Natural Resources Conservation Service

CONSERVATION PRACTICE STANDARD

POND

CODE 378

(no)

DEFINITION

A pond is a water impoundment made by constructing an embankment, by excavating a dugout, or by a combination of both.

In this standard, NRCS defines ponds constructed by the first method as embankment ponds, and those constructed by the second method 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 above the lowest original ground along the centerline of the embankment.

PURPOSE

This practice is used to accomplish one or more of the following purposes:

- Store water for livestock
- Store water for fish and wildlife
- Store water for recreation use
- Store water for fire control
- Store water for erosion control
- Store water for flow detention
- Improve water quality

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to all excavated ponds. It also applies to embankment ponds that meet all of the criteria for low-hazard dams as listed below:

- The 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 acre-feet^2. Storage is the capacity of the reservoir in acre-feet below the elevation of the crest of the lowest auxiliary spillway or the elevation of the top of the dam if there is no open channel auxiliary spillway. The effective height of the dam is the difference in elevation, in feet, between the lowest open channel auxiliary spillway crest and the lowest point in the original cross section taken on the centerline of the dam. If there is no open channel auxiliary spillway, use the lowest point on the top of the dam instead of the lowest open channel auxiliary spillway crest.
- The effective height of the dam is 35 feet or less.

CRITERIA

General Criteria Applicable to All Purposes

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

Colorado statutes govern the use of surface and underground water. The owner is responsible for securing necessary permits and water rights, complying with all laws and regulations, and meeting legal requirements applicable to the installation, operation, and maintenance of the pond and associated structures.

Reservoirs excavated for the acquisition of groundwater shall meet the requirements of the State of Colorado - State Board of Examiners of Water Well Construction and Pump Installation Contractors.

State of Colorado Jurisdictional Dams
Jurisdictional dams having a height greater than 10 feet to the spillway crest, or stores more than 100 acre-feet of water, or covers more than 20 acres at the high waterline shall be approved by the State Engineer of Colorado.

State of Colorado Non-Jurisdictional Dams
Non-Jurisdictional Dams are smaller than jurisdictional dam and a Notice of Intent to Construct a Non-Jurisdictional Water Impoundment Structure must be filed 45 days prior to construction. Approval from the Colorado Division Engineer is required for construction.

State of Colorado Erosion Control Dams and Livestock Water Tanks
Livestock Water Tanks and Erosion Control Dams approved with a State of Colorado standard application form cannot exceed 15 feet in height measured vertically from the upstream toe to the auxiliary spillway crest and the capacity of the reservoir cannot exceed 10 acre-feet. They are permitted only on watercourses, which are determined by the State Engineer of Colorado to be normally dry.

Erosion Control Dams with more than 2 acre-feet capacity must have an ungated outlet large enough to pass stored water in excess of 2 acre-feet within a 36-hour period. The minimum pipe diameter shall be 12 inches with the inlet placed at or below the 2 acre-feet storage volume level.

Design a minimum sediment storage capacity equal to the design life of the structure, or provide for periodic cleanout. Protect the drainage area above the pond to prevent sedimentation from adversely affecting the design life.

Design measures necessary to prevent serious injury or loss of life in accordance with requirements of NRCS National Engineering Manual (NEM), Part 503, Safety.

Seed or sod the exposed surfaces of earthen embankments, earth spillways, borrow areas, and other areas disturbed during construction in accordance with the criteria in NRCS Conservation Practice Standard (CPS) Code 342, Critical Area Planting. When necessary to provide surface protection where climatic conditions preclude the use of seed or sod, use the criteria in CPS Code 484, Mulching, to install inorganic cover material such as gravel.

Fencing shall be installed as required for the protection of vegetation and for safety considerations. Fencing shall comply with the guidelines in conservation practice standard 382, Fencing.

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

Site conditions
Select or modify the site to allow runoff from the design storm to safety pass through (1) a natural or constructed auxiliary spillway, (2) a combination of a principal spillway and an auxiliary spillway, or (3) a principal spillway.

Select a site that has an adequate supply of water for the intended purpose via surface runoff, groundwater, or a supplemental water source. Water quality must be suitable for its intended use.

Reservoir
Provide adequate storage volume to meet user demands for all intended purposes. Account for sedimentation, season of use, evaporation loss, and seepage loss when computing the storage volume.

Ponds for fish shall have a minimum size of one-half surface acre. No more than 20% of the area should have water depths less than 2 feet. Fish-out and rearing ponds may be smaller and shallower.

