NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

(No.)

CODE 410

DEFINITION

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

SCOPE

The standard applies to all types of grade stabilization structures. They may be a combination of earth embankments and mechanical spillways and may be full-flow or detention-type structures. This standard also applies to channel side-inlet structures installed to lower the water from a field elevation, a surface drain, or a waterway to a deeper outlet channel. It does not apply to structures designed to control the rate of flow or to regulate the water level in channels (587).

PURPOSE

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.

CONDITION 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.

PLANNING CONSIDERATIONS

Selecting the proper structure for a given location and function is the key to successful and economical control of erosion and runoff. Each type structure has its own range of use for a given set of conditions. Some sites will permit the use of more than one type of structure however, there generally is one type that will provide the most economical control.

Generally, the degree of control or protection and size of the watershed are the primary considerations in structure selection.

DESIGN CRITERIA

General

Structures found in this standard are divided into four types: Embankment Structure, Full Flow Open Structure, Island-Type Structure, and Side Inlet Drainage Structure. The structure must be designed for stability after installation. The crest of the inlet must be set at an elevation that stabilizes upstream head cutting.

EMBANKMENT STRUCTURES

Large Dams

Class A dams having a product of storage times the effective height of the dam of 3,000 or more, those where the total settled height of dam is 25 feet or more, or those having a greater than 50 acre-feet of storage, and all Class B and Class C dams shall meet or exceed the requirements specified in Technical Release No. 60. Exempted from this requirement are Class A dams with an effective height of 35 feet or less, and with a storage volume of 15 acre-feet or less.

Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the emergency spillway. 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. The height of dam is the vertical dimension as measured from the natural streambed or watercourse at the downstream toe of the dam to the top settled elevation of the dam.

Pond Size Dams

The minimum capacity of the principal spillway shall be that required to pass the peak flow of a 2-year frequency, 24-hour duration storm when the drainage area is 100 acres or less, and a 10-year frequency, 24-hour duration storm when the drainage area exceeds 100 acres. The spillway capacity may be the peak flow from the design storm or a reduced capacity because of detention storage.

If the effective height of dam is less than 20 feet, drainage area is less than 100 acres, and the emergency spillway has a stable grade throughout its length with no overfalls and has good vegetation along its reentry into the downsteam channel, the principal spillway capacity may be determined using 80 percent of the 2-year frequency, 24-hour duration storm. The principal spillway capacity may be the peak flow of the design storm or a reduced capacity because of detention storage.

Except as stated in the preceding two paragraphs the embankment and spillway system will be designed to meet the requirements for ponds (378).

Grade stabilization structures with a settled fill height of less than 15 feet and 10-year frequency, 24-hour duration storm runoff less than 10 acre-feet, shall be designed to control the 10-year frequency storm without overtopping.

The mechanical spillway, regardless of size, may be considered in the design and an emergency spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm. The embankment can be designed to meet the requirements for water and sediment control basins (638) rather than the requirements for ponds (378).

FULL FLOW OPEN STRUCTURES

Full flow open structures may be one of the following:

Straight Drop Spillway
Box Inlet Drop Spillway
Rock Chutes
Toewall Structure
Drop Box on Culvert

A full flow open structure is used to lower water from a higher to lower elevation. The site is usually entrenched and it is not feasible or economical to construct an auxiliary spillway.

The design shall be according to the principals set forth in the Engineering Field Manual for Conservation Practices, the National Engineering Handbook, and other applicable NRCS publications and reports. The minimum capacity shall be a design storm of the frequency and duration shown in Table 1, less any reduction because of detention storage.

Toewall 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 overflow.

The capacity of drop boxes on new road culverts shall be as required by the responsible road authority or as specified in Table 1 or 2, as applicable, less any reduction because of detention storage. The capacity of a drop box to be installed on an existing culvert that is in good condition and will not be replaced in the near future, shall equal or exceed the culvert capacity.

Table 1. Minimum Capacity for Full Flow Open Structure

Drainage Area – Acres	Vertical Drop Ft.	Frequency of Minimum Design 24 Hour Duration Storm-Yr.
0-320	0-5	10
321-900	0-10	25
All Others		100

ISLAND TYPE STRUCTURES

The following structures can be designed as an island type if an emergency spillway is added to them:

Drop Box on Culvert
Straight Drop Spillway
Box Inlet Drop Spillway
Rock Chutes
Aluminum Toe wall

Island type structures are located in low hazard areas and flows in excess of the design can by-pass the structure and re-enter the stream without causing excessive erosion. They can be installed at the head of a channel or along the side.

