NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

DIKE
(feet)
CODE 356

DEFINITION

An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

Scope

This standard applies to dikes or levees used to prevent or reduce flood damage to land and property, for flow control in conjunction with floodways or to impound or regulate water for fish and wildlife management. It also applies to dikes that are used to isolate, restore, create and enhance wetlands.

Dikes are divided into classes determined by the value of the land, crops, and other improvements and the hazard to life within the area to be protected.

PURPOSES

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features and archaeological sites from damage.

CONDITIONS WHERE PRACTICE APPLIES

Class I dikes are those constructed on sites where:

1. Failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways or railroads, and high value land, crops, or other improvements.

2. Unusual or complex site conditions require special construction procedures to ensure satisfactory installations.

3. Protection is needed to withstand more than 12 ft of water above normal ground surface, exclusive of crossing of sloughs, or other channels, or low areas.

Class II dikes are those constructed in highly developed and productive agricultural areas where:

1. Failure may damage isolated homes, highways or minor railroads, or cause interruption in service of relatively important public utilities.

2. The maximum design water stage against the dike is 12 ft.

Class III dikes are those constructed in rural or agricultural areas where:

1. Damage likely to occur from dike failure is minimal.

2. The maximum design water stage against the dike is 6 ft for mineral soils and 4 ft for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

Class IV-A dikes are those constructed for enhancement in wetlands and wildlife areas where:

1. Damage likely to occur from dike failure is minimal.

2. The maximum design water stage against the dike is 2 feet for mineral soils. (Include channels, sloughs, swales, and gullies in determining the design water stage.)

3. Frequent overtopping of the dikes is expected.

Class IV-B dikes are those constructed for enhancement in wetlands and wildlife areas where:

1. Damage likely to occur from dike failure is minimal.

2. The maximum design water stage against the dike is 2 feet for mineral soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

3. Dikes are not expected to overtop frequently.

CRITERIA

In locating dikes, careful considerations shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. If dike construction will adversely affect such values, concerned public agencies and private organizations shall be consulted about the project.

Protection

A protective cover of grasses shall be established on all exposed surfaces of the dike and other disturbed areas. Seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with recommendations in local technical guides. When excavation of borrow areas serves the dual purpose of providing wetland habitat as part of wetland restoration activities, and the objective is to create deep water channels or shallow water areas which will be inundated for 3 months or longer, seeding of the excavated areas is not recommended.

If vegetation will not control erosion, riprap or other protective measures shall be installed.

Maintenance

All dikes must be adequately maintained to the required shape and height. The maintenance of dikes must include periodic removal of woody vegetation that may become established on the embankment. Provisions for maintenance access must be provided.

Design criteria - Class I dikes

Location

Conditions to be considered in designing Class I dikes are foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available.

Height

The design height of a dike shall be the design high water depth plus 2 ft of freeboard or 1 ft of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

1. If dike failure is likely to cause loss of life, extensive high-value crop or property damage, the elevation of design high water shall be that associated with the stage of the 100-year-frequency flood or of the maximum flood of record, whichever is greater.

2. If dike failure is unlikely to result in loss of life or extensive high-value crop or property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will insure the desired level of protection or the 50-year-frequency flood whichever is greater.

3. If the dike will be subject to stages from more than one stream or source, the criteria indicated shall be met for the combination that causes the highest stage.

4. If the dike will be subject to tidal influence as well as streamflow, the streamflow peak shall be assumed to occur in conjunction with the mean high tide to determine the design high water depth.

The design height of the dike shall be increased by the amount needed to insure that the design top elevation is maintained after settlement. This increase shall be not less than 5 percent.

Interior drainage

If inflow from the area to be protected by the dike may result in loss of life or extensive high-value crop or property damage, provisions shall be included in the plans to provide interior protection against a 100-year-frequency hydrograph, plus base flow, and an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value crop or property damage, storage areas, gravity outlets, or a pumping plant, alone or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak

flow from the storm that will insure the desired level of protection, whichever is greater.

In sizing outlet works in combination with available storage, the minimum design storm duration for interior drainage shall be 10 days. If outlet works are designed using peak flood frequency flows without considering storage, the minimum design storm duration shall be 24 hours.

