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 applies where it is determined that stormwater management, water supply, or temporary storage is justified and it is feasible and practicable to build a pond which will meet local and state law requirements.It also applies to embankment ponds that meet all criteria for low-hazard potential dams as listed below:

- The pond is a low hazard structure, which is unlikely to 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 total height of dam is not greater than 20 feet;
- The contributory drainage area is less than 1 square mile (640 acres);
- The maximum storage area at the top of the dam is less than 50 acre-feet.

The total height of dam is defined as the vertical distance between the lowest point on the top of the dam to thelowest point along the upstream toe. If the bottom of the impoundment is excavated below the embankment, then the height shall include the excavation depth if there is potential for theimpounded water to be released as a result of dam failure.

Exemptions

A person who wishes to construct, reconstruct, repair, or alter a dam, reservoir, or similar waterway obstruction (including a small pond) is required to obtain a permit from the Maryland Department of the Environment (MDE), Dam Safety program. Certain small ponds, meeting the criteria presented above, may be reviewed and approved by the local Soil Conservation District in lieu of obtaining an MDE Dam Safety permit, with the following exemptions:

- A small pond located within the watersheds of the Jones Falls, Gwynns Falls, or Herring Run streams may not be approved by the SCD.
- A small pond that serves as a “waste stabilization lagoon” (CPS #313 or CPS #359) may not be approved by the SCD.
- Certain small ponds located in cold water resource areas that do not meet MDE Thermal Design Criteria may not be approved by the SCD.

Exemptions are authorized when ponds are designed to meet requirements established in the *Maryland Department of Environment Policies and Procedures for Small Pond Approval* and related MDE dam safety policy memoranda. Refer to MDE policy for exemption criteria.

CRITERIA

General Criteria Applicable to All Ponds

Plan, design, and construct the pond to comply with all Federal, State (Maryland Department of Environment rules and regulations), 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 and approvals (e.g. Soil Conservation District Small Pond Approval) 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 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). When necessary to provide surface protection where climatic conditions preclude the use of seed or sod, use the criteria in NRCS CPS Mulching (Code 484) to install inorganic cover material such as gravel. Alternatively, criteria described in MDE erosion control guidance may be utilized for the protection of exposed surfaces.

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.

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.

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.

For ponds whose primary purpose is to trap sediment for water quality, adequate storage should be provided to trap the projected sediment delivery from the drainage area for the life of the pond.

Soils investigation
A soils investigation is required on all ponds. As a minimum it shall include information along the centerline of the proposed dam, in the auxiliary spillway location, and the planned borrow area. The type of equipment used and the extent of the investigation will vary from site to site. All investigations shall be logged using the Unified Soil Classification System. Refer to MDE guidance for additional criteria.

Structure hazard classification
Documentation of the classification of dams is required. Documentation is to include but is not limited to location and description of dam, configuration of the valley, description of existing development (houses, utilities, highways, railroads, farm or commercial buildings, and other pertinent improvements), potentialfor future development, and recommended classification. It is also to include results obtained from breach routings, if breach routings are used as part of the classification process. The hazard class as contained in this document is related to the potential hazard to life and property that might result from a sudden breach of the earth embankment. Structure classification and land use for runoff determination must take into consideration the anticipated changes in land use throughout the expected life of the structure. The classification of a dam is the responsibility of the designer, and subject to review and concurrence of the approving authority.

The classification of a dam is determined only by the potential hazard from failure, not by the criteria. Classification factors in the National Engineering Manual, as supplemented, are given below:

Low Hazard Potential - Structures in rural, agricultural, or urban areas where failure may damage farm buildings, agricultural land, or township and country roads. No loss of life is expected.

Significant Hazard - Structures in predominantly rural, agricultural, or urban areas where failure may damage isolated homes, main highways, or minor railroads, or interrupt service of relatively important public utilities. Loss of life is possible but not expected.

High Hazard - Structures where failure is expected to cause loss of life or serious damage to homes, industrial or commercial buildings, important public utilities, main highways, or railroads.