When the principal spillway is designed as an island type structure, its minimum capacity should equal the capacity of the downstream channel computed at a depth of flow equal to the vertical drop of the structure. If the channel capacity is restricted due to vegetation and sediment, an channel modifications are planned in the near future, the minimum structure capacity shall be based on the future channel capacity. For channels with very small drainage areas, less than 50 acres, the principal spillway shall carry at least the two-year frequency, 24-hour duration storm or the “B” Curve drainage runoff.

For all other channels with larger drainage areas, the minimum principal spillway capacity shall be as shown in Table. 2

The minimum emergency 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. Provisions must be made for safe re-entry of bypassed flow as necessary.

Table 2 Minimum Capacity for Island Type Structures

Drainage Area – Acres	Vertical Drop Ft.	Frequency of Minimum Design 24 Hour Duration Storm-Yr.	
		Principal Spillway Capacity	Total Capacity
50-320	0 - 5	5	10
321-900	0 - 10	10	25
All Others		10	50

Box inlet drop spillway structures shall meet the following requirements:

(1) Aluminum toewall drop structures shall have a maximum overfall F-4.0 ft. and a maximum notch height, H-2.5 ft. Install in accordance with manufacturer's instructions.

(2) Reinforce concrete drop box spillways shall be built in accordance with EFM, Ohio Supplement, Exhibit OH6-2.

(3) All structures will be designed with the elevation of the control section of the emergency spillway 0.5 ft. below the top of the headwall.

(4) A dike will be constructed to a height of at least 1.0 ft. above the top of the headwall and extend a minimum of 15 feet beyond the end of the headwall. The dike shall have a minimum top width of 4 feet and the steepest sideslopes shall be 2-1/2:1.

(5) ODOT Type D riprap shall be placed around the box inlet for a horizontal distance of 2 ft. and a depth of 1 ft.

(6) The approach channel shall have a minimum bottom width, BW=2L-hz, where L=weir length, h=notch height, and z=sideslope. The channel grade must be flat for a distance sufficiently long enough to encompass the entrance to the emergency spillway.

SIDE-INLET DRAINAGE STRUCTURE

The following drainage structures can be used to lower surface water from field elevations or lateral field ditches into deeper open channels:

Drop Box Inlets on Pipes
Pipe Drop Inlets on Pips
Straight Pipes

The minimum principal spillway capacity shall equal the "B" Curve drainage runoff for all conditions or the capacity of a 12-inch diameter pipe, whichever is greater. Table 3 shall be used to determine the total combined principal and emergency spillway capacity.

A dike will be constructed to a height of at least 1.0 ft. above the low bank or flow depth in the emergency spillway, whichever is higher, and extend a minimum of 20 ft. both ways from the structure centerline. The dike shall have a minimum top width of 8 ft. and the steepest sideslopes shall be 2:1.

Table 3 Minimum Capacity for Side Inlet Type Structures

Drainage Area – Acres	Vertical Drop Ft.	Frequency of Minimum Design 24 Hour Duration Storm-Yr.
		Total Capacity
0-450	0 - 5	10[1/]
0-450	5 – 10	10
900	0 – 10	25
All Others		50

1/ Structures with drainage areas having an average watershed slope of 2 percent or less and good conservation treatment can be designed without an emergency spillway. The total capacity for these structures is the capacity of the principal spillway.

Visual Resources

In highly visible public areas and those associated with recreation, careful consideration should be given to landscape resources. Land forms, 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 finish to reduce reflectiveness and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.

General Criteria

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. The foundation preparation, compaction, top width, and side slopes must ensure a stable dam for anticipated flow conditions. Discharge from the structure shall be sufficient that no crop damage results from flow detention.

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

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

If the area is used for livestock, the structure, earth fill, vegetated spillways, and other areas will 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 to tress passers.

Vegetative 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. Requirements for establishing vegetation will be in accordance with Ohio Technical Standard 342 – Critical Area Planting.

