



## Natural Resources Conservation Service

### CONSERVATION PRACTICE STANDARD

#### POND

#### CODE 378

#### (no)

#### DEFINITION

A water impoundment made by constructing an embankment, excavating a dugout, or 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 using a combination of the excavation and 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
  - Fish and wildlife
  - Recreational use
  - Fire control
  - Erosion control
  - 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 criteria for low-hazard potential 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<sup>2</sup>. 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 Ponds

Plan, design, and construct the pond to comply with all Federal, State, and local laws and regulations. Notify landowners and/or contractor of their responsibility to locate all buried utilities in the project area, including drainage tile and other structural measures. The landowner is also required to obtain all necessary permits for project installation prior to construction.

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 according to the requirements of NRCS National Engineering Manual (NEM) (Title 210), Part 503, "Safety."

Seed, sprigs 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) Critical Area Planting (Code 342) and/or the *Oklahoma Plant Materials Technical Note 21*. When necessary to provide surface protection where climatic conditions preclude the use of seed, sprigs or sod, use the criteria in NRCS CPS Mulching (Code 484) to install inorganic cover material such as gravel. If necessary, temporary vegetation may be applied on exposed surfaces using the Oklahoma NRCS CPS, Cover Crop (340) criteria, until permanent vegetation can be established.

### **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 safely pass through a natural or constructed auxiliary spillway, a combination of a principal spillway and an auxiliary spillway, or a principal spillway.

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

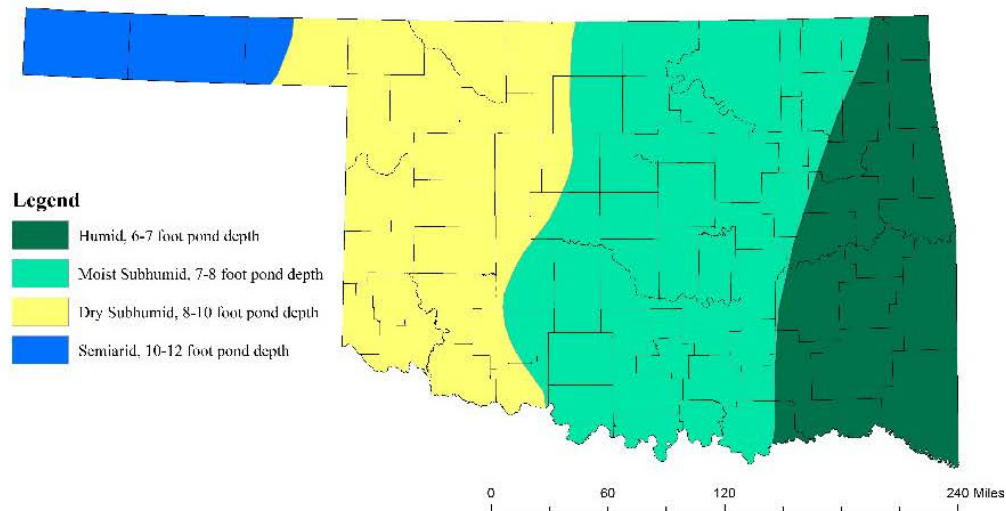
Where surface runoff is the main source of water supply, the contributing drainage area must be large enough to yield enough runoff to maintain the water supply in the pond during all periods of intended use. However, the drainage area should not be so large that expensive overflow structures are needed to bypass excess storm runoff.

Figure 1 is a general guide for estimating the approximate size of a drainage area required for each acre-foot of storage in a pond to maintain normal pool level. If reliable local runoff information is available, use it in preference to the guidance provided in the figure. The information in Figure 1 does not apply when ponds are used for irrigation.