“Rural areas” is defined as those areas in which residents live on farms, in unincorporated settlements, or in incorporated villages or small towns. It is where agriculture, including woodland activities, and extractive industries, including seafood harvesting, provides an employment base for residents and where such enterprises are dependent on local residents for labor.

Non-rural areas shall be classified as urban.

Refer to MDE guidance for additional criteria.

Peak breach discharge criteria
Breach routings are used to help delineate the area potentially impacted by inundation should a dam fail and can be used to aid dam classification. The breach hydrograph is the outflow hydrograph attributed to

the sudden release of water in reservoir storage. This is due to a dam breach during non-storm conditions.

Stream routings made of the breach hydrograph are to be based upon topographic data and hydraulic methodologies mutually consistent in their accuracy and commensurate with the risk being evaluated.

The minimum peak discharge of the breach hydrograph, regardless of the techniques used to analyze the downstream inundation area, is as follows:

$Q_{max} = 3.2\ H_W^{2.5}$ where,

Q_{max} = the peak breach discharge, cfs.

H_W = depth of water at the dam at the time of failure; however, in the case of dam overtopping, not to exceed depth at the top of the dam, feet. Use “nonstorm” conditions downstream of the dam.

Where breach analysis has indicated that only overtopping of downstream roads will occur, the following guidelines will be used:

Class	Depth of Flow (d) ft.
Low	$d \leq 1.5$
Significant & High	$d > 1.5$

Use and importance of the roadway shall be considered when assigning a hazard potential classification. MDE breach analysis guidance contained in *Guidance for Completing a Dam Breach Analysis for Small Ponds and Dams in Maryland, 2018,* can be utilized alternatively when making a determination of hazard class.

Hydrology

Principal and auxiliary spillways will be designed within the limitations shown on Table 1. The storm duration used shall be 24 hours except where TR-60 is specified. The pond shall be designed to safely pass the base flow along with volume and peak rates of runoff from design storms, as specified in Table 1. All storm water management ponds shall be designed using urban criteria. This can be done by using principal and auxiliary spillways. The following shall be used to determine runoff rates and volumes:

1. NRCS “Engineering Field Handbook, Part 650” or;
2. NRCS, NEH, Part 630 - Hydrology” or;
3. NRCS, TR-55, “Urban Hydrology for Small Watersheds” or;
4. NRCS, TR-20, “Computer Program for Project Formulation” or,
5. Computer programs using NRCS hydrology methods with identifiable inputs and outputs as approved by the reviewing agency (e.g. HEC software).

Infiltration and water quality basins

Ponds, either excavated or embankment, that are designed solely for infiltration or as water quality basins will have an auxiliary spillway. The capacity of the spillway will be determined by the following procedure:

Pass the routed 100-Year Storm with the appropriate freeboard as specified in Table 1, to the top of dam elevation. Routing will begin at the auxiliary spillway crest.

Tables

Table 1. Hydrologic Criteria for Ponds.

Structure Class	Detention Storage (ac-ft)	Watershed Area (acres)	Height to Auxiliary Spwy Crest (feet)	Spillway Capacity[4]				Freeboard[5] Rural & Urban
				Principal[1]		Auxiliary[2,3]		
				Rural	Urban	Rural	Urban	
High & Significant	Any	Any	Any	TR 60	TR 60	TR 60	TR 60	TR 60
Low	Any	Any	Any	TR 60	TR 60	TR 60	TR 60	TR 60
Low	Less than 50	320 and larger	≤ 20	10 YR	25 YR	100 YR	100 YR	2.0’ above A.S. Design Storm
			< 15	5 YR	10 YR	50 YR	100 YR	
		100 to 320	≤ 20	5 YR	10 YR	50 YR	100 YR	1.0’ above A.S. Design Storm
			< 15	2 YR	5 YR	25 YR	100 YR	
		Less than 100	≤ 20	2 YR	5 YR	25 YR	100 YR	1.0’ above A.S. Design Storm

