NATURAL RESOURCES CONSERVATION SERVICE

CONSERVATION PRACTICE STANDARD

POND

(No.)

CODE 378

DEFINITION

A water impoundment made by constructing 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 the auxiliary spillway elevation is 3 feet or more.

PURPOSE

To provide water for livestock, fish and wildlife, recreation, fire control, develop renewable energy systems, and other related uses, and to maintain or improve water quality.

CONDITIONS WHERE PRACTICE APPLIES

This standard establishes the minimum acceptable quality for the design and construction of low-hazard ponds where:

Failure of the dam will not result in loss of life; damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.

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 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 taken along the centerline of the dam. If there is no auxiliary spillway, the top of the dam is the upper limit.

The effective height of the dam is 35 feet or less.

The NRCS classification of the dam is Class (a).

<u>General Criteria Applicable to All Ponds</u>

All federal, State and local requirements shall be addressed in the design.

A protective cover of vegetation shall be established on all exposed areas of embankments, spillways and borrow areas as climatic conditions allow, according to the guidelines in conservation practice standards 342, Critical Area Planting or 327, Conservation Cover, as applicable.

The downstream area below the dam must be evaluated carefully to determine what impact a sudden breach of the proposed dam would have. This evaluation must consider all existing improvements and those improvements that may reasonably be expected to be made during the useful life of the structure. The results of this examination provide for the proper hazard class of the dam. See Pond, Engineering Notekeeping (N378 - 1) for documentation of hazard class determination.

Any dam that is 25 feet or over in height and has an impoundment capacity of 50 acre-feet or more (as defined by the NC Dam Safety Law) will require a permit under the North Carolina Dam Safety Law. NRCS hazard classification may differ from that of the NC Department of Environment and Natural Resources (DENR). Pipe materials for dams constructed under a dam safety permit will meet the requirements of DENR when they are more stringent than NRCS requirements.

Site conditions. Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary 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 will provide an adequate supply of water for the intended purpose unless an alternate water source exists to serve this purpose. The quality shall be suitable for the water's intended use.

Reservoir area. The topography and geology of the site shall permit storage of water at a depth and volume that will 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. Areas at design normal pool and top of dam should be measured and not estimated. This is critical in determining storage volumes for flood routing and for determining Dam Safety Law requirements.

Design Criteria for Embankment Ponds

Geological Investigations. Pits, trenches, borings, review of existing data or other suitable means of investigation shall be conducted to characterize materials within the embankment foundation, auxiliary spillway and borrow areas. Soil materials shall be classified using the Unified Soil Classification System.

Foundation cutoff. A cutoff of relatively impervious material shall be provided under the dam if necessary to reduce seepage through the foundation. 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 could create 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 filters and drains; (2) reservoir blanketing; or (3) a combination of these measures.

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 feet for one-way traffic and 26 feet for two-way traffic. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority. For dams less than 20 feet in height, maintenance considerations or construction equipment limitations may require increased top widths from the minimum shown in Table 1. The total height of embankment is the difference in elevation, in feet, between the top of the dam and the lowest point in the cross section taken along the centerline of the dam.

Table 1. Minimum top width for dams

Total height of embankment	Top width
feet	*feet*
Less than 10	8
10 – 19.9	10
20 – 24.9	12
25 – 34.9	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. Downstream or upstream berms can be used to help achieve stable embankment sections. Dams to be mowed shall have side slopes of three horizontal to one vertical (3:1) or flatter.

Slope Protection. If needed to protect the slopes of the dam from erosion, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (Technical Releases 56, "A guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments" and 69, "Riprap for Slope Protection Against Wave Action" contain design guidance).

Freeboard. The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the reservoir with the auxiliary spillway flowing at design depth. The minimum difference in elevation between the crest of the auxiliary spillway and the settled top of the dam shall be 2 feet for all dams having more than a 20-acre drainage area or more than 20 feet 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 10 percent **unless** the maximum thickness of layer before compaction is 9 inches or less **and** compaction is equivalent to or better than the following: The routing of the loaded hauling and spreading equipment over the fill in such a manner that every point on the surface of each layer of fill will be traversed by not less than one tread track of the loaded equipment traveling in a direction parallel to the main axis of the fill. Under these conditions, the allowance for settlement may be reduced to 5 percent. The allowance for settlement may be reduced below 5% where detailed soil testing and laboratory analyses or experience in the area show that a lesser amount is adequate. A sheepsfoot roller shall be used when the backfill has a moderate to high clay content.