Depth along the shoreline of fishponds should slope abruptly into three (3) feet of water with consideration of appropriate safety measures. In addition, ponds where fish will be overwintered:

1. Below 6,000 feet or warmwater ponds at any elevation should have a minimum depth of 8 feet over one-third of the pond area during the lowest water period.
2. Above 6,000 feet or coldwater ponds at any elevation should have a minimum depth of 10 feet over 0ne-third of the pond area. Where a live stream or aerated spring water flows continuously into a pond, the minimum depth required is 7 feet over one-third of the pond area.

Criteria Applicable to Embankment Ponds

Geological investigations
Use pits, trenches, borings, review of existing data or other suitable means of investigation to characterize materials within the embankment foundation, auxiliary spillway, and borrow areas. Classify soil materials using the Unified Soil Classification System (ASTM D2487).

Foundation cutoff
Design a cutoff of relatively impervious material under the dam and up the abutments as required for preventing seepage. Locate the cutoff at, or upstream from, the centerline of the dam. Extend the cutoff deep enough to intercept flow and connect with a relatively impervious layer. Combine seepage control with the cutoff as needed. Use a cutoff bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. The cutoff trench shall be trapezoidal with a minimum bottom width of five (5) and a minimum depth of four (4) feet. Design cutoff side slopes no steeper than one horizontal to one vertical.

Seepage control
Include seepage control if (1) foundation cutoff does not intercept pervious layers, (2) seepage could create undesired wet areas, (3) embankment stability requires seepage control, or (4) special problems require drainage for a stable dam. Control seepage by (1) foundation, abutment, or embankment filters and drains; (2) reservoir blanketing; or (3) a combination of these measures.

Top width
Table 1 provides the minimum top widths for dams of various total heights. Total height is the vertical distance between the settled top of the dam and the lowest elevation at the downstream toe.

Design a minimum width of 16 feet for one-way traffic and 26 feet for two-way traffic for the top of dams used as public roads. Design guardrails or other safety measures where necessary and follow the requirements of the responsible road authority. For dams less than 20 feet in total height, maintenance considerations or construction equipment limitations may require increased top widths from the minimum shown in table 1.

Table 1. Minimum top width for dams.

Total height of dam *(feet)*	Top width *(feet)*
Less than 10	6
10–14.9	8
15–19.9	10
20–24.9	12
25–34.9	14
35 or more	15

Side slopes
Design each side slope with a ratio of two horizontal to one vertical or flatter. Design the sum of the upstream- and downstream-side slopes with a ratio of five horizontal to one vertical or flatter. As required, design benches or flatten side slopes to assure stability of all slopes for all loading conditions.

Slope protection
Design special measures such as berms, rock riprap, sand-gravel, soil cement, or special vegetation as needed to protect the slopes of the dam from erosion. Use NRCS Engineering Technical Release (TR) 210 56, A Guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments, and TR-210-69, Riprap for Slope Protection against Wave Action, as applicable.

Freeboard
Design a minimum of 1.0 feet of freeboard between design high-water-flow elevation in the auxiliary spillway and the top of the settled embankment. Design a minimum 5 feet for all Jurisdictional dams unless the Colorado State Engineer approves a lesser amount. State of Colorado – Erosion Control Dams and Livestock Water Tanks shall have a minimum of 4 feet of elevation difference between the auxiliary spillway and top of dam.

Settlement
Increase the height of the dam by the amount needed to ensure that the settled top elevation of the dam equals or exceeds the design top elevation. Design a minimum of 5 percent of the total height of the dam associated with each dam cross section, except where detailed soil testing and laboratory analyses or experience in the area shows that a lesser amount is adequate.

Principal spillway and pipe conduit through the embankment
Design a pipe conduit with needed appurtenances through the dam, except where rock, concrete, or other types of lined spillways are used, or where a vegetated or earth spillway can safely handle the rate and duration of base flow.

Design a minimum of 0.5-feet difference between the crest elevation of the auxiliary spillway and the crest elevation of the principal spillway when the dam has a drainage area of 20 acres or less. Design a minimum of 1.0-foot difference when the dam has a drainage area of over 20 acres.

Erosion Control Dams that store less than two acre-feet must (1) be large enough to store the runoff from a 5 year 24 hour frequency storm where the auxiliary spillway is located on erosive soils or (2) be large enough to contain the runoff from a 2 year 24 hour storm if the auxiliary spillway is on non-erosive soils and (3) must store at least the ten year sediment yield from the watershed. Otherwise an ungated principal spillway shall be constructed.

