

NATURAL RESOURCES CONSERVATION SERVICE CONSERVATION PRACTICE STANDARD

POND (no.) CODE 378

DEFINITION

A water impoundment made by constructing a dam or an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at spillway elevation is 3 ft or more.

PURPOSE

To provide erosion control, water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related uses, and to maintain or improve water quality.

SCOPE

This standard establishes the minimum acceptable quality for the design and construction of ponds if:

1. Failure of the dam will not result in loss of life; in damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.
2. The product of the storage times the effective height of the dam is less than 3,000. 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 taken along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.

3. The effective height of the dam is 35 ft or less, and the dam is hazard class (a).

CONDITIONS WHERE PRACTICE APPLIES

Site conditions. Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed emergency spillway, (2) a combination of a principal spillway and an emergency spillway, or (3) a principal spillway.

Drainage area. The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. The drainage area shall be large enough so that surface runoff and groundwater flow will maintain an adequate supply of water in the pond. The quality shall be suitable for the water's intended use.

Reservoir area. The topography and soils of the site shall permit storage of water at a depth and volume that ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable. The pond should have a depth of 6 feet over at least one-fourth of the pond area.

PLANNING CONSIDERATIONS

Water Quantity

1. Effects upon components of the water budget, especially effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
2. Variability of effects caused by seasonal or climatic changes.
3. Effects on the downstream flows or aquifers that could affect other water uses or users.
4. Potential for multiple use.
5. Effects on the volume of downstream flow to prohibit undesirable environmental, social or economic effects.

Water Quality

1. Effects on erosion and the movement of sediment, pathogens, and soluble and sediment attached substances that are carried by runoff.
2. Effects on the visual quality of onsite and downstream water resources.
3. Short-term and construction-related effects of this practice on the quality of downstream water courses.
4. Effects of water level control on the temperatures of downstream water to prevent undesired effects on aquatic and wildlife communities.
5. Effects on wetlands and water-related wildlife habitats.
6. Effects of water levels on soil nutrient processes such as plant nitrogen use or denitrification.
7. Effects of soil water level control on the salinity of soils, soil water, or downstream water.
8. Potential for earth moving to uncover or redistribute toxic materials such as saline soils.

DESIGN CRITERIA FOR EMBANKMENT PONDS

Foundation cutoff. A cutoff of relatively impervious material shall be provided under the dam if necessary. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall not be steeper than one horizontal to one vertical.

Seepage control. Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage creates swamping downstream, (3) such control is needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage may be controlled by (1) foundation, abutment, or embankment drains; (2) reservoir blanketing; or (3) a combination of these measures.

Earth embankment. The minimum top width for a dam is shown in table 1. If the embankment top is to be used as a public road, the minimum width shall be 16 ft for one-way traffic and 26 ft for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority.

Table 1.- Minimum top width for dams

| Total height of embankment | Top width |
|-------------------------------|-----------|
| <i>ft</i> | <i>ft</i> |
| 15 or less | 8 |
| 15 - 20 | 10 |
| 20 - 25 | 12 |
| 25 - 35 | 14 |
| 35 or more | 15 |

Side slopes. The combined upstream and downstream side slopes of the settled embankments shall not be less than five horizontal to one vertical, and neither slope shall be steeper than two horizontal to one vertical. All slopes must be designed to be stable, even if flatter side slopes are required.

Protection from wave damage. Where the surface of the pond exceeds five acres, the upstream slope shall be protected from wave damage by one of the following methods:

1. At least an 8 foot wide berm located approximately 1 foot above the water line.
2. A 4 foot band of riprap 2 feet thick and properly bedded extending at least 2 feet below and 2 feet above the normal water line.
3. Increase the width through the dam at the planned water line at least 4 feet. This increase in width may be obtained by increasing the top width or freeboard, or by flattening the side slopes.

Any exceptions to these requirements must be approved by GS-11, or higher, engineering specialist. If needed to protect the slopes of the dam, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (Technical Releases 56 and 69).