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

The minimum detention storage and principal spillway capacity shall be as shown in Table 2. This may be accomplished by one of the following design options: (1) The principal spillway design storm runoff may be impounded as detention storage in the reservoir, or (2) the principal spillway design storm runoff may be flood routed through the reservoir using a combination of detention storage and pipe flow without flow through the auxiliary spillway. Current NRCS methods and programs for flood routing shall be used when flooding routing is required.

Table 2. Minimum Spillway Capacity

Job Class[1]	Principal Spillway Design Storm[2] or Detention Storage	Auxiliary Spillway Design Storm[2]	
	(years)	(years)[3]	(years)[4]
I & II	1	25[5]	50
III	2	50[6]	50
IV	5	50[6]	50
V	10	50[6]	50

[1] National Engineering Manual - Part 501 and NC Bulletin 210-2-1, NC-ENG-33. When job class is raised because of pipe size, it is not required that the hydrologic design criteria be raised.

[2] 24-hour

[3] When storage is less than 50 acre-feet

[4] When storage is 50 acre-feet or more

[5] Where drainage area is less than 20 acres and total dam height is less than 20 feet, design storm may be reduced to 10 year

[6] Where drainage area is less than 20 acres, design storm may be reduced to 25 year.

For dams with a drainage area of 20 acres or less, the principal spillway crest elevation shall not be less than 0.5 feet below the auxiliary spillway crest elevation. For dams with a drainage area over 20 acres, this difference shall not be less than 1.0 feet.

When design discharge of the principal spillway is considered in calculating peak outflow through the auxiliary spillway, the crest elevation of the inlet shall be such that the design discharge will be generated in the conduit before there is discharge through the auxiliary spillway.

Pipe conduits designed for pressure flow must have adequate anti-vortex devices. 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 auxiliary spillways. The diameter of the principal spillway pipe shall not be less than 4 inches. Pipe conduits used solely as a supply pipe through the dam for watering troughs and other appurtenances shall not be less than 1-1/4 inches in diameter. Supply pipes shall be equipped with valves and seepage control.

If the pipe conduit diameter is 10 inches or greater, its design discharge may be considered when calculating the peak outflow rate through the auxiliary spillway.

Pipe conduits shall be ductile iron, welded steel, corrugated steel, corrugated aluminum, reinforced concrete (pre-cast or site-cast), or plastic. Pipe conduits through dams of less than 20 feet total height may also be cast iron or unreinforced concrete.

Dissimilar metals, such as aluminum and steel, must not be installed in direct contact with each other.

Pipe conduits shall be designed and installed to withstand all external and internal loads without yielding, buckling, or cracking. Rigid pipe shall be designed for a positive projecting condition. Flexible pipe shall be designed for a maximum deflection of 5 percent. The modulus of elasticity for PVC pipe shall be assumed as one-third of the amount designated by the compound cell classification to account for long-term reduction in modulus of elasticity. Different reductions in modulus may be appropriate for other plastic pipe materials.

The minimum thickness of flexible pipe shall be SDR 26, Schedule 40, Class 100, or 16 gage as appropriate for the particular pipe material. Connections of flexible pipe to rigid pipe or other structures shall be designed to accommodate differential movements and stress concentrations. Pipe strengths shall not be less than the values shown in Tables 3 and 4 for polyvinyl chloride (PVC), steel, and aluminum pipe.

Table 3. Acceptable PVC pipe[1]

Nominal Pipe size (in)	Schedule or Standard Dimension Ratio	Maximum depth of fill (ft)
4 or less	Schedule 40	15
	Schedule 80	20
	SDR 26	10
6,8,10,12	Schedule 40	10
	Schedule 80	15
	SDR 26	10

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

Table 4. Minimum gage for corrugated metal pipe (2-2/3 in X 1/2 in and 3 in X 1 in)[1]

Fill height (ft)	Minimum gage for steel pipe with diameter (in) of ≤ 21	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 dia. (in) of ≤ 21	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	0.135	----[3]

[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.

All pipe conduits shall be designed and installed to be water tight by means of couplings, gaskets, caulking, waterstops, or welding. Joints shall be designed to remain watertight under all internal and external loading including pipe elongation due to foundation settlement. “Dimple” connecting bands shall not be used.