Erosive soils are considered to be those with an erosive index “K” greater than 0.35; this includes most SC’s, SP’s, SP-SM’s, SM’s and some CH’s soils as classified by the Unified Soil Classification System.

The capacity of the principal spillway shall be such that the frequency of flow through the auxiliary spillway as related to the general condition of the auxiliary spillway shall not exceed those in Table 3.

Table 2. Frequency of Auxiliary Spillway Flow.

General Condition of Auxiliary Spillway	**Frequency of Flow Expected in Auxiliary Spillway**
Sod, small drop	Every two years
Good spread, over shrubby banks	Every three or four years
No spread, over raw bank	Every eight years
Over sand bank or in building lots	Every twenty-five years

Provide an antivortex device for a pipe conduit designed for pressure flow. Design the inlet and outlet to function for the full range of flow and hydraulic head anticipated.

Design adequate pipe conduit capacity to discharge long-duration, continuous, or frequent flows without causing flow through the auxiliary spillway. Design a principal spillway pipe with a minimum inside diameter of 4 inches. Design pipe with a minimum inside diameter of 1-1/4 inches for water supply pipes or for pipes used for any other purpose.

Design pipe conduits using ductile iron, welded steel, corrugated steel, corrugated aluminum, reinforced concrete (pre-cast or site-cast), or plastic. Do not use cast iron or unreinforced concrete pipe if the dam is 20 feet or greater in total height.

Design and install pipe conduits to withstand all external and internal loads without yielding, buckling, or cracking. Design rigid pipe for a positive projecting condition. Design flexible pipe conduits in accordance with the requirements of NRCS National Engineering Handbook (NEH), Part 636, Chapter 52, Structural Design of Flexible Conduits.

The minimum thickness of flexible pipe shall be SDR 26, Schedule 40, Class 100, or 16 gage as appropriate for the particular pipe material. Table 4 & 5 provides details.

Table 3. Acceptable PVC* pipe for use in earth dams

Nominal Pipe Size	Schedule or Standard	Maximum Depth of Fill over Pipe
(inches)	Dimension Ratio (SDR)	(feet)
1 1/2**, 2**	Schedule 40 or 80 or SDR 13.5	30
4**	Schedule 40 or SDR 17	20
6, 8, 10, 12	Schedule 40 or SDR 26	10
6, 8, 10, 12	SDR 21	12
6, 8	Schedule 80 or SDR 17	15
10, 12	Schedule 80	15
* Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM D 1785 or ASTM D 2241 ** Limited to water supply lines		

Table 4. Minimum thickness - corrugated metal pipe

Pipe Dia. (inches)	Steel with 2 2/3 In. x 1/2 In. Corrugation (gage)			Steel with 3 In. x 1 In. Corrugation (gage)			Aluminum* with 2 2/3 In. x 1/2 In. Corrugation			
	Fill Height above Pipe (feet)									
	<15	15-20	20-25	<15	15-20	20-25	<15	15-20	20-25	
21 & Less	16	16	16	—	—	—	.06	.06	.06	
24	16	16	16	—	—	—	.06	.075	.105	
30	16	16	14	—	—	—	.075	.105	.135	
36	14	14	12	16	16	16	.075	.105	**	
42	12	12	10	16	16	16	**	**	—	
48	10	10	10	16	16	14	—	—	—	
54	—	—	—	16	16	12	—	—	—	
60	—	—	—	16	14	10	—	—	—	
66	—	—	—	16	14	8	—	—	—	
72	—	—	—	16	14	8	—	—	—E	
*Riveted or helical fabrication										

Design connections of flexible pipe to rigid pipe or other structures to accommodate differential movements and stress concentrations. Design and install all pipe conduits to be watertight using couplings, gaskets, caulking, water stops, or welding. Design joints to remain watertight under all internal and external loading including pipe elongation due to foundation settlement.

Design a concrete cradle or bedding for pipe conduits if needed to reduce or limit structural loading on pipe and improve support of the pipe.

Design outlet structures, such as cantilever pipe outlet sections and impact basins, to dissipate energy as needed.

Corrosion protection
Provide protective coatings for all steel pipe and couplings in areas that have traditionally experienced pipe corrosion or in embankments with saturated soil resistivity less than 4,000 Ohm-cm or soil pH less than 5. Protective coatings may include asphalt, polymer over galvanizing, aluminized coating, or coal tar enamel.

Ultaviolet protection
Use ultraviolet-resistant materials for all plastic pipe or provide coating or shielding to protect plastic pipe exposed to direct sunlight.