Freeboard. The minimum elevation of the top of the settled embankment shall be 1 ft above the water surface in the reservoir with the emergency spillway flowing at design depth. The minimum difference in elevation between the crest of the emergency spillway and the settled top of the dam shall be 2 ft for all dams having more than a 20-acre drainage area or more than 20 ft in effective height.

Settlement. The design height of the dam shall be increased by the amount needed to insure that after settlement the height of the dam equals or exceeds the design height. This increase shall

not be less than 5 percent, except where detailed soil testing and laboratory analyses show that a lesser amount is adequate.

Principal spillway. A pipe conduit, with needed appurtenances, shall be placed under or through the dam, except where rock, concrete, or other types of mechanical spillways are used, or where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

Vegetated earth spillways shall be protected from erosion by a principal spillway that provides flood storage between the inlet crest and the vegetated spillway when:

1. The drainage area exceeds 50 acres.
2. Continuous spring flow or prolonged flow exists at the site.

These provisions shall apply unless otherwise approved by a GS-11, or higher, engineering specialist.

The volume of flood storage is related to drainage area, principal spillway capacity, and site conditions. The combined principal spillway release and flood storage shall be such that the emergency spillway will not operate during the passage of the 24-hour 2-year frequency storm.

The principal spillway crest elevation shall be no less than 0.5 ft below the crest of the emergency spillway for dams having a drainage area of 20 acres or less, and no less than 1 ft for those having a drainage area of more than 20 acres.

When design discharge of the principal spillway is considered in calculating peak outflow through the emergency spillway, the crest elevation of the inlet shall be such that the full flow will be generated in the conduit before there is discharge through the emergency spillway. The inlets and outlets shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long-duration, continuous, or frequent flows without flow through the emergency spillways. The diameter of the pipe shall not be less than 4 in. If the pipe conduit diameter is 10 in or greater, its design discharge may be considered when calculating the peak outflow rate through the emergency spillway.

Pipe conduits. Pipe conduits under or through the dam shall meet the following requirements. The pipe shall be capable of withstanding external loading without yielding, buckling, or cracking. Flexible pipe strength shall not be less than that necessary to support the design load with a maximum of 5 percent deflection. The inlets and outlets shall be structurally sound and made of materials compatible with those of the pipe. All pipe joints shall be made watertight by the use of couplings, gaskets, caulking, or by welding.

For dams 20 ft or less in effective height, acceptable pipe materials are cast-iron, steel, corrugated steel or aluminum, concrete, plastic, and cast-in-place reinforced concrete. Concrete pipe shall be laid in a concrete bedding. Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet-resistant materials and protected by coating or shielding, or provisions for replacement should be made as necessary. Connections of plastic pipe to less flexible pipe or structures must be designed to avoid stress concentrations that could rupture the plastic.

For dams more than 20 ft in effective height, conduits shall be plastic, reinforced concrete, cast-in-place reinforced concrete, corrugated steel or aluminum, or welded steel pipe. The maximum height of fill over any principal spillway aluminum pipe must not exceed 25 ft. Pipe shall be watertight. The joints between sections of pipe shall be designed to remain watertight after joint elongation caused by foundation consolidation. Concrete pipe shall have concrete bedding or a concrete cradle, if required. Cantilever outlet sections, if used,

shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed. Other suitable devices such as a Saint Anthony Falls stilling basin or an impact basin may be used to provide a safe outlet. Protective coatings, asphalt coated, or vinyl coating on galvanized corrugated metal pipe, or coal tar enamel on welded steel pipe should be provided in areas that have a history of pipe corrosion, or where the saturated soil resistivity is less than 4,000 ohms-cm, or where soil pH is lower than 5.

Specifications in tables 2, 3, and 4 are to be followed for polyvinyl chloride (PVC), steel, and aluminum pipe.

Used steel pipe may be used provided the quality of the pipe is such that it will provide the stability and durability during the planned life of the structural measure.

