STANDARD

DIKE (Ft.)

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, to impound or regulate water for fish and wildlife management, or to manage water for cranberry production.

Dikes for cranberry water management include perimeter and interior dikes to temporarily impound water for harvesting, trash removal, pest control, winter flooding or other management purposes. Dikes also include "low flow" dikes constructed to contain stream flow in the stream channel and temporarily retain chemically polluted water on the bog for the required holding period after chemigation to maintain water quality.

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.

Purpose

To permit improvement of agricultural land by preventing overflow and better use of drainage facilities, to prevent damage to land and property, to facilitate water storage and control in connection with cranberry production, wildlife and other developments, and to maintain water quality from chemigation on cranberry bogs. Dikes can also be used to protect natural areas, scenic features, and archeological 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. (3.7 m.) of water above normal ground surface, exclusive of crossings of sloughs, old 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. (3.7 m.).

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. (1.8 m.) for mineral soils and 4 ft. (1.2 m.) for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

Class IV dikes are those constructed for water management on cranberry producing bogs and improving water quality downstream where:

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

2. **The maximum design water stage against the dike is 6 ft. (1.8 m.) for mineral soils and 4 ft. (1.2 m.) for organic soils. Exclude channels, sloughs, swales and gullies in determining the design water stage.**

3. **The dike is not being used to store water in a reservoir. This type of embankment shall be designed in accordance with the requirements in the Pond Standard (378).**

Planning Considerations for Water Resources

WATER QUANTITY

This practice is used to prevent water flowing onto an area, or it is used to prevent water flowing off an area. When it prevents water from flowing onto an area, it may decrease the time of peak flow downstream when the channel is diked on both sides. It also may increase the headwater elevation in the channel, often moving the area of flooding into a different reach of the stream. When one side of a channel is diked the floodwater will be forced on the other side more often and at a greater depth. Where dikes are used to control water and retain it within a specific area, there may be an increase of available water within the wetland or cropland.

WATER QUALITY

When used to control the division of chemigation water, this practice may have a significant effect on the quality of surface and ground water. This

will reduce the amount of suspended chemicals which are attached to organic material and soil particles from entering surface waters. This will allow for the biological treatment of dissolved chemicals when detained in the system for the required holding period. Chemicals that remain in the system may be bound up in the soil organic matter; however, soils that are low in organic matter may have a tendency to allow for the leaching of dissolved chemicals into the ground water.

Where dikes are used to prevent water from flowing onto the flood plain, the pollution dispersion effect of the temporary wetlands and backwater are decreased. The sediment, sediment-attached, and soluble materials being transported by the water are carried farther downstream. The final fate of these materials must be investigated on site. Where dikes are used to retain runoff on the flood plain or in wetlands the pollution dispersion effects of these areas may be enhanced. Sediment and related materials may be deposited, and the quality of the water flowing into the stream from this area will be improved.

Dikes are used to prevent wetlands and to form wetlands. The formed areas may be fresh, brackish, or saltwater wetlands. In tidal areas dikes are used to stop saltwater intrusion, and to increase the hydraulic head of fresh water which will force intruded saltwater out the aquifer. During construction there is a potential of heavy sediment loadings to the surface waters. When pesticides are used to control the brush on the dikes and fertilizers are used for the establishment and maintenance of vegetation there is the possibility for these materials to be washed into the surface waters.

Design Criteria--All Dikes

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.

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 embanklment must be available.

HEIGHT. The design height of a dike shall be the design high water depth plus 2 ft. (0.6 m.) of freeboard or 1 ft. (0.3 m.) 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 or 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 have high specific gravity and 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 foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 ft. (3 m.) for embankment heights of 15 ft. (4.6 m.) or less and 12 ft. (3.6 m.) for heights more than 15 ft. (4.6 m.). 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 waterside 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 landside 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 be not less than 1 ft. (0.3 m.) 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 slopes 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 pervious 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. Landside ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the waterside of dikes shall be wide and shallow. Plugs, at least 15 ft. (4.6 m) in width, shall be left in the ditches at intervals not greater than 400 ft. (121.9 m.) 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. (1.8 m.)	12 ft. (3.7 m.)
More than 6 ft. (1.8 m.)	18 ft. (5.5 m.)