Pipe conduits shall have a concrete cradle or bedding if needed to provide improved support for the pipe to reduce or limit structural loading on pipe to allowable levels.

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.

All steel pipe and couplings shall have protective coatings in areas that have traditionally experienced pipe corrosion, or in embankments with saturated soil resistivity less than 4000 ohms-cm or soil pH less than 5. Protective coatings shall be asphalt, polymer over galvanizing, aluminized coating or coal tar enamel as appropriate for the pipe type. Plastic pipe that will be exposed to direct sunlight shall be ultraviolet-resistant and protected with a coating or shielding, or provisions provided for replacement as necessary. Aluminum surfaces to be covered with concrete shall be coated with an appropriate material such as bituminous coating.

Renewable Energy. For detailed criteria where the purpose is to develop renewable, energy systems refer to interim conservation practice standard Renewable Energy Production (716).

Cathodic Protection. 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.

Outlet Works. The principle spillway shall outlet into a plunge basin or other energy dissipating device. The outlet channel shall be of adequate size and capacity to convey the pipe discharge without submerging the pipe outlet and shall be aligned with the barrel.

Seepage Control. Seepage control along a pipe conduit spillway shall be provided if any of the following conditions exist:

- The effective height of dam is greater than 15 feet.
- The conduit is of smooth pipe larger than 8 inches in diameter.
- The conduit is of corrugated pipe larger than 12 inches in diameter.

Seepage along pipes extending through the embankment shall be controlled by use of a drainage diaphragm, unless it is determined that anti-seep collars will adequately serve the purpose.

Drainage Diaphragm. The drainage diaphragm shall function both as a filter for adjacent base soils and a drain for seepage that it intercepts. The drainage diaphragm shall consist of sand meeting the requirements of ASTM C-33, for fine aggregate. If unusual soil conditions exist such that this material may not meet the required filter or capacity requirements, a special design analysis shall be made.

The drainage diaphragm shall be a minimum of 2 feet thick and extend vertically upward and horizontally at least three times the outside pipe diameter, and vertically downward at least 18 inches beneath the conduit invert. The drainage diaphragm shall be located immediately downstream of the cutoff trench, but downstream of the centerline of the dam if the cutoff is upstream of the centerline. The minimum cover on the diaphragm shall be at least 2 feet as measured to the nearest surface of the embankment.

The diaphragm shall be located downstream of the core zone and/or cutoff trench, maintaining the minimum cover as indicated above. For zoned embankments, if the downstream shell is more pervious than the diaphragm material, the diaphragm shall be located at the downstream face of the core zone.

The drainage diaphragm shall be outletted at the embankment downstream toe using a drain backfill envelope continuously along the pipe to where it exits the embankment or by use of an adequate pipe drain. Drain fill shall be protected from surface erosion by using filter fabric covered by small riprap. Adequate protection of the outlet, including adequate animal guards, shall be provided.

Anti-seep Collars. When anti-seep 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 but not more than 25 feet. The minimum spacing shall be 10 feet. The anti-seep collars shall be located in the normal saturation zone. Collar material shall be compatible with pipe materials. The anti-seep collar(s) shall increase by at least 15 percent the seepage path along the pipe.

Trash Guard. To prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser unless the watershed does not contain trash or debris that could clog the conduit.

Other Outlets. 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.

Auxiliary spillways. Auxiliary spillways convey large flood flows safely past earth embankments and have historically been referred to as “Emergency Spillways”.

An auxiliary 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 auxiliary spillway: a conduit with a cross-sectional area of 3 ft^2 or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

The minimum capacity of a natural or constructed auxiliary spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2, less any reduction creditable to conduit discharge and detention storage.

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

Constructed auxiliary 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 or in-situ rock. The freeboard portion of the spillway depth may be against compacted fill for Job Class I and II ponds. A portion of the design flow may be located in compacted earth, if approved by the engineer. 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 feet, the auxiliary spillway shall have a bottom width of not less than 10 feet.

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 auxiliary spillway shall fall within the range established by discharge requirements and permissible velocities.

Structural auxiliary spillways. If chutes or drops are used for principal spillways or auxiliary spillways, they shall be designed according to the principles set forth in the Part 650, Engineering Field Handbook 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 2, less any reduction creditable to conduit discharge and detention storage.