Cathodic protection is to be provided for coated welded steel and galvanized corrugated metal pipe where soil and resistivity studies indicate that the pipe needs a protective coating, and where the need and importance of the structure warrant additional protection and longevity. If cathodic protection is not provided for in the original design and installation, electrical continuity in the form of joint-bridging straps should be considered on pipes that have protective coatings. Cathodic protection should be added later if monitoring indicates the need.

Practice standard 430-FF provides criteria for cathodic protection of welded steel pipe.

Anti-seep collars: Seepage control along a pipe conduit spillway shall be provided if any of the following conditions exist:

1. The effective height of dam is greater than 15 ft.
2. The conduit is of smooth pipe larger than 8 in. in diameter.
3. The conduit is of corrugated pipe larger than 12 in. in diameter.

Table 2.- Acceptable PVC pipe for use in earth dams¹

| Nominal pipe size | Schedule for standard dimension ratio (SDR) | Maximum depth of fill over pipe |
|-------------------|---|---------------------------------|
| <i>in</i> | | <i>ft</i> |
| 4 or less | Schedule 40 | 15 |
| | Schedule 80 | 20 |
| | SDR 26 | 10 |
| | Schedule 40 | 10 |
| 6,8,10,12 | | |
| | Schedule 80 | 15 |
| | SDR 26 | 10 |

¹Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ATSM-D-1785 or ATSM-D-2241.

Table 3. - Minimum gage for corrugated metal pipe [2-2/3-in x 1/2-in corrugations]¹

| Fill height (ft) | Minimum gauge for steel pipe with diameter (in) of ____ | | | | | |
|------------------|---|-------|-------|-------|--------------|----|
| | 21 and less | 24 | 30 | 36 | 42 | 48 |
| 1 - 15 | 16 | 16 | 16 | 14 | 12 | 10 |
| 15 - 20 | 16 | 16 | 16 | 14 | 12 | 10 |
| 20 - 25 | 16 | 16 | 14 | 12 | 10 | 10 |
| Fill height (ft) | Minimum thickness (in) of aluminum pipe ² with diameter (in) of ____ | | | | | |
| | 21 and less | 24 | 30 | 36 | | |
| 1 - 15 | 0.06 | 0.06 | 0.075 | 0.075 | | |
| 15 - 20 | 0.06 | 0.075 | 0.105 | 0.105 | | |
| 20 - 25 | 0.06 | 0.105 | 0.105 | ---- | ³ | |

Table 4. – Welded Steel Pipe Thickness (in)

| Pipe Dia. | 6-10 | 12-24 | 26-36 | 42-48 |
|-----------|------|-------|-------|-------|
| Thickness | .188 | .251 | .312 | .375 |

¹ Pipe with 6-, 8-, and 10-in diameters has 1-1/2 in x 1/4-in corrugations.

² Riveted or helical fabrication.

³ Not permitted.

Seepage along pipes extending through the embankment shall be controlled by use of a

filter and drainage diaphragm, unless it is determined that antiseep collars will adequately serve the purpose

The drain is to consist of sand, meeting fine concrete aggregate requirements (at least 15% passing the No. 40 sieve but no more than 10% passing the No. 100 sieve). If unusual soil conditions exist, a special design analysis shall be made.

The drain shall be a minimum of 2 ft thick and extend vertically upward and horizontally at least three times the pipe diameter, and vertically downward at least 18 in. beneath the conduit invert. The drain diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam.

The drain shall be outletted at the embankment downstream toe, preferably using a drain backfill envelope continuously along the pipe to where it exits the embankment. Protecting drain fill from surface erosion will be necessary.

When antiseep collars are used in lieu of a drainage diaphragm, they shall have a watertight connection to the pipe. Maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe. Collar material shall be compatible with pipe materials. The antiseep collar(s) shall increase by 15% the seepage path along the pipe.

Anti-vortex. Closed conduit spillways designed for pressure flow must have adequate antivortex devices.

Trash guard. To prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser.

Drain pipe. A pipe with a suitable valve shall be provided to drain the pool area if needed for

proper pond management or if required by State law. The principal spillway conduit may be used as a pond drain if it is located where it can perform this function.