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

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the landside 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 distances 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 antiseep collars.

All conduits through a dike below the design high waterline shall be equipped with antiseep 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 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. (3.7 m.) 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. (1.2 m.) 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 freeboard of at least 2 ft. (0.6 m.) or freeboard of 1 ft. (0.1 m.) plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus an 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.	m.	ft.	m.	
0-6	(0-1.8)	6	(1.8)	1 1/2:1
6-12	(1.8-3.7)	8	(2.4)	2:1

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

Design Water Height		Minimum Top Width		Steepest Side Slope
ft.	m.	ft.	m.	
0-6	(0-1.8)	8	(2.4)	2:1
6-12	(1.8-3.7)	10	(3)	2 1/2:1

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

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. (3 m.) if a maintenance road is planned on top of 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 landside 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. (1.8 m.)	10 ft. (3 m.)
More than 6 ft. (1.8 m.)	15 ft. (4.6 m.)

A landside 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. (1.5 m.) the landside 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 landside 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 antiseep collars.

All conduits through the dike below the design high waterline shall be equipped with antiseep 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 landside, have a graded sand-gravel filter, and be designed and installed in accordance with Soil Conservation Service standards for such drains.

Field subsurface drains shall not be installed or permitted to remain without protection closer to the landside 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 Dikes

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

TOP WIDTH. Minimum top width is 4 ft. (1.2 m.).

SIDE SLOPES. Minimum side slope is 1:1.

FREEBOARD. The minimum freeboard is 1 ft. (0.3 m.) 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.).

Design Criteria—Class IV Dikes
(Cranberry-growing Areas)

HEIGHT.

1. **Perimeter and Interior Dikes - The minimum settled top elevation of the dike shall provide for a minimum freeboard of 0.5 foot where the water surface dimension perpendicular to the dike is 660 feet or less; 1.5 feet for distances 660 to 1,320 feet and 2 feet if the distance exceeds 1,320**

feet. The freeboard shall be measured from the maximum design water elevation from the 10-year storm runoff, or from the maximum expected flood elevation for water management purposes, whichever is higher.

2. Low flow dikes - Low flow dikes are to be constructed on both sides of the main stream in the bog. The minimum settled top elevation of the dike shall be 0.5 foot above the adjacent bog elevation along the entire length of the dike. They should be constructed so that they do not interfere with cranberry production. Vines may be allowed to grow on the low flow dikes if care is taken to maintain the minimum fill height.

3. Water Control Structures - The minimum settled top elevation of the dike in the vicinity of water control structures shall be as described in Dimensions.

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

EMBANKMENT MATERIALS. Materials used for dike construction will be any readily available mineral soils. Sands containing silts and clays are preferable.

DIMENSIONS.

1. The minimum top width of dikes shall be as follows:

Design High Water (ft.)	Minimum Top Width (ft.)	
	Perimeter Dikes	Interior Dikes
0 - 2	4	2
2 - 4	4	4
4 - 6	6	6

2. Low flow dikes shall have a minimum base width of 2 feet.

3. Steepest side slopes for perimeter and interior dikes shall be 1 1/2:1, with the exception that they may be as steep as 1:1 if special stabilization methods are employed (for example, stabilizing with sod or woods turf).

4. The following requirements apply to perimeter and interior dikes in the vicinity of water control structures being either rebuilt or newly installed:

   a. Existing dikes with side slopes steeper than those described in the preceding paragraphs need not be rebuilt if performing

satisfactorily, have stabilized side slopes, show no indications of erosion or other failure, and the top elevation is adequate to provide the required freeboard. The top of the dike for a minimum of 25 feet each side of the centerline of the water control structure shall be at least 0.5 foot above the normal dike level. There shall be a transition section on both ends of the elevated portion of the dike with slopes no steeper than 4:1.

b. The side slopes immediately adjacent to a water control structure shall be no steeper than 1/2:1 where the slope is protected with riprap, and no steeper than 1/4:1 where the slope is protected with woods turf.