Cathodic protection
Provide cathodic protection 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 the original design and installation did not include cathodic protection, consider establishing electrical continuity in the form of joint-bridging straps on pipes that have protective coatings. Add cathodic protection later if monitoring indicates the need.

Filter diaphragms
When the effective height of the dam is 15 feet or greater and the effective storage of the dam is 50 acre-ft. or more, provide filter diaphragms to control seepage on all pipes extending through the embankment with inverts below the peak elevation of the routed design hydrograph. Design filter diaphragms or

alternative measures as needed to control seepage on pipes extending through all other embankments or for pipes with inverts above the peak elevation of the routed design hydrograph.

Design the filter diaphragm in accordance with the requirements of NEH, Part 628, Chapter 45, Filter Diaphragms. Locate the filter diaphragm immediately downstream of the cutoff trench, but downstream of the centerline of the dam if the foundation cutoff is upstream of the centerline or if there is no cutoff trench.

To improve filter diaphragm performance, provide a drain outlet for the filter diaphragm at the downstream toe of the embankment. Protect the outlet from surface erosion and animal intrusion.

Ensure filter diaphragm functions both as a filter for adjacent base soils and as a drain for seepage that it intercepts. Materials for the filter diaphragm shall meet the requirements of NEH Part 628, Chapter 45, Filter Diaphragms, Section 628.4503(d), Filter and Drain Gradation.

When using anti-seep collars in lieu of a filter diaphragm, ensure a watertight connection to the pipe. Limit the maximum spacing of the anti-seep collars to 14 times the minimum projection of the collar measured perpendicular to the pipe, or 25 feet, whichever is less. Locate anti-seep collars no closer than 10 feet apart. Use a collar material that is compatible with the pipe material.

When using anti-seep collars, design the collars to increase the seepage path along the pipe within the fill by at least 15 percent.

Trash guard
Install a trash guard at the riser inlet to prevent clogging of the conduit, unless the watershed does not contain trash or debris that could clog the conduit.

Pool Drain
Provide a pipe with a suitable valve to drain the pool area if needed for proper pond management or if required by State Engineer of Colorado to prevent interference with natural stream flow through the reservoir or injury of another appropriator downstream. The designer may use the principal spillway conduit as a pond drain if it is located where it can perform this function.

Auxiliary spillways
A dam must have an open channel auxiliary spillway, 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 minimum criteria for acceptable use of a closed conduit principal spillway without an auxiliary spillway consist of a conduit with a cross-sectional area of 3 feet2 or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash.

Design the minimum capacity of a natural or constructed auxiliary spillway to pass the peak flow expected from a total design storm of the frequency and duration shown in table 5, less any reduction creditable to the conduit discharge and detention storage.

Design the auxiliary spillway to safely pass the peak flow through the auxiliary spillway, or route the storm runoff through the reservoir. Start the routing 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. Compute the 10-day drawdown from the crest of the auxiliary spillway or from the elevation attained from impounding the entire design storm, whichever is lower. Design the auxiliary spillway to pass the design flow at a safe velocity to a point downstream where the flow will not endanger the dam.

A constructed auxiliary spillway consists of an inlet channel, a control section, and an exit channel. Design the auxiliary spillway with a trapezoidal cross section. Locate the auxiliary spillway in undisturbed or compacted earth or in-situ rock. Design for stable side slopes for the material in which the spillway is to be constructed. Design a minimum bottom width of 10 feet for dams having an effective height of 20 feet or more.

Design a level inlet channel upstream from the control section for the distance needed to protect and maintain the crest elevation of the spillway. If necessary, curve the inlet channel upstream of the level section to fit existing topography. Design the exit channel grade in accordance with NEH Part 628, Chapter 50, Earth Spillway Design, or with equivalent procedures.

Structural auxiliary spillways
When used for principal spillways or auxiliary spillways, design chute spillways or drop spillways according to the principles set forth in NEH, Part 650, Engineering Field Handbook; and NEH, Section 5, Hydraulics; Section 11, Drop Spillways; and Section 14, Chute Spillways. Design a structural spillway with the minimum capacity required to pass the peak flow expected from a total design storm of the frequency and duration shown in table5, less any reduction creditable to the conduit discharge and detention storage.

Table 5. Minimum auxiliary spillway capacity

Minimum design storm2				
Drainage area *(acre)*	Effective height of dam1 *(feet)*	Detention storage *(acre-feet)*	Frequency *(years)*	Minimum duration *(hours)*
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

[1]. Defined under "Conditions where Practice Applies."

[2.] rain distribution based on climatological region.