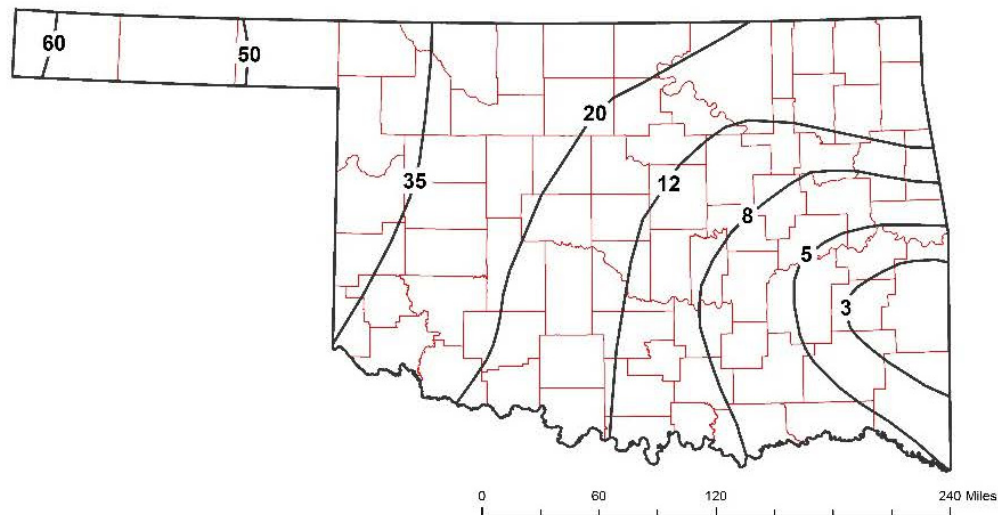
Figure 2 provides the recommended minimum depth for ponds. These recommended depths are to be considered minimum depth unless the drainage area has characteristics other than normal. To apply the information given in figure 2, some adjustments may be necessary to meet local conditions. Consult local climatic and hydrological records to account for microclimates and other variations from the norm.

### **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.

*Figure 1***Recommended Minimum Depths of Ponds and Reservoirs**

Map adapted from Figure 11-19 National Engineering Handbook (210-650-H, 2nd Ed., Feb 2021)

*Figure 2***A General Guide for Use in Estimating the Approximate Size of Drainage Area Required for a Desired Storage Capacity in Either Excavated or Impounding Reservoirs**

The numbers on the chart show number of acres of drainage area required for 1 acre-foot of water impounded

Map adapted from Figure 11-18 National Engineering Handbook (210-650-H, 2nd Ed., Feb 2021)

## **Additional Criteria for Embankment Ponds**

### **Geological investigations**

Use pits, trenches, borings, and reviews 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 ASTM D2487-17e1, "Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)." Determine from the investigations if problem soils exist at the embankment pond site for defensive design measures. Problem soils, include but are not limited to dispersive clays, collapsible soils, soft clays, expansive clays, low internal erosion resistance soils, loose coarse-grained soils, high soluble content soils, and caliche soils.

### **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. Design cutoff side slopes no steeper than one horizontal to one vertical.

### **Seepage control**

Include seepage control if—

- Foundation cutoff does not intercept pervious layers.
- Seepage could create undesired wet areas.
- Embankment stability requires seepage control.
- Special problems require drainage for a stable dam.

Filter zones may be required in some embankment designs to address the problem of cracking and internal erosion of the embankment for sites with problematic conditions such as dispersive clays, steep abutments, and other issues.

Control seepage with—

- Foundation, abutment, or embankment filters and drains.
- Filter diaphragms.
- Reservoir bottom blanketing.
- 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 a dam used as a public road. 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 a Dam.

| Total Height of Dam<br>(feet) | Top Width<br>(feet) |
|-------------------------------|---------------------|
| Less than 10                  | 6                   |
| 10–14.9                       | 8                   |

|         |    |
|---------|----|
| 15–19.9 | 10 |
| 20–24.9 | 12 |
| 25–35   | 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. Flatter slopes may be required for stability for some problematic embankment or foundation soils such as highly plastic embankment soils or very soft clays. Downstream or upstream berms can be used to help achieve stable embankment slopes.