5. Where low flow dikes cross perimeter and interior lateral ditches, the ditches in the vicinity of the low flow dike shall be filled to the elevation of the dike. Where a turnout structure is placed in the ditch, the dike shall have a minimum top width of 2 feet and the maximum side slopes shall be 1 1/2:1. Interior lateral ditches shall either be completely filled in, or graded so that they drain toward the perimeter ditch. Consideration should be given to installing drainage tubing in the lateral ditches prior to filling to facilitate drainage.

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 shall be developed and provided to the landowner. This plan should consider the following general recommendations as applicable:

1. Maintain vigorous growth of desirable vegetative coverings. This includes reseeding, fertilization and controlled application of herbicides when necessary. Periodic mowing may also be needed to control height.
2. Periodically check the elevation of the earthfills and restore to grade, if necessary.

3. Remove all foreign debris that hinders system operation.

4. Determine and eliminate causes of settlement or cracks in the earthen sections and repair damage.

5. Check all areas where embankment protection was installed (rock riprap, woods turf, sod, etc.) for accelerated weathering or displacement. Repair or replace as needed.

6. Eradicate or otherwise remove all rodents or burrowing animals and repair any damage caused by their activity.

7. Immediately repair any vandalism, vehicular or livestock damage to any earthfills, spillways, outlets or other appurtenances.

8. Remove woody vegetation from embankments.

Supporting Data for Documentation

Design Data. The following information shall be recorded in the design and/or on the drawings, as applicable:

1. Sketch showing location of all dikes being designed and their lengths in feet.

2. The dike class, design frequency storm runoff, maximum design water elevation and depth, minimum required top width and maximum side slopes, including provisions for slope protection, if needed.

3. Depth of freeboard and the minimum elevation of top of dike. For Class IV dikes, also show the elevations of the dike within 25 feet on either side of the water control structure.

4. Provisions for foundation cutoff, drains and filters, and interior drainage.

CHECK DATA. The following information shall be recorded on the drawings to certify installation of the dike:

1. Location of the installed dike if changed from the design.

2. Length of the installed dike.

3. Check notes showing elevations of top of dike, top width, and side slopes, including slope protection measures.

4. For Class IV dikes, check notes shall also show the elevation, length and slope of the dike in the area of the water control structure.

References

1. Engineering Field Manual, Chapter 13 - Dikes and Levees - Wildlife Wetland Development

2. Massachusetts Engineering Technical Note No. 213 - Cranberry Bog Engineering

Specifications

1. Construction shall be in accordance with an approved plan, as staked in the field, and conforming to Soil Conservation Service Standards. The top of the dike shall not be below grade after settlement.

2. Trees and stumps, brush, and other vegetation shall be cut at approximate ground level. They shall be removed from the site, except when the dike is being constructed over deep (more than 10 feet) organic material. The surface layer of organic material shall be removed for dikes constructed in mineral soil.

3. All conduits through the dike shall be placed on a firm foundation to the lines and grades shown on the plans. Care should be taken not to excavate below the depth specified. Overexcavation shall be corrected by placing firmly compacted layers of earth to provide a firm foundation. If rocks or boulders are exposed in the bottom of the excavation, they shall be removed to a minimum depth of eight (8) inches below the invert of the pipe and the excess excavation replaced with firmly compacted earth to the specified grade.

4. Earth fill material shall be free of organic matter and other objectionable material. Placing and spreading of fill shall begin on the lowest part of the working area and continue in horizontal layers of approximate uniform thickness, preferably 6 inches thick, but not more than 12 inches thick, depending on the equipment used. The construction equipment shall be operated over the entire area of each layer in a manner to break up large clods and obtain compaction.

5. Fill material shall be moist, but not too wet for equipment operations and shaping. Water shall be added to the fill material where it is too dry to permit proper compaction.

6. When earthfill is to be added to an existing dike, the top of the dike shall be excavated to remove all vegetative and organic material. After removal of the top layer, the foundation shall be scarified and if too dry, moistened, before fill is added.

7. When a dike is to be constructed over organic material of depths greater than 2 feet, an initial fill layer of 2-foot minimum depth shall be placed.

8. All areas disturbed during construction will be treated to minimize erosion of the site during the construction period. Upon the completion of construction, all disturbed areas will be seeded or sodded in accordance with Critical Area Planting (342), unless protected with mechanical means, such as riprap.