Embankment and foundation

The embankment shall be constructed of mineral soils, which when placed and compacted will result in a stable earth fill. No organic soil shall be used in the dike. Soils must be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundations, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 ft for embankment heights of 15 ft or less and 12 ft for heights more than 15 ft. If maintenance roads are to be established on the dike top, "turnarounds" or passing areas shall be provided, as needed.

Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the water side shall not be steeper than 4 horizontal to 1 vertical if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the land side toe shall be protected by a banquette or constructed berm. Banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall not be less than 1 ft above mean ground and shall be sloped away from the dike.

A cutoff shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slope adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If previous foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to insure stability of the dike shall be used.

Ditches and borrow pits

Land side ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 ft in width, shall be left in the ditch at intervals not greater than 400 ft to form a series of unconnected basins.

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill height	Minimum berm width
Less than 6 ft	12 ft
More than 6 ft	18 ft

A drainage system shall be used if necessary to insure the safety of a dike. Toe drains, if used, shall be located on the land side and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the land side toe of a dike than a distance three times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distanced from the dike.

Pipes and conduits

Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with anti-seep collars.

All conduits through a dike below the design high waterline shall be equipped with anti-seep collars designed to increase the distance of the seepage line

along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed water line shall be equipped with a Dayton or a similar coupling to prevent vibration of the pumping plant being transmitted to the discharge conduits.

Design criteria - Class II dikes

Design water stage

The maximum design water stage permitted is 12 ft above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes, based on the required level of protection, exceeds 4 ft the design shall be based on at least a 25-year-frequency flood. If this degree of protection is not feasible, the design shall approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

Height

The design height of an earth dike shall be the design water depth plus a free-board of at least 2 ft (0.6m) or freeboard of 1 ft plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus allowance for settlement necessary to insure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

Interior drainage

Provisions must be made for adequate drainage for the area to be protected by the dike.

Cross section

The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Design water height	Minimum top-width	Steepest side slope
ft	*ft*	
0-6	6	2:1
6-12	8	2.5:1

Side slopes of 3 horizontal to 1 vertical on waterside and 2:1 on land side may be used instead of 2.5:1 for both slopes.

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and minimum cross section dimensions shall be incorporated in the fill as follows:

Design water height	Minimum top-width	Steepest side slope
ft	*ft*	
0-6	8	3:1
6-12	10	4:1

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall be not less than 10 ft if a maintenance road is planned on top the dike. "Turnarounds" or passing areas shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity such as SM and ML, are used in construction.

A banquette (or constructed berm) shall reinforce the land side toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analyses show a different design is adequate.

Foundation cutoff

A cutoff shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

Ditches and borrow pits

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill Height	Minimum berm width
Less than 6 ft	10 ft
More than 6 ft	15 ft

A land side ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having a design water depth of more than 5 ft, the land side ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design waterline with the waterside of the dike and the land side toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipes and conduits

The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water if feasible, or else equipped with anti-seep collars.

All conduits through the dike below the design high waterline shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibrations of the pumping plant being transmitted to the discharge conduits.

Drains

Drains shall be used where necessary to insure safety of dikes and shall be located on the land side, have a graded sand gravel filter, and be designed and installed in accordance with Natural Resources Conservation Service standards for such drains.

Field subsurface drains shall not be installed or permitted to remain without protection closer to the land side toe of a dike than a distance three times the design water height for the dike. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Design criteria - Class III dike

The design criteria shall be based on site conditions for mineral or organic soils as applicable.

Top width. Minimum top width is 4 ft.

Side Slopes. Minimum side slope is 1:1.

Freeboard

The minimum freeboard is 1 ft plus wave height. The constructed height shall be increased by the amount necessary to insure that the settled top is at design elevation but not less than 5 percent.

Foundation cutoff

A cutoff shall be installed if necessary to insure dike stability.

Ditches and borrow pits

Minimum berm widths between the toe and the dike and the edge of the excavated channel or borrow shall be two times the depth of the ditch but not less than 8 ft (2.4 m).

Class III Dikes. (Marshland)

Class III dikes are also used to improve marshland and/or facilitate water storage and control in connection with wildlife habitat.