NOTES

1) Principal – minimum storm to be contained below the crest of the auxiliary spillway including any combination of temporary storage and principal spillway discharge.
2) Auxiliary (Emergency) – minimum storm used to proportion the auxiliary spillway to meet the limitations for shape, size, velocity, and exit channel. This storm can be handled by any combination of principal spillway discharge, auxiliary spillway discharge, and storage.
3) For ponds without a separate auxiliary spillway, the principal spillway functions as the auxiliary spillway. In this situation, the principal spillway must comply with the auxiliary spillway hydrologic criteria.
4) All ponds, which are being designed to meet local stormwater requirements, will be required to use the urban criteria. Storm duration used shall be 24 hours except where TR-60 is specified.
5) For ponds without a functioning open channel auxiliary spillway, minimum freeboard will be 2 feet.

Table 2. Minimum Top Width for a Dam.

Height of Dam (feet)	Top Width (feet)
Less than 10	6
10 – 14.9	8
15 – 19.9	10
20	12

Table 3[1,2]. Minimum Gages.

Corrugated Steel Pipe
2 – 2/3 inches x ½ inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter in Inches				
	24 & Less	30	36	42	48
1 - 15	16	16	14	10	10
15 - 20	16	12	10	*	*

Corrugated Steel Pipe
3 inches x 1 inch or 5 inch x 1 inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter in Inches						
				Flowable Fill			
	36	42	48	54[3]	60[3]	66[3]	72[3]
1 - 15	16	16	16	14	14	14	14
15 - 20	16	16	12	14	14	14	14

* Not Permitted.

Table 4[1,2]. Minimum Gages.

Corrugated Aluminum Pipe
2 – 2/3 x ½ inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter in Inches		
	21 & Less	24	30
1 – 15	16	14	10
15 – 20	12	10	*

Corrugated Aluminum Pipe
3 inches x 1 inch Corrugations

Fill Height Over Pipe (Feet)	Pipe Diameter in Inches				
	30	36	42	48	54[3]
1 – 15	16	16	14	10	14
15 - 20	16	12	*	*	*

* Not Permitted.

[1] Coatings for corrugated metal shall be specified by the MD-378 Construction Specifications.

[2] Tables 3 and 4 were developed using the modified Spangler equation. Sizes other than those shown above are not permitted.

[3] Must use flowable backfill as specified by the MD-378 Construction Specifications and the pipe must be bituminous coated.

Table 5. Acceptable Plastic Pipe for Use in Earth Dam[1,2]

Nominal Pipe Size (Inches)	Schedule or Standard Dimension Ratio (SDR)	Maximum Depth of Fill Over[3]
6 – 24	PVC Schedule 40	10
6 – 24	PVC Schedule 80	15
6 – 24	PVC SDR 26	10
6 – 24	Corrugated HDPE	10

[1] See Specifications, Plastic Pipe.
[2] All designs based on NEH Part 636, Chapter 52, Structural Design of Flexible Conduits. Other diameters and/or fill heights may be used that meet all the requirements of NEH Part 636, Chapter 52.
[3] Larger fill heights may be permitted when using flowable fill.

Table 6. Permissible Velocities (Ft/Sec) for Auxiliary Spillways Lined with Vegetation

Type of Cover	Slope of Exit Channel 0 – 5%	5 – 10%
Bermudagrass	6	5
Reed Canarygrass	5	4
Tall Fescue	5	4
Kentucky Bluegrass	5	4
Grass-legume Mixture	4	3

Additional Criteria for Embankment Ponds

Geotechnical/ 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, acid sulfate bearing material, and caliche soils. Hazards may also exist in karst soil regions (land made up of limestone) where sinkhole formation is of prime concern. Refer to MDE guidance for additional criteria.

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 with the minimum width being four (4) feet, and minimum depth being four (4) feet below the proposed pond bottom elevation. Design cutoff side slopes no steeper than one horizontal to one vertical (1H:1V).

Impervious core

Any impervious core within the embankment shall be located at or upstream of the centerline of the dam, and shall extend up the abutments to the 10-year water surface elevation. The impervious core shall extend vertically from the cutoff trench up to the 10-year water surface elevation (WSEL) throughout the embankment.

