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.

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).

4. For class "a" dams with a height-storage product greater than 3,000, and for class "b" and "c" dams, the design criteria shall be the more restrictive of the criteria set forth herein or as outlined in TR-60.

5. Hazard classification shall be documented by the procedures in NEM, Section 520.23(b), CA-Supplement.

PURPOSES

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

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 3 that sealing is practicable.

CRITERIA

Design criteria for embankment ponds

Geological Investigations

Pits, trenches, borings, or other suitable means of investigation for sampling and classification of materials shall be conducted within the embankment foundation, along the emergency spillway centerline and within the borrow areas. Soil materials shall be classified using the Unified Soil Classification System.

The embankment foundation shall be investigated thoroughly to determine the following:

1. Depth to competent impervious layer.
2. Ability of the foundation to withstand load.
3. Seepage potential through the abutments and foundation.

The emergency spillway shall be investigated to determine the following:

1. The suitability of the material as a borrow source.
2. The potential for the spillway to erode.
3. The difficulty of excavation.

The borrow areas shall be defined by at least three pits, trenches, or borings. Quantities of borrow volumes shall be computed based upon the extent of investigation.

The percentage of over-runs of borrow volume to embankment volume is determined by the degree of borrow investigation. The minimum borrow volume, excluding waste, shall exceed the embankment volume by 1.5.

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) previous 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
ft	ft
10 or less	8
10-15	10
15-20	10
20-25	12
25-35	14
35 or more	15

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.

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).

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.

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.

The borrow operation shall not be permitted closer than 50 feet from the upstream toe of the embankment except where the cutoff trench extends into firm impervious material for its entire length.

Since all of California is classified as a high seismic area, special considerations shall be incorporated into the design of each embankment as a defensive measure for earthquakes (NEM 520.24(a)(1). Examples of such considerations that would help the embankment withstand seismic loads include:

1. Constructing the embankment of compacted clayey materials.

2. The addition of a berm (or berms).

3. Increase the embankment top width.

4. Include an embankment drain.

5. Add additional freeboard to the top of the dam if foundation settlements are anticipated.

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.

The 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 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, asbestos-cement, concrete, plastic, vitrified clay with rubber gaskets, and cast-in-place reinforced concrete. Asbestos-cement, concrete, and vitrified clay 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 steel or 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 of asbestos-bonded, 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 resisitivity is less than 4,000 ohms-cm, or where soil pH is lower than 5.

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

Cathodic protection is to be provided for coated welded steel and galvanized corrugated metal pipe where soil and resisitivity 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

Table 2. - Acceptable PVC pipe for use in earth dams[1]

Nominal pipe size	Schedule for standard dimension ratio (SDR)	Max. depth fill over pipe
in.		ft
4 or smaller	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 3. - Minimum gage for corrugated metal pipe (2-2/3in X 1/2 in corrugations)[1]

Fill of height (ft)	Minimum gauge for steel pipe with diameter (in) of: 21 and less	24	30	36	42	48	Min. thickness of aluminum pipe[2] with diameter (in): 21 and less	24	30	36
1-15	16	16	16	14	12	10	.06	.075	.075	.075
15-20	16	16	16	14	12	10	.06	.075	.075	.105
20-25	16	16	14	12	10	10	.06	.105	.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.

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

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.

Seepage along pipes extending through the embankment shall be controlled by use of a filter and drainage diaphragm, unless it is determined that anti-seep 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 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. Collar material shall be compatible with pipe materials the anti-seep collar(s) shall increase by 15% the seepage path along the pipe.

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

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

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.

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

Pipe Conduits

Pipe conduits shall be placed through or under embankments where required for safety, for proper operation of the reservoir and spillway, or for water rights requirements.

Where a pipe conduit is to be installed, the following shall apply:

1. No valve shall be installed when the conduit serves the single purpose of carrying flow from a trickle tube riser. For secondary discharge systems, control valves shall be installed on the upstream end unless otherwise approved by the State Conservation Engineer.

2. The conduit shall be placed in a trench excavated in firm foundation or in compacted fill not more than three feet above firm foundation.

3. All pipe conduits through earth embankments shall be concrete bedded or encased in concrete as defined below:

Embankment Minimum Treatment Height:

A. Concrete Pipe with Round Rubber Gasket joints

10 feet or less	2-inch concrete bedding up 1/3 the O.D.on both sides of the pipe centerline.
10 to 25 feet	1/2 O.D. Concrete cradle
25 to 35 feet	1/2 O.D. Concrete cradle

B. Corrugated Metal Pipe and Plastic

25 feet	Complete encasement
25 feet or greater	CMP shall not be used

4. When a pipe conduit is to be encased with concrete, the trench shall be excavated to the neat lines and grades so that the bottom and two sides become suitable forms for the concrete.

5. Anti-seep collars shall be installed around all conduits within the normal saturation zone, the upstream two thirds of the conduit length or upstream of a positive embankment drainage system.

   These collars shall extend beyond the pipe or encasement not less than 18 inches in all directions except where a watertight seal can be obtained by tying the collar into firm rock.

   The maximum spacing shall not exceed 15 feet. Corrugated metal collars are not permitted.

6. The installation of trickle tubes are allowed provided the tube is buried in the embankment side slopes at a shallow depth of 1.0 feet to protect the pipe. Usually trickle tubes are installed to convey water to a trough for livestock use.

7. When cathodic protection is needed, the procedures of Design Note 12 shall be used.

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 over topping 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 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 emergency spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in table 4, less any reduction creditable to conduit discharge and detention storage.