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.

NATURAL RESOURCES CONSERVATION SERVICE
CONSTRUCTION SPECIFICATION

GRADE STABILIZATION STRUCTURE

Code 410

Specified materials shall provide stability, durability, and safety characteristics required to achieve the planned objective.

Specifications for grade stabilization structures within the scope of the standard for ponds (378) shall, as a minimum, be commensurate with those for ponds. Grade stabilization structures within the scope of
TR-60 shall be constructed according to the guide specifications in the National Engineering Handbook, Section 20.

Reinforced concrete structures shall be constructed according to the Ohio Supplement to the National Engineering Manual, OH 512.34, Quality Control of Reinforced Concrete Structures.

NATURAL RESOURCES CONSERVATION SERVICE
CONSTRUCTION SPECIFICATION

CONCRETE BLOCK CHUTE

(Grade Stabilization Structure – 410)

SCOPE – The work shall consist of all excavating, filling, and placement of filter fabric and concrete blocks as shown on the plans.

SITE PREPARATION – All trees, brush, stumps, rubbish, and other unsuitable material shall be removed from the site. Disposal will be as shown on the plans.

SUBGRADE PREPARATION - The subgrade surface on which the bedding will be placed shall be excavated or filled to the lines and grades shown on the plans. When fill is required it shall consist of cohesive earth material and thoroughly compacted in place, or bedding material may be used.

MATERIALS – A minimum of 3 inches of clean or washed sand or gravel fill (base) shall be placed between the natural ground (subgrade) and the filter fabric. At least 80 percent of the materials in the base shall be larger than the holes in the filter fabric. No material shall be placed between the blocks and the filter fabric.

Standard concrete building blocks with nominal dimensions of 8 inches wide, 8 inches high, and 16 inches long shall be used. Cull or used blocks may be used if they are in god condition and free of excess mortar.

Filter fabric meeting the requirements shown on the plans shall be used.

CONSTRUCTION – Excavation should begin at the downstream cutoff and exit apron, proceed up the chute slope, and end at the entrance apron and upstream cutoff. Subgrade alignment and grade should be referenced to offset stakes.

Normally, exact subgrade depth is not required. Sand or gravel shall be used to compensate for over excavation or irregularities. In general, no earth fill should be placed under the blocks or filter fabric to minimize the potential for differential settlement.

Once excavation is completed, filter fabric is placed in the downstream cutoff trench. The trench is then backfilled with compacted soil.

Once the trench is backfilled, fill material is placed in all areas not to grade. In most cases, random grade stakes or screed boards are utilized to level the material. It is desirable that the surface be uniform to prevent any irregularities from being transposed to the block surface. Filter fabric is then placed over the subgrade and down into the upstream cutoff trench. After installing the plastic cutoff, the trench is backfilled with compacted material. It is important that the cutoff trenches and filter fabric extend to the full width of the concrete blocks to be laid.

The concrete blocks are now placed tightly together with the holes up on all areas. Length of the blocks are placed parallel with the direction of flow, except on the side slopes where they are placed perpendicular to the direction of flow.

The triangular void areas at the joints between the entrance apron, chute slope and side slopes are grouted using a mixture of 3 parts sand to 1 part cement. Bagged mortar mix may also be used. Adding a capful of liquid detergent to the grout slurry aids in placement.

Holes in the concrete blocks shall be filled with loose, friable soil suitable for a seedbed.

VEGETATIVE TREATMENT – Areas adjacent to the block chute that are disturbed by construction, will be seeded. A seedbed shall be prepared by loosening the soil to an approximate depth of 4 inches and smoothed as required to meet the design cross section.

Unsuitable material that will interfere with seeding or maintenance shall be removed and disposed of. Stabilizing crop, seed, fertilizer, lime, mulch, and other requirements will be of the type and rates specified on the plans.

The entire surface of the block chute should be seeded and mulched at the same rates and type as above. Seedbed preparation is not required.

NATURAL RESOURCES CONSERVATION SERVICE
CONSTRUCTION SPECIFICATION

PIPE DROP INLET OR PIPE STRUCTURE

(Grade Stabilization Structure-410)

Scope – The work shall consist of all site preparation, excavation, earth fill, pipe drop structure, rock slope protection, and seeding necessary for the construction of structure.