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.
- The phreatic line intersects the downstream slope. The phreatic line shall be drawn on a 4:1 slope starting on the inside slope at the normal pool elevation. When normal pool elevation is unknown, assume a 10-yr WSEL. For stormwater management ponds, normal pool shall be considered as the 10-year water surface elevation.

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.
- Anti-seep collars
- Reservoir blanketing.
- A combination of these measures.

Filter diaphragms
Filter and drainage diaphragms are always recommended, but are required when any of the following conditions are encountered:

1. The embankment is 15 feet or greater.
2. The pond requires design according to TR-60.
3. Embankment soils with high piping potential such as Unified Classes GM, SM, and ML. When embankment borrow soils are not identified during the design phase, soils must be assumed to have a high piping potential.
4. When criteria for anti-seep collars is not met.

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, 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. The drainage diaphragm shall usually consist of sand, meeting the fine concrete aggregate requirements (ASTM C-33). Materials for the filter diaphragm must meet the requirements of 210-NEH-Part 633, Chapter 26, "Gradation Design of Sand and Gravel Filters".

The drainage diaphragm shall be a minimum of 3 ft thick and extend vertically upward and horizontally at least three times the conduit outside diameter or the width of the cradle, whichever is greater except that:

1. The vertical extension need be no higher than the design high water level, and
2. The horizontal extension need be no further than 5 feet beyond the sides and slopes of any excavation made to install the conduit.
3. The minimum soil cover over any portion of the filter-drainage diaphragm measured normal to the nearest embankment surface shall be at least 2 feet.

It shall extend vertically downward at least 2 ft beneath the conduit outside diameter or bottom of the cradle, whichever is greater. The drainage diaphragm shall be located immediately downstream of the cutoff trench, approximately parallel to the centerline of the dam but no further upstream than the centerline of the dam.

The drainage diaphragm shall outlet 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.

It is required that the outlet for the filter diaphragm is sized to safely discharge the design flow. Where a drain backfill envelope is used as the outlet, it is recommended that it be designed so the hydraulic head does not exceed the depth of the drain outlet. The exposed area of the drain outlet must also be protected from external attack such as surface erosion and slope instability due to horizontal seepage pressures. A weighted toe cover such as riprap can be effective if protected with a properly designed filter between the sand drain material and the riprap cover.

If pipe drain outlets are used, consideration must be given to the structural design of the conduit in resisting external loading and the design life of the pipe must be consistent with the design life of the dam and physical conditions of the site. Also, the pipe must be designed for capacity and size of perforations as outlined in NEH Part 633, Chapter 26 and Soil Mechanics Note 3. If the pipe corrodes, is crushed by exterior loading, or is otherwise damaged, the outlet of the filter diaphragm is lost and a piping failure may occur.

The design quantity (Q) used to size the outlet can be calculated by Darcy's Law, Q = kiA where:

k = permeability of the embankment or drain outlet material (ft/day)

i = hydraulic gradient where i = h/l

h = head differential (ft)

l = seepage path (ft)

A = area of flow (diaphragm or outlet) (ft^2)

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

- When the use of filter diaphragms is not required as indicated above.
- 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.

Anti-seep collars shall be installed around all conduits through earth fills according to the following criteria:

1. Sufficient collars shall be placed to increase the seepage length along the conduit by a minimum of 15 percent of the pipe length located within the saturation zone.
2. The assumed normal saturation zone shall be determined by projecting a line at a slope (4) horizontal to (1) vertical from the point where the normal water elevation meets the upstream slope to a point where this line intersects the invert of the pipe conduit or bottom of the cradle, whichever is lower. When normal pool elevation is unknown, assume a 10-yr WSEL. For Stormwater Management ponds, the phreatic line starting elevation shall be the 10-year water elevation.
3. Maximum collar spacing shall be 14 times the required projection above the pipe. The minimum collar spacing shall be 5 times the required minimum projection.
4. Anti-seep collars should be placed within the saturated zone. In cases where the spacing limit will not allow this, at least one collar will be in the saturated zone.
5. All anti-seep collars and their connections to the conduit shall be watertight and made of material compatible with the conduit.
6. Collar dimensions shall extend a minimum of 2 feet in all directions around the pipe.
7. Anti-seep collars shall be placed a minimum of two feet from pipe joints except where flanged joints are used.
8. For pipes with concrete cradles, the projection shall be measured from the cradle.