Water supply. Supply pipes through the dam to watering troughs and other appurtenances shall have an inside diameter of not less than 1-1/4 in.

Emergency spillways. Emergency spillways convey large flood flows safely past earth embankments.

An emergency spillway must be provided for each dam, unless the principal spillway is large enough to pass the peak discharge from the routed design hydrograph and the trash that comes to it without overtopping the dam. The following are minimum criteria for acceptable use of a closed conduit principal spillway without an emergency spillway: a conduit with a cross-sectional area of 3 ft² or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

Capacity. The minimum capacity of a natural or constructed emergency spillway 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 creditable to conduit discharge and detention storage. For dams requiring a state permit, refer to state criteria for minimum spillway capacity, NEM, Subchapter A, Part 506, Dam Safety.

The emergency spillway shall safely pass the peak flow, or the storm runoff shall be routed through the reservoir. The routing shall start either with the water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days' drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the emergency

spillway or from the elevation that would be attained if the entire design storm were impounded, whichever is lower. Emergency spillways shall provide for passing the design flow at a safe velocity to a point downstream where the dam will not be endangered.

Constructed emergency spillways are open channels that usually consist of an inlet channel, a control section, and an exit channel. They shall be trapezoidal and shall be located in undisturbed or compacted earth. The side slopes shall be stable for the material in which the spillway is to be constructed. For dams having an effective height exceeding 20 ft, the emergency spillway shall have a bottom width of not less than 10 ft.

Upstream from the control section, the inlet channel shall be level for the distance needed to protect and maintain the crest elevation of the spillway. The inlet channel may be curved to fit existing topography. The grade of the exit channel of a constructed emergency spillway shall fall within the range established by discharge requirements and permissible velocities.

Structural emergency spillways. If chutes or drops are used for principal spillways or principal emergency or emergency spillways, they shall be designed according to the principles set forth in the Engineering Field Manual for Conservation Practices and the National Engineering Handbook-Section 5, Hydraulics; Section 11, Drop Spillways; and Section 14, Chute Spillways. The minimum capacity of a structural spillway 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 creditable to conduit discharge and detention storage.

Table 5.-Minimum spillway capacity

| Drainage area | Effective ht. of dam ¹ | Storage | Minimum design storm ² | |
|---------------|-----------------------------------|--------------|-----------------------------------|------------------|
| | | | Freq- uency | Minimum duration |
| <i>acre</i> | <i>ft</i> | <i>ac-ft</i> | <i>yr</i> | <i>hr</i> |
| 20 or less | 20 or less | < than 50 | 10 | 24 |
| 20 or less | > than 20 | < than 50 | 25 | 24 |
| > than 20 | | < than 50 | 25 | 24 |
| All others | | | 50 | 24 |

¹As defined under "Scope."

²Select rain distribution based on climatological region.

Visual resource design. The visual design of ponds shall be carefully considered in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that it is generally curvilinear rather than rectangular. Excavated material can be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and to attract wildlife.

DESIGN CRITERIA FOR EXCAVATED PONDS

Runoff. Provisions shall be made for a pipe and emergency spillway if necessary. Runoff flow patterns shall be considered when locating the pit and placing the spoil (see table 5).

Side slopes. Side slopes of excavated ponds shall be stable and shall not be steeper than 1.5 horizontal to one vertical. If livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than 4 horizontal to one vertical.

Perimeter form. If the structures are to be used for recreation or are highly visible to the public, the perimeter or edge should be curvilinear.

Inlet protection. If surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Excavated material. The material excavated from the pond shall be placed so that its weight will not endanger the stability of the pond side slopes and so that it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

1. Uniformly spread to a height that does not exceed 3 ft, with the top graded to a continuous slope away from the pond.
2. Uniformly placed or shaped reasonably well, with side slopes assuming a natural angle of repose. The excavated material will be placed at a distance equal to the depth of the pond but not less than 12 ft from the edge of the pond.
3. Shaped to a designed form that blends visually with the landscape.
4. Used for low embankment and leveling.
5. Hauled away.

PLANS AND SPECIFICATIONS

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