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.

Capacity

The minimum capacity of the natural or constructed emergency spillway shall be that required to pass the peak outflow expected from a 50-year 24 hour frequency storm, less any reduction creditable to conduits or detention storage.

When drainage areas are less than 20 acres, the minimum depth of an open emergency spillway will be the depth of flow plus 1.0 feet, but never less than 1.5 feet. The minimum bottom width shall be 5 feet.

The minimum capacity of a closed emergency spillway shall be sufficient to pass the peak flow expected from a 100-year 24-hour frequency storm, less any reduration reditable to principal spillways or detention storage.

Where there are dams in series (NEM, 520.24(a)(1), the design of the downstream structure shall address what will happen should the upstream structure fail. Some precautions that could be considered are:

1. Adding additional freeboard to the embankment.
2. Larger capacity emergency spillway.
3. Address how overtopping will affect the structure being designed.

Freeboard

The minimum difference in elevation between the crest of the emergency spillway and the settled top of dam shall be either depth of design flow plus 1 foot or 3 feet whichever is greater.

For concrete chute spillways the minimum difference in elevation between the crest of the emergency spillway and the settled top of dam shall be either the depth of flow plus 0.5 feet or 2.0 feet whichever is greater.

Erosion Protection

Earth or vegetated spillways shall be non-erosive for the runoff from a 50 year 24 hour frequency storm. Pipe spillways may be used to carry part or all of this flow where erosion will occur. If some erosion will occur during higher frequency storms, the quantity of sediment and its effect downstream shall be addressed.

Side Slopes

Where spillway levees or training dikes are required to protect the downstream toe of the fill, they shall have side slopes not steeper than 3:1.

The minimum top width for the spillway training dikes or levees shall be 12 feet.

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 4, less any reduction creditable to conduit discharge and detention storage.

Table 4. - Minimum spillway capacity

Drainage Minimum area	Effective height of dam[1]	Storage	Minimum design storm[2] Frequency	Duration
ac	ft	ac-ft	yr	hr
20 or less	20 or less	<50	10	24
20 or less	>20	<50	25	24
>20	20 or less	<50	25	24
All others			50	24

1. As defined under "Scope".
2. Select rain distribution based on climatological data.

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 4).

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 three 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.

STATE AND LOCAL REQUIREMENTS

All state and local requirements shall be addressed in the design.

Water Rights

It is imperative that any owner planning to construct a facility to store runoff water be advised that the state water code requires filing for a water right, regardless of the amount of that storage.

Such a filing is made to the Water Rights Division of the California Water Resources Control Board. The Board may require a conduit or other satisfactory means to enable water to pass through the embankment or other barrier creating the storage. The requirement for a conduit cannot be prejudged. It is determined by the Board based on the circumstances of each individual situation.

It is the responsibility of the owner to file for the water rights and advise NRCS of the Board's decision on the requirements for a conduit. The owner should also be advised of the possible need for other local, state or federal permits.

State Division of Dam Safety

Drawings and specifications for dams within the jurisdiction of the California Division of Safety of Dams shall also meet the requirements of that organization.

Dams within the State jurisdiction dams are:

1. Dams over 25 feet in height and with storage of 15 acre-feet or more.

2. Dams over 6 feet in height and with storage of 50 acre-feet or more.

In general the design for state-size dams will need to meet the minimum requirements for a "b" hazard structure as outlined in Technical Release 60.

Pipe conduits must be placed through or under all embankments that are of a size to be within the jurisdiction of the California Division of Safety of Dams.

CONSIDERATIONS

Water Quantity

Ponds impound water. In doing so they create a new surface and ground regime. The peak discharge downstream may be reduced, and in dry weather the downstream flow may go to zero. Depending on the site, there may be an increased flow to the ground water. With some seepage the base flow may be extended over a longer period of time. By impounding water at times of over a longer period of time. By impounding water at times of runoff, ponds make water available for use at some later date.

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

Ponds may trap nutrients and sediment that wash into the basin. This removes these substances from downstream. Chemical concentrations in the pond may be higher during the summer months. By reducing the amount of water that flows in the channel downstream, the frequency of flushing of the stream is reduced and there is a temporary collection of substances held temporarily within the channel. A pond may cause more leachable substances to be carried into the goundwater.

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.

Endangered Species Considerations

Determine if installation of this practice with any others proposed will have any effect on any federal or state listed Rare, Threatened or Endangered species or their habitat. NRCS's objective is to benefit these species and others of concern or at least not have any adverse effect on a listed species. If the Environmental Evaluation indicates the action may adversely affect a listed species or result in adverse modification of habitat of listed species which has been determined to be critical habitat, NRCS will advise the land user of the requirements of the Endangered Species Act and recommend alternative conservation treatments that avoid the adverse effects. Further assistance will be provided only if the landowner selects one of the alternative conservation treatments for installation; or at the request of the landowners, NRCS may initiate consultation with the Fish and Wildlife Service, National Marine Fisheries Service and/or California Department of Fish and Game. If the Environmental Evaluation indicates the action will not affect a listed species or result in adverse modification of critical habitat, consultation generally will not apply and usually would not be initiated. Document any special considerations for endangered species in the Practice Requirements Worksheet.

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

Maintenance item shall be reviewed with the landowner. A copy of the construction specifications indicating the O & M items are to be given to the landowner, and his acknowledgement of the content to be given by his signature on the NRCS file copy.