### **Slope protection**

Design special measures such as berms, riprap, sand-gravel, soil cement, or use 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 foot of freeboard between design high-water flow elevation in the auxiliary spillway and the top of the settled embankment. Design a minimum 2 feet of elevation difference between the crest of the auxiliary spillway and the top of the settled embankment when the dam has more than 20 acre drainage area or more than 20 feet in effective height. Design a minimum of 1 foot of freeboard above the peak elevation of the design hydrograph to the top of the settled embankment when the pond has no auxiliary spillway.

### **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 settlement allowance of 5 percent of the total height of the dam for dams constructed with a carryall and 10 percent for dams constructed with a dozer or with both a dozer and a carryall, except where detailed laboratory soil testing and settlement analyses or experience in the area shows that a lesser amount is adequate.

### **Principal spillway**

A pipe 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 a vegetated or earth spillway can safely handle the rate and duration of the design flow. additional design guidance is provided in Oklahoma Engineering Technical Note 19 - Structure Plannig, Deign and Layout Guidance.

Design a minimum of 6-inches 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 foot difference when the dam has a drainage area of over 20 acres.

Provide an anti-vortex device to handle pressure flow in the principal spillway pipe. Design the inlet and outlet to function for the full range of flow and hydraulic head anticipated.

Design adequate pipe 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 6 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 using ductile iron, welded steel, corrugated steel, corrugated aluminum, reinforced concrete (precast 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 to withstand all external and internal loads without yielding, buckling, or cracking. Design rigid pipe for a positive projecting condition. Design flexible pipe according to the requirements of NRCS National Engineering Handbook (NEH) (Title 210), Part 636, Chapter 52, "Structural Design of Flexible Conduits."

Design connections of flexible pipe to rigid pipe or other structures to accommodate differential movements and stress concentrations. Design and install all pipes 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 if needed to reduce or limit structural loading on the 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.

### **Ultraviolet 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.

### **Internal erosion**

Install filter diaphragms for internal erosion control or anti-seep collars to reduce hydraulic gradient along the pipe extending through the embankment with inverts below the peak elevation of the routed hydrograph when the effective height of the dam is 15 feet or greater.

Additional design guidance for is provided in *Oklahoma Engineering Technical Note 19 - Structure Planning, Design and Layout Guidance*.

### **Filter diaphragms**

Design the filter diaphragm according to the requirements of 210-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 that the filter diaphragm functions both as a filter for adjacent base soils and as a drain to intercept seepage. Materials for the filter diaphragm must meet the requirements of 210-NEH-Part 633, Chapter 26, "Gradation Design of Sand and Gravel Filters".

Anti-seep collars can be used where the following soil and site conditions apply:

- Embankment soils are documented to be non-dispersive by crumb testing or evidence that the site is located in geologic formations that are known to be non-dispersive.

- Soils tests show that embankment soils have a plasticity index (PI) equal to or greater than 15.
- The water content of the soils at the time of construction is such that a 1/8-inch diameter thread 1/2-inch long may be rolled out on a flat surface without breaking or falling apart.
- Natural or excavated ground slopes transverse to the embankment centerline in the vicinity of the conduit are no steeper than 2 horizontal to 1 vertical.
- Laboratory or field tests show that the foundation soils left in-place under the embankment and principal spillway are medium to very stiff in saturated consistency or medium dense to very dense depending on if these soils are cohesive or cohesionless, respectively.

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.

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 pipe, unless the watershed does not contain trash or debris that could clog the pipe.

#### **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 law. The designer may use the principal spillway pipe 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 design hydrograph and the trash that comes to it without overtopping the dam. The minimum criteria for acceptable use of a closed pipe principal spillway without an auxiliary spillway consists of a pipe with a cross-sectional area of 3 square feet 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 2, less any reduction creditable to the principal spillway 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 a 10-day 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 earth or in-situ rock. Design stable side slopes for the material in which the spillway is to be constructed. Design a minimum bottom width of 10 feet for dams requiring a constructed auxiliary spillway or 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 according to 210-NEH-628, Chapter 50, "Earth Spillway Design," or with equivalent procedures.

### Structural auxiliary spillways

Design chute spillways or drop spillways according to the principles set forth in 210-NEH, Part 650, "Engineering Field Handbook"; and 210-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 table 2, less any reduction creditable to the pipe discharge and detention storage.