Site Preparation – Area will be cleared of all trees, stumps, roots and other debris. After stripping and examination of the foundation where structure and pipe will be installed, all pockets of organic soil, sand and gravel and other unsuitable material will be removed.

Excavation – Excavation will meet the lines and grades as shown on the plans. Prior to back filling, the site will be examined for unanticipated unsuitable material that would require additional excavation. Excavated area will be dewatered prior and during backfilling operation.

Principal Spillway – The type and quality (ASTM, Federal Spec.) of materials for principal spillway will be designated on the plans. Material will be inspected in the field prior to installation. All damaged materials will be repaired according to manufacturer's recommendation. Unless otherwise specified on the plans, cutoff collars, connecting bands, and other appurtenance will be of the same material as the pipe conduit.

Earth Fill – Backfill material will be free of all sod, roots, frozen soil, stones large than (6") six inches in diameter and other objectionable material. Unless otherwise specified on the plans, backfilling of pipe will be done in (4") four inch lifts with mechanical tampers or by hand tampers to at least (1') one foot above the pipe and (1') one foot around all sides of the structure. Once the file is (1') one foot above the pipe the backhoe bucket may be used to compact the soil in (6") six-inch lifts. There must be enough moisture in the soil for good compaction and sufficient moisture to produce a hand-molded ball that will hold its shape. Four inches to topsoil should be spread over the finished fill for a good seedbed.

Vegetative Treatment – Areas adjacent to the structure that are disturbed by construction, will be seeded. A seedbed shall be prepared by loosening the soil to an approximate depth of 4 inches and smoothed as required to meet the design cross section.

Unsuitable material that will interfere with seeding or maintenance shall be removed and disposed of. Stabilizing crop, seed, fertilizer, lime, mulch, and other requirements will be of the type and rates specified on the plans.

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE SPECIFICATION

ROCK RIPRAP CHUTE

(Grade Stabilization Structure – 410)

SCOPE – The work shall consist of all excavating, filling, rock placement and seeding necessary for the construction of the rock chutes as shown on the plans.

SITE PREPARATION – All trees, brush, stumps, rubbish, and other unsuitable material shall be removed from the site. Disposal will be as shown on the plans.

SUBGRADE PREPARATION – The subgrade surface on which the bedding will be placed shall be excavated or filled to the lines and grades shown on the plans. When fill is required it shall consist of cohesive earth material and thoroughly compacted in place, or bedding material may be used.

MATERIALS – Individual rock fragments shall be dense, sound and free from cracks, seams, and other defects that adversely affect the durability of the fragments shall be angular to subrounded in shape.

The smallest dimension of an individual rock shall not be less than one-third the greatest dimension. The size and gradation of the rock fragments will be shown on the plans.

Bedding material shall consist of gravel or rock spalls with the size and gradation as shown on the plans.

BEDDING PLACEMENT – Bedding material will be spread uniformly on the subgrade surface to the depth shown on the plans. Compaction will not be required unless it is shown on the plans.

ROCK RIPRAP PLACEMENT – Rock shall be placed on the bedding surface to the depth shown on the plans. The rock shall be constructed to the full depth in one operation and in such a manner to avoid serious displacement of the bedding. The rock shall be placed to achieve a reasonably uniform, compact surface with large rocks well distributed and small rocks and spalls filling the voids between the larger rocks.

Some hand placement of rocks and tamping with the construction equipment may be required to obtain a relatively smooth compact layer of rock. It is extremely important that the entrance and exit aprons be level and have sharp changes in grade with the chute section.

After all the rock has been placed, enough gravel and/or soil shall be worked into the rock layer to fill the voids and provide a relatively smooth finished surface.

VEGETATIVE TREATMENT – Areas adjacent to the rock riprap chute that are disturbed by construction, will be seeded. A seedbed shall be prepared by loosening the soil to an approximately depth of 4 inches and smoothed as required to meet the design cross section.

Unsuitable material that will interfere with seeding or maintenance shall be removed and disposed of. Stabilizing crop, seed, fertilizer, lime, mulch, and other requirements will be of the type and rates specified on the plans.

The entire rock surface of the riprap chute should be seeded and mulched at the same rates and type as above. Seedbed preparation is not required.