The design criteria shall be on site conditions for mineral or organic soils with low coarse fiber content.

Top Width and Side Slopes. The minimum top width and the steepest side slope shall be:

Water Depth	Top Width	Side Slope
0-2	4	2:1
2-4	8	2:1
4-6	12	2:1

Freeboard. The minimum freeboard shall be two feet.

Berm and Borrow Pits. The minimum berm width between the toe of the dike and the edge of the borrow shall be ten feet.

A land side ditch or borrow shall be far enough away from the dike so that a line drawn between the point of intersection of the high water line and the upstream face of the dike, and the point of the downstream toe of the dike shall not intersect the ditch or borrow pit cross section.

Compaction - Settlement. The earthfill shall be compacted to insure a dense fill to withstand the water pressure. An allowance of 20 percent shall be added to the height of fill to account for settlement.

Slope Protection. The slope protection shall be established as specified by Practice Standard 342, Critical Area Treatment.

Class IV-A & Class IV-B Dikes.

The design criteria shall be on-site conditions for mineral soils. The embankment materials shall be ML, CL, MH, or CH based on the Unified Soil Classification, which when placed will result in a stable earth fill.

The minimum top width shall be 12 feet.

The steepest side slope, for Class IV-A, shall be 6:1. The steepest side slope for a Class IV-B shall be 4:1 on the side with ponded water and 2:1 on the side without ponded water.

Freeboard shall be 1 foot.

A land side ditch or borrow shall be far enough away from the dike so that a line drawn between the point of intersection of the high water line and the upstream face of the dike, and the point of the downstream toe of the dike shall not intersect the ditch or borrow pit cross section.

An allowance of 5 percent shall be added to the height of fill to account for settlement.

The earth fill shall be compacted using one of the methods described in the dike specification, except that Method A shall be used when working with the high ash content of the intermountain soils. Compaction testing on the high ash content soils shall be by Method D with the blow count modified to 50 blows per layer.

The minimum berm width between the toe of the dike and the edge of the borrow shall be ten feet.

Slope protection, for Class IV-A dikes, shall be established as specified by Practice Standard 342, Critical Area Treatment, using a perennial sod forming grass when climatic and soil conditions are suitable. Consider the use of a temporary, biodegradable erosion control product, to provide site protection until the perennial grass has a chance to be established.

CONSIDERATIONS

Water Quantity

1. 1. Effects upon components of the water budget, especially on volumes and rates of runoff, infiltration, evaporation and transpiration.

2. Potential for changes in rates of plant growth and transpiration because of changes in the volume of soil water.

3. Effects of changes to upstream or downstream flows on aquifers or other water uses.

4. Effects on the rate or volume of downstream flow to prohibit undesirable environmental, social or economic effects.

Water Quality

1. Effects on erosion and the movement of sediment and soluble and sediment-attached substances carried by runoff.

2. Effects on the movement of dissolved substances to ground water.

3. Short-term, construction and maintenance related effects on the quality of water resources.

4. Potential for earthmoving to uncover or redistribute toxic materials such as saline soils and make them available for undesirable effects on water or vegetation.

5. Effects on temperature of water resources to prevent undesired effects on aquatic and wildlife communities.

6. Effects on wetlands or water-related wildlife habitats.

7. Effects on the visual quality of water resources.

Endangered Species

Determine if installation of this practice, along with any others proposed, will have an 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 that 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 U.S. 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.

Cultural Resources

NRCS's objective is to avoid any effect to cultural resources and protect them in their original location. Determine if installation of this practice will have any effect on any cultural resources.

Document any specific considerations for cultural resources in the design docket and the Practice Requirements worksheet.

GM 420, Part 401, the California Environmental Handbook and the California Environmental Assessment Worksheet provide guidance on how the NRCS must account for cultural resources. The Field Office Technical Guide, Section II contains general information, with Web sites for additional information,

PLANS AND SPECIFICATIONS

Plans and specifications for constructing dikes shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An operation and maintenance plan must be prepared by the Designer for use by the owner or other person responsible for operating this practice. The plan should provide specific instructions for operating and maintaining the system to insure that it functions properly. It should also provide for periodic inspections and prompt repair or replacement of damaged components.