Top width
Table 2 provides the minimum top widths for dams of various heights. The height used to determine the top width is the vertical distance between the settled top of the dam and the lowest elevation at the downstream toe (eg. invert of principal spillway barrel).

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. Maintenance considerations or construction equipment limitations may require increased top widths from the minimum shown in Table 2.

Side slopes
Design each side slope with a ratio of two horizontal to one vertical (2H:1V) or flatter. Design the sum of the upstream and downstream side slopes with a ratio of five horizontal to one vertical (5H:1V) 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 maintenance and/ or 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 320 acre drainage area. Design a minimum of 2 feet of freeboard above the peak water elevation of the design storm to the top of the settled embankment when the pond has no auxiliary spillway. Refer to Table 1 for additional information on freeboard criteria.

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 for a settlement allowance of 5 percent of the total height of the dam associated with each dam cross section, except where detailed laboratory soil testing and settlement analyses or experience in the area shows that a lesser amount is adequate; in particular, structural components such as conduits, auxiliary spillway, cradle, riser, etc. should be designed to meet maximum allowable total and differential settlement requirements of federal and the state of Maryland for the structural components

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. Refer to Table 1 for minimum hydrologic design criteria.

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. See "Anti-Vortex" section for additional criteria.

Design adequate pipe capacity to discharge long-duration, continuous, or frequent flows without causing flow through the auxiliary spillway. The minimum pipe capacity will be no less than the peak discharge rate from a 2-year, 24-hour storm event. Design a principal spillway pipe with a minimum inside diameter of 6 inches. The inlet or riser size for the pipe drops shall be such that the flow through the structure goes from weir-flow control to pipe-flow control without going into orifice-flow control in the riser. The inlets and outlets shall be designed and analyzed to function satisfactorily for the full range of flow and hydraulic head anticipated. The riser shall be analyzed for flotation assuming all orifices and pipes are plugged. The factor of safety against flotation shall be 1.2 or greater, and shall include the buoyancy force on the base, if applicable.

Design pipe with a minimum inside diameter of 1-1/4 inches for water supply pipes or for pipes used for any other purpose.

All pipes shall be circular in cross section except for cast-in-place reinforced concrete box culverts.

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 shown on Tables 3, 4 and 5 for corrugated steel, aluminum, and plastic pipes and applicable ASTM's for other materials or according to the requirements of NRCS National Engineering Handbook (NEH) (Title 210), Part 636, Chapter 52, "Structural Design of Flexible Conduits.

Where inlet or outlet flared sections are used, they will be made from materials compatible with the pipe.

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. Provide 2' pipe stub on all pipe materials from riser joint to protect integrity of riser-barrel joint connection in the event of settlement or movement of structure.

The following pipe materials are acceptable: cast-iron, ductile iron, steel, corrugated steel or aluminum, concrete with rubber gaskets, plastic, and cast-in-place reinforced concrete box culverts.

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. Concrete pipe shall have a concrete cradle extending up the sides of the pipe at least 50% of its outside diameter with minimum thickness of 6 inches. Where a concrete cradle is not needed for structural reasons, flowable fill may be used as described in the construction specifications. Gravel bedding is not permitted.

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 plunge basin, stilling basin, impact basin, or rock riprap spreader should be used to provide a safe outlet.

Where multiple conduits are used, there shall be sufficient space between the conduits and the installed anti-seep collars to allow for backfill material to be placed between the conduits by the earth moving equipment and for easy access by hand operated compaction equipment. This distance between conduits shall be equal to or greater than half the pipe diameter but not less than 2 feet.

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.

Trash guard
All pipe and inlet structures shall have a trash rack. Openings for trash racks shall be no larger than 1/2 of the barrel conduit diameter, but in no case less than 6 inches.