Additional Criteria for Excavated Ponds

Runoff
Design a minimum of 1.0 feet of freeboard above the peak elevation of the routed design hydrograph. Design a pipe and auxiliary spillway (when embankments are part of the excavated pond design) that will meet the capacity requirements of table 5. Consider runoff flow patterns when locating the excavated pond and placing the spoil.

Side slopes
Design stable side slopes no steeper than three horizontal to one vertical on the pond side and no steeper than 2:1 on the outside slope.

Watering Ramp
When wildlife or livestock need access to stored water, use the criteria in NRCS CPS Code 614, Watering Facility, to design a watering ramp.

Inlet protection
Protect the side slopes from erosion where surface water enters the pond in a natural or excavated channel.

Excavated material
Place the material excavated from the pond so that its weight does not endanger the stability of the pond side slopes and so that the soil will not wash back into the pond by rainfall.

Dispose of excavated material 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 place or shape reasonably well, with side slopes assuming a natural angle of repose. Place excavated material at a distance equal to the depth of the pond, but not less than 12 feet

from the edge of the pond.

- Shape to a designed form that blends visually with the landscape.
- Provide for low embankment construction and leveling of surrounding landscape.
- Haul material offsite.

CONSIDERATIONS

Visual resource design

Carefully consider the visual design of ponds in areas of high public visibility and those associated with recreation. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their function.

Shape the embankment to blend with the natural topography. Shape the edge of the pond so that it is generally curvilinear rather than rectangular. Shape excavated material so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, add islands to provide visual interest and to attract wildlife.

Fish and wildlife

Locate and construct ponds to minimize the impacts to existing fish and wildlife habitat.

When feasible, retain structures such as trees in the upper reaches of the pond and stumps in the pool area. Shape upper reaches of the pond to provide shallow areas and wetland habitat. Consider constructing an undulating pond bottom to maximize wetland and wildlife benefits.

If operations include stocking fish, use CPS Code 399, Fishpond Management.

Vegetation

Stockpile topsoil for placement on disturbed areas to facilitate revegetation.

Consider selecting and placing vegetation to improve fish habitat, 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 groundwater 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.

Water quality

Consider the effects of—

- Erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that runoff carries.
- Short-term and construction-related effects of this practice on the quality of downstream watercourses.
- Water-level control on the temperatures of downstream water to prevent undesired effects on aquatic and wildlife communities.
- Wetlands and water-related wildlife habitats.
- Water levels on soil nutrient processes such as plant nitrogen use or denitrification.

- Soil water level control on the salinity of soils, soil water, or downstream water.
- Potential for earth moving to uncover or redistribute toxic materials.
- Livestock grazing adjacent to the pond. Consider fencing to keep livestock activities out of direct contact with the pond and dam

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice according to this standard. As a minimum, include the following items:

- A plan view of the layout of the pond and appurtenant features
- Typical profiles and cross sections of the principal spillway, auxiliary spillway, dam, and appurtenant features as needed
- Structural drawings adequate to describe the construction requirements
- Requirements for vegetative establishment and/or mulching, as needed
- Safety features
- Site-specific construction and material requirements

OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator.

As a minimum, include the following items in the operation and maintenance plan:

- Periodic inspections of all structures, earthen embankments, spillways, and other significant appurtenances
- Prompt repair or replacement of damaged components
- Prompt removal of sediment when it reaches predetermined storage elevations
- Periodic removal of trees, brush, and undesirable species
- Periodic inspection of safety components and immediate repair if necessary
- Maintenance of vegetative protection and immediate seeding of bare areas as needed

REFERENCES

State of Colorado - Rules and Regulations for Dam Safety and Dam Construction, 2 CCR 402-1, can be located at the following web address: http://water.state.co.us/SurfaceWater/DamSafety

State of Colorado - Rules and Regulations for Water Well Construction, Pump Installation, and Monitoring and Observation Hole/Well Construction (Water Well Construction Rules) 2 CCR 402-2 can be located at the following web address: http://water.state.co.us/Groundwater/boe/

American Society for Testing and Materials. Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), ASTM D2487. West Conshohocken, PA.

USDA NRCS. Engineering Technical Releases, TR-210-60, Earth Dams and Reservoirs. Washington, DC.

USDA NRCS. National Engineering Handbook (NEH), Part 628, Dams. Washington, DC. USDA NRCS. NEH, Part 633, Soil Engineering. Washington, DC.

USDA NRCS. NEH, Part 636, Structural Engineering. Washington, DC. USDA NRCS. NEH, Part 650, Engineering Field Handbook. Washington, DC. USDA NRCS. National Engineering Manual. Washington, DC.