
40 (100)	all	5	25
180 (450)	1.5 (5)	5	10
375 (900)	10	10	25

1/ If site conditions exceed those shown in Table 5, the minimum design 24-hour storm frequencies are 25 years for the principal spillway and 100 years for the total capacity.

2/ For geosynthetic chutes with a maximum 10 year - 24 hour frequency design storm of 2.3 cubic meters per second (80 cfs) and a maximum drop of 4.5 m (15 ft.), the minimum design for total capacity shall be for a 10 year frequency, 24 hour duration storm.

Island-type structures. The minimum hydraulic capacity of "island type structures" shall be equal to or greater than the capacity of the downstream channel at bank full stage. The effects of tailwater submergence shall be included in the hydraulic calculations. Auxiliary spillways shall be designed to provide the additional capacity required to handle the peak discharge from the 24-hour duration, 25-year frequency design storm. See EFH p. 6-17 for discussion of "island type structures". Provisions must be made for safe reentry of bypassed flow.

Embankment dams. Class (a) dams that have a product of storage times the effective height of the dam of less than 1 300 000 m^4 (3000 ac. $ft.^2$) and an effective height of 10.5 m (35 ft.) or less shall meet or exceed the requirements specified for ponds (378).

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

Embankment dams 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.

Dams with a settled fill height of less than 4.5m (15 ft.) and 10-year frequency, 24-hour storm runoff less than 12 000 m^3 (10 ac.-ft.), shall be designed to control a minimum of the 10-year frequency storm without overtopping. The mechanical spillway,

regardless of size, may be considered in design and an emergency spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm. The embankment will be designed to meet the requirements for water and sediment control basins (638).

CONSIDERATIONS

Cultural resources. Consider the potential effects of installation and operation of grade stabilization structures on the cultural, archeological, historic and economic resources.

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.

Fish and Wildlife. Special attention shall be given to maintaining or improving habitat for fish and wildlife where applicable.

PLANS AND SPECIFICATIONS

Support data documentation requirements are as follows:

- Inventory and evaluation records
  - Assistance notes or special report
- Survey notes, where applicable
  - Design survey
  - Construction layout survey
  - Construction check survey
- Design records
  - Physical data, functional requirements and site constraints, where applicable
  - Soils/subsurface investigation report, where applicable
- Design and quantity calculations
- Construction drawings/specifications with:
  - Location map
  - Designed by" and "Checked by" names or initials
  - Approval signature
  - Job class designation
  - Initials from preconstruction conference
  - As-built notes
- Construction inspection records
  - Assistance notes or separate inspection records
  - Construction approval signature
- Record of any variances approved, where applicable
- Record of approvals of in-field changes affecting function and/or job class, where applicable.

OPERATION AND MAINTENANCE

A plan shall be prepared with the owner/operator for maintaining the embankment, the design capacity, the vegetative cover, and the outlet. After each large storm, structures shall be checked and needed maintenance performed. If the storage provided for sediment has been used, structures must be cleaned out to restore capacity. Excavations for fill material shall be made in a manner that enhances the topography.

Grade Stabilization Structure-Chute Spillway

OPERATION & MAINTENANCE PLAN

Inspections and maintenance are required to obtain intended function and life of the chute spillway. Items to inspect and maintain during the life of the chute spillway are:

1. Check structure after heavy rains for possible damage. Inspect annually for damage due to normal use.

2. Protect the structure from damage by farm equipment and livestock.

3. Maintain the proper embankment height to reduce the chances of overtopping.

4. Repair any erosion that occurs near the upstream or downstream aprons of the chute with riprap.

5. Repair any erosion that occurs along the sides of the chute with soil, then re-seed.

6. Replace any concrete blocks or rock riprap that have been displaced.

7. Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials, and reseed.

8. Maintain good vegetation on the embankment and upstream channel by mowing at least annually. Time the first mowing after nesting birds have hatched (about August 15). Remove excess growth. Do not burn or overgraze.

9. Fertilize grassed areas to maintain a vigorous vegetative cover.

10. Control tree and bush growth by hand cutting, mowing, or chemicals. Avoid damaging grass with herbicide sprays.

11. If holes occur in filter fabric, repair immediately by overlaying damaged fabric with new material and replacing riprap or concrete block.

Grade Stabilization Structure–Open Weir Drop Spillway

OPERATION & MAINTENANCE PLAN

Inspections and maintenance are required to obtain intended function and life of the open weir drop spillway. Items to inspect and maintain during the life of the open weir drop spillway are:

1. Check structure after heavy rains for possible damage. Inspect annually for damage due to normal use.

2. Protect the structure from damage by farm equipment and livestock.

3. Maintain the proper embankment height to reduce the chances of overtopping.

4. Repair any settlement or erosion that occurs around the headwall or wingwalls by backfilling with soil and reseeding.

5. Repair any scouring that occurs directly upstream of the weir or downstream of the apron with rock riprap over a non-woven geotextile.

6. If constructed with concrete blocks, repair any exposed cracks in mortar joints and maintain the mortar cap on top of the headwall and weir to keep water out of the blocks.

7. Patch any exposed cracks in reinforced concrete with mortar.

8. Replace broken or decayed boards and timbers. Replace broken or missing hardware.

9. Clear debris from weep holes to maintain free drainage of water from upstream of the walls.

10. Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials, and reseed.

11. Maintain good vegetation on the berms and upstream waterways by regular mowing and fertilization. Time the first mowing after nesting birds have hatched (about August 15). Remove excess top growth of grass. Do not burn or overgraze.

12. Prevent woody vegetation from growing in or around structure. Control tree and bush growth by hand cutting, mowing, or chemicals. Avoid damaging grass with herbicide sprays.

Grade Stabilization Structure–Pipe Drop Spillway

OPERATION & MAINTENANCE PLAN

Inspections and maintenance are required to obtain intended function and life of the pipe drop spillway. Items to inspect and to maintain during the life of the pipe drop spillway are:

1. Check structure after heavy rains for possible damage. Inspect annually for damage due to normal use.

2. Replace or repair broken or corroded pipe materials when needed.

3. Protect the structure from damage by farm equipment and livestock.

4. Maintain the proper embankment height to reduce the chances of overtopping.

5. Repair any settlement or erosion that occurs around the pipe with soil and reseeding. If this problem persists, evaluate the pipe for leakage and erosion of the fill material into or along the pipe.

6. Repair any scouring that occurs directly upstream or downstream of the pipe with a non-woven geotextile covered by rock riprap.

7. Check frequently for burrowing animals. When found, remove the burrowing animals, replace embankment materials and reseed.

8. Maintain good vegetation on the berms and upstream waterways by regular mowing. Time the first mowing after nesting birds have hatched (about August 15). Remove excess growth. Do not burn or overgraze.

9. Control tree and bush growth by hand cutting, mowing, or chemicals. Avoid damaging grass with herbicide sprays.

10. Fertilize grassed areas to maintain a vigorous vegetative cover.