Flush grates for trash racks are not acceptable. Inlet structures that have flow over the top shall have a non-clogging trash rack such as a hood-type inlet extending a minimum of 8 inches below the weir openings, which allows passage of water from underneath the trash rack into the riser.

For inlet structures with solid covered tops, the bottom of the cover slab must be set at an elevation to prevent orifice flow control before pipe flow control governs.

Low stage releases, where the opening is larger than 6 inches, shall have a non-clogging trash rack with openings no larger than half the low flow dimension.

For all low stage releases 6 inches or smaller in any direction, the auxiliary spillway design storm shall be routed assuming the release has failed, using storage and discharge only above the elevation of the next opening larger than 6 inches in all directions. This design storm routing shall not overtop the dam.

Pool drain
Provide a pipe with a suitable valve to drain the pool area. 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 storm and the debris 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 debris.

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 1, 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 non-erosive velocities through the control section and to a point downstream where the dam will not be endangered. The maximum permissible velocity for the grass and grass mixture to be used shall be selected from Table 6. Velocities exceeding these values will require use of linings other than vegetation.

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 but not steeper than 2H:1V. A minimum bottom width of eight (8) feet can be used for dams having an effective height of less than 20 feet. Effective height is defined as the difference in elevation in feet between the lowest open-channel auxiliary spillway crest and the lowest point in the original cross section on the centerline of the dam. If there is no open channel auxiliary spillway, the top of the dam becomes the upper limit.

Design a level inlet channel upstream from the control section for the distance needed to protect and maintain the crest elevation of the spillway, but not less than 25 feet in length. If necessary, curve the inlet channel upstream of the level section to fit existing topography. Exit channel centerline shall be perpendicular to the level section downstream edge and must be straight for a distance beyond the downstream toe, so that discharges will not reach the earth embankment. The grade of the exit channel shall fall within the range established by discharge requirement and permissible velocities. 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 1, less any reduction creditable to the pipe discharge and detention storage.

Anti-Vortex Devices
Drop inlet spillways are to have adequate anti-vortex devices. Design the inlet and outlet to function for the full range of flow and hydraulic head anticipated. Splitter type anti-vortex devices shall be placed in line with the barrel. An anti-vortex device is not required if weir control is maintained in the riser through all flow stages.

Wave Erosion Protection
Where needed to protect the face of the dam, special wave protection measures such as a bench, rock riprap, sand-gravel, soil cement or special vegetation shall be provided. (Reference NRCS Technical Releases 56 & 69)

Trees and Shrubs
Refer to MDE Dam Safety Policy Memorandum #1 Maintenance and Repair: Trees and Woody Vegetation, for tree and shrub requirements.

Additional Criteria for Excavated Ponds

General
Excavated ponds that create a failure potential through a constructed or created embankment will be designed as embankment ponds. Excavated ponds that include a pipe or weir outlet control system for urban stormwater management shall be designed using the principal and auxiliary spillway hydrologic criteria for Embankment Ponds, Table 1.

Runoff
Design a minimum of 1 foot of freeboard above the peak elevation of the design water surface. Design a pipe and auxiliary spillway that meets the capacity requirements of Table 1. 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 two horizontal to one vertical (2H:1V). Flatter slopes are to be utilized where safety for children, livestock watering, etc. is a design factor.

Inlet protection
When the excavated pond is a bypass type and water is being diverted from a stream, the minimum size inlet line shall be a 4-inch diameter pipe. All state laws concerning water use and downstream rights shall be strictly adhered to.Protect the side slopes from erosion where surface water enters the pond in a natural or constructed channel.

Outlet protection
An excavated pond with a low embankment (combination excavation / embankment pond) shall be designed to ensure a stable outfall for the 10-year, 24-hour frequency storm.

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 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.

Reservoir area for wet ponds
For most ponds, the topography of the site shall permit storage of water at a depth and volume that ensures a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. Soils in the reservoir shall be impervious enough to minimize seepage losses or shall be of a type that sealing is practical.