Ponds in Series. Hydrology for all ponds in series will be evaluated by an engineer with adequate expertise in this field. The hydrologic criteria and procedures for the design of an upper dam shall not be less than that used for dams downstream if failure of the upper dam would contribute to failure of the lower dam. For dams not flood routed, the volume of detention storage in the lower dam shall be based on runoff from the entire drainage area with appropriate reduction due to detention storage in the upper pond. The release rate of the pipe spillway in the downstream pond shall be greater than the pipe spillway of the upstream pond. The emergency spillway of the lower site shall be designed to safely pass the peak flow from the entire drainage area as if the upper pond was not in place. For ponds which are flood routed, procedures as outlined in Technical Release 60, "Earth Dams and Reservoirs" shall be followed.

Reservoir Clearing. Reservoir areas shall be cleared at least to the elevation of the crest of the principle spillway; however, less clearing may be approved for a specific site if the structure incorporates fish and other wildlife features and the owner requests that the area not be cleared. The minimum area cleared must extend the full length of the dam for a distance of at least 400 feet upstream from the principal spillway and of the auxiliary spillway. When the reservoir area exceeds 100 acres, North Carolina law requires complete clearing of the reservoir area.

Criteria for Excavated Ponds

Runoff. Provisions shall be made for a pipe and auxiliary spillway if the planned depth of water in the excavated pond is increased due to a planned embankment, and the embankment shall meet the requirements listed for Embankment Ponds. Runoff flow patterns shall be considered when locating the excavated pond and placing the spoil.

Side slopes. Side slopes of excavated ponds shall be stable and shall not be steeper than one 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 five horizontal to one vertical. A wearing coarse on the surface of the ramp shall be considered and planned when needed.

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 it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

- Uniformly spread to a height that does not exceed 3 feet, with the top graded to a continuous slope away from the pond.
- 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 feet from the edge of the pond.
- Shaped to a designed form that blends visually with the landscape.
- Used for low embankment construction and leveling of surrounding landscape.
- Hauled away.

CONSIDERATIONS

Visual resource design. The visual design of ponds should 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.

Cultural Resources. Consider existence of cultural resources in the project area and any project impacts on such resources. Consider conservation and stabilization of archeological, historic, structural, and traditional cultural properties when appropriate.

Fish and Wildlife. Project location and construction should minimize the impacts to existing fish and wildlife habitat.

When feasible, structure should be retained, such as trees in the upper reaches of the pond and stumps in the pool area. Upper reaches of the pond can be shaped to provide shallow areas and wetland habitat.

If fish are to be stocked, consider criteria and guidance in conservation practice standard 399, Fishpond Management.

Vegetation. Stockpiling topsoil for placement on disturbed areas can facilitate revegetation.

Consider placement and selection of vegetation to improve fish and wildlife habitat and species diversity.

Water Quantity. Consider effects upon components of the water budget, especially:

- Effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
- Variability of effects caused by seasonal or climatic changes.
- Effects on downstream flows and impacts to environment, such as wetlands, aquifers, and social and economic impacts to downstream uses or users.
- Potential for multiple purposes.

Water Quality. Consider effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that are carried by runoff.

- Effects on the visual quality of onsite and downstream water resources.
- Short-term and construction-related effects of this practice on the quality of downstream water courses.
- Effects of water level control on the temperatures of downstream water to prevent undesired effects on aquatic and wildlife communities.
- Effects on wetlands and water-related wildlife habitats.
- Effects of water levels on soil nutrient processes such as plant nitrogen use or denitrification.
- Effects of soil water level control on the salinity of soils, soil water, or downstream water.
- Potential for earth moving to uncover or redistribute toxic materials such as saline soils.

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.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed and reviewed with the landowner or individual responsible for operation and maintenance.

Ponds must be adequately maintained if their purposes are to be realized throughout the expected life. Special considerations shall be given for maintenance needs during the planning, design, and construction of the pond.

REFERENCES

USDA-NRCS Publications:
National Engineering Manual
Engineering Field Handbook
National Engineering Handbook
Technical Releases
SITES – Dam Spillway Evaluation
NC Field Office Technical Guide Section IV
NC Bulletin 210-2-1(NC-ENG-33)

NC Dam Safety Law - G.S. 143-215.24

NC Administrative Code - 15A NCAC 02K.0100

NC Administrative Code - 15A NCAC 18B.0100

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