### Additional Criteria for Excavated Ponds

#### Runoff

Design a minimum of 1 foot of freeboard above the peak elevation of the design hydrograph. Design a pipe and auxiliary spillway that meets the capacity requirements of table 2 when needed. Consider runoff flow patterns when locating the excavated pond and placing the spoil.

#### Side Slopes

In the excavated area, design side slopes that are no steeper than one horizontal to one vertical.

#### Inlet Protection

Protect the side slopes from erosion where surface water enters the pond in a natural or constructed 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 and 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.

**Table 2.** Minimum auxiliary spillway capacity

| Drainage area<br>( <i>acre</i> )                            | Effective height of<br>dam <sup>1</sup> ( <i>feet</i> ) | Detention storage<br>( <i>acre-feet</i> ) | Minimum design storm <sup>2</sup> |                                      |
|-------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------|-----------------------------------|--------------------------------------|
|                                                             |                                                         |                                           | Frequency ( <i>years</i> )        | Minimum duration<br>( <i>hours</i> ) |
| 20 or less                                                  | 20 or less                                              | < 50                                      | 10                                | 24                                   |
| 20 or less                                                  | > 20                                                    | < 50                                      | 25                                | 24                                   |
| > 20                                                        | all                                                     | < 50                                      | 25                                | 24                                   |
| All others                                                  | all                                                     | all                                       | 50                                | 24                                   |
| 1. Defined above in "Conditions where Practice Applies."    |                                                         |                                           |                                   |                                      |
| 2. Select rain distribution based on climatological region. |                                                         |                                           |                                   |                                      |

## 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 function.

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

### Fish and Wildlife

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

When feasible, retain 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.

If operations includes stocking fish, use NRCS CPS Fishpond Management (Code 399).

### Watering ramp

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

### 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 on 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 the 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 temperature 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.
- Earth moving potentially uncovering or redistributing toxic materials.
- Livestock grazing adjacent to the pond. Consider fencing to prevent livestock activities having 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—

- 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 establishing vegetation or other ground surface protection, as needed.
- Safety features.
- Site-specific construction and material specifications.
- Utility location and notification requirements.

## OPERATION AND MAINTENANCE

Prepare an operation and maintenance plan for the operator.

As a minimum, include—

- Periodically inspect all structures, earthen embankments, spillways, and other significant appurtenances.
- Promptly repair or replace damaged components.
- Promptly remove trash from pipe inlet and trash rack.
- Promptly remove sediment when it reaches predetermined storage elevations.
- Periodically remove trees, brush, and undesirable species.
- Periodically inspect safety components and immediately repair if necessary.
- Maintain vegetative protection and immediately seeding bare areas, as needed.
- Prevent the establishment of woody vegetation on constructed embankment fill and around spillway appurtenances.

## REFERENCES

American Society for Testing and Materials. ASTM D2487-17e1, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System). West Conshohocken, PA. DOI: 10.1520/D2487-17E01

USDA NRCS. 2019. Engineering Technical Releases, TR-210-60, Earth Dams and Reservoirs. Washington, D.C. <https://directives.sc.egov.usda.gov/>

USDA NRCS. 2008. National Engineering Handbook (Title 210), Part 628, Dams. Washington, D.C. <https://directives.sc.egov.usda.gov/>

USDA NRCS. 2017. National Engineering Handbook (Title 210), Part 633, Soil Engineering. Washington, D.C. <https://directives.sc.egov.usda.gov/>

USDA NRCS. 2008. National Engineering Handbook (Title 210), Part 636, Structural Engineering. Washington, D.C. <https://directives.sc.egov.usda.gov/>

USDA NRCS. 2012. National Engineering Handbook (Title 210), Part 650, Engineering Field Handbook. Washington, D.C. <https://directives.sc.egov.usda.gov/>

USDA NRCS. 2017. National Engineering Manual (Title 210). Washington, D.C.

<https://directives.sc.egov.usda.gov/>