Excavation and shaping required to permit the reservoir area to suitably serve the planned purpose shall be included in the construction plans.

Reservoirs designed specifically for fish production or wildlife management shall follow design criteria in the standards and specifications for Wetland Wildlife Habitat Management (MD-644), as appropriate.

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.

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.

If the intent is to maintain a permanent pool, the drainage area should be at least 4 acres for each acre-foot of permanent storage. These recommendations may be reduced if a dependable source of ground water or diverted surface water contributes to the pond. The water quality shall be suitable for its intended use.

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 movement 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.

Safety

Special considerations should be made for safety and access during the design of a pond. Measures to be considered may include fencing, slope benching, access roads, flattened side slopes, warning signs, etc. When fencing a structure, the fence will be located so it will not interfere with the operation of the auxiliary spillway.

PLANS AND SPECIFICATIONS

Prepare plans and specifications that describe the requirements for applying the practice according to this standard. Refer to the Maryland NRCS Construction Specifications for Excavated Ponds and the Construction Specifications for Embankment Ponds, as applicable, for additional materials and construction requirements. 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.

SUPPORTING DATA AND DOCUMENTATION

Field data and survey notes

The following is a list of the minimum data needed:

1. Profile along centerline of structure.
2. Profile along centerline of principal spillway.
3. Profile along centerline of auxiliary spillway.
4. Survey of storage area to develop topography and storage volumes.
5. Soil investigation logs and notes.

Design data

Record on appropriate engineering paper. The following is a list of the minimum required design data:

1. Determine pond class and list appropriate spillway design criteria, including map.
2. Determine peak runoff from the contributing area for the design storms selected, including topo map.
3. Develop a stage-storage/discharge curve for the site.
4. Determine the pipe spillway by storm routing using the procedure in the SWM Pond Design Manual; Chapter 11, EFH; Chapter 6, TR-55; or TR-20.
5. Design auxiliary spillway using EFH 11-61.
6. Drawings should show the following as a minimum: profile along centerline of dam; profile along centerline of auxiliary spillway; cross section through dam at principal spillway; cross section through auxiliary spillway; plan view; and construction details & notes and soil logs.
7. Compute earth fill (if needed).
8. Special design feature details; watering, fire hydrants, fish management, irrigation, outfall stabilization, etc.; structural details with design loadings, if applicable, should be shown on the drawings.
9. Complete data required on the Pond Summary Sheet.
10. Record seeding plan on drawings or seeding specifications.
11. A written Operation and MaintenancePlan.

Refer to the MDE design review checklist for additional design data requirements.

Construction check data/as-built

Record on survey note paper, ENG-28. Survey data for ponds will be plotted in red. All construction inspection visits shall be recorded on the CPA-6 or appropriate documentation paper. The documentation shall include the date, who performed the inspection, specifics as to what was inspected, all alternatives discussed, and decisions made and by whom. The following is a list of the minimum data needed for As-Builts:

1. A profile of the top of the dam.
2. A cross-section of the auxiliary spillway at the control section.
3. A profile along the centerline of the auxiliary spillway.
4. A profile along the centerline of the principal spillway extending at least 100 feet downstream of the

fill.

5. The elevation of the principal spillway crest.
6. The elevation of the principal spillway conduit invert (inlet and outlet).
7. The diameter, length, thickness and type of material for the riser.
8. The diameter, length, and type of material for the conduit.
9. The size and type of anti-vortex and trash rack device and its elevations in relation to the principal spillway crest.
10. The number, size and location of the antiseep collars.
11. The diameter and size of any low stage orifices or drain pipes.
12. Show the length, width, and depth of contours of the pool area so that design volume can be verified.
13. Notes and measurements to show that any special design features were met.
14. Statement on seeding and fencing.
15. Notes on site clean up and disposal.
16. Sign and date check notes to include statement that practice meets or exceeds plans and specifications.

Refer to MDE as-built requirements for additional data needed for as-builts.

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

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U.S.Bureau of Reclamation, Acer Technical Memorandum No. 11 (ACER 11) Downstream Hazard Classification Guidelines (USBR 1988)

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