Vegetation Management at Levees, Floodwalls and Dams

Course No: C03-037

Credit: 3 PDH

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ETL 1110-2-583
30 April 2014

US Army Corps of Engineers®
ENGINEERING AND DESIGN

GUIDELINES FOR LANDSCAPE PLANTING AND VEGETATION MANAGEMENT AT LEVEES, FLOODWALLS, EMBANKMENT DAMS, AND APPURTENANT STRUCTURES

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DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
CECW-CE Washington, DC 20314-1000

Technical Letter
No. ETL 1110-2-583 30 April 2014

EXPIRES 30 APRIL 2019

Engineering and Design
GUIDELINES FOR LANDSCAPE PLANTING AND VEGETATION MANAGEMENT AT LEVEES, FLOODWALLS, EMBANKMENT DAMS, AND APPURTENANT STRUCTURES

1. Purpose. This ETL provides guidelines to assure that landscape planting and vegetation management provide aesthetic and environmental benefits without compromising the reliability of levees, floodwalls, embankment dams, and appurtenant structures. It is important to note that all minimum guidelines presented herein are just that—minimums. The dimensions of the vegetation-free and root-free zones defined in this document provide the minimum acceptable buffer between vegetation and flood damage reduction structures. For each individual project, the design team must consider whether these minimums are adequate to the specific needs and conditions of the project.

2. Applicability. This ETL applies to all USACE Commands having Civil Works responsibilities. This ETL is not applicable to determinations for eligibility in the Rehabilitation Program (previously called the Rehabilitation and Inspection Program) under ER 500-1-1 and the provisions of Public Law 84-99.

3. Distribution Statement. Approved for public release, distribution is unlimited.

4. References.

a. USACE Publications.

(1) EM 1110-2-38, Environmental Quality in Design of Civil Works Projects, 3 May 1971.

(2) EM 1110-2-1205, Environmental Engineering and Local Flood Control Channels, 15 November 1989 (Sections 4-8.d (4) and 5-1).

(3) EM 1110-2-1601, Hydraulic Design of Flood Control Channels, 1 July 1991, with Change 1, 30 June 1994 (Sections 3-3 and 3-5).

(4) EM 1110-2-1913, Design and Construction of Levees, 30 April 2000 (Sections 4-4 and 8-17).

(5) EM 1110-2-2300, General Design and Construction Considerations for Earth and Rock Fill Dams, 30 July 2004.

This ETL supersedes: ETL 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures, dated 30 April 2009.

(6) EM 1110-2-2502, Retaining Walls and Floodwalls, 29 September 1989 (Section 7-16).

(7) EP 500-1-1, Emergency Employment of Army and Other Resources. Civil Emergency Management Program – Procedures, 30 September 2001 (Section 5.8.k and Appendix E).

(8) ER 200-1-5, Policy for Integrated Application of U.S. Army Corps of Engineers (USACE) Environmental Operating Principles (EOP) and Doctrine, 30 October 2003.

(9) ER 1110-1-12, Quality Management, Change 1, 30 September 2006.

(10) ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999.

(11) ER 1130-2-530, Project Operations - Flood Control Operations and Maintenance Policies, 30 October 1996.

b. FEMA Publications.

(1) FEMA 473, FEMA (2005a), Technical Manual for Dam Owners, Impacts of Animals on Earthen Dams, FEMA 473, September 2005, http://www.fema.gov/plan/prevent/damfailure/publications.shtm

(2) FEMA 534, FEMA (2005b), Technical Manual for Dam Owners, Impacts of Plants on Earthen Dams, FEMA 534, September 2005, http://www.fema.gov/plan/prevent/damfailure/publications.shtm

(3) 44 CFR Chapter 65.10, "Mapping of Areas Protected by Levee Systems," 24 October 2012.

c. Other Publications.

(1) Association of State Dam Safety Officials (2002), Association of State Dam Safety Officials (ASDSO) (2002), A Technical Manual on the Effects of Tree and Woody Vegetation Root Penetrations on the Safety of Earthen Dams, December 2002.

5. General. Levees, floodwalls, embankment dams, and their appurtenant structures serve a common purpose in that they are designed to contain water and prevent flooding for varying lengths of time. They must also be readily accessible by equipment and personnel essential to reliable operation and maintenance. The possibility for long-term saturation of levee materials or levee and floodwall foundations, together with their specific operation and maintenance requirements, makes it necessary to exercise caution in the design of landscape planting and vegetation management at these structures. This ETL describes important characteristics of levees, floodwalls, embankment dams, and their appurtenant structures.

6. Future Guidance. Planned research will complement this guidance. Future editions will include field studies of vegetation impacts to flood damage reduction structures and helpful information on the root system characteristics of various plant species.

FOR THE COMMANDER:

JAMES C. DALTON, P.E., SES
Chief, Engineering and Construction Division
Directorate of Civil Works

2 Appendices
Appendix A-Illustrations
Appendix B-Acronyms, Abbreviations, and Glossary of Terms

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CHAPTER 1

Introduction

1-1. Purpose.

This ETL provides guidelines to assure that landscape planting and vegetation management provide aesthetic and environmental benefits without compromising the reliability of levees, floodwalls, embankment dams, and appurtenant structures. It is intended as a guide for safe design and not as a restriction to the initiative of designers. These guidelines should be used with reasonable judgment and practicality, and should be tailored to the specific requirements and conditions of each individual project. A design that integrates landscape plantings and vegetation management into a system for flood damage reduction requires a coordinated, interdisciplinary effort that involves the local sponsor and the following disciplines: civil engineer, landscape architect, levee and/or dam safety engineer, environmental engineer, geologist, biologist, and additional related disciplines, as appropriate.

1-2. Applications.

a. Where the safety of the structure is not compromised, and effective surveillance, monitoring, inspection, maintenance, and flood-fighting of the facility are not adversely impacted, appropriate landscape planting (trees, shrubs, vines, forbs, and grasses) may be incorporated into the design of all flood damage reduction projects, subject to the limitations set forth in this document. Because landscape plantings enhance the environment, with respect to both natural systems and human use, they are to be considered in all flood damage reduction project planning and design studies and will be fully presented in design documentation reports. For projects in which the maintenance of the completed facility will be the responsibility of the local sponsor, the landscape planting will be fully coordinated with the local sponsor during planning and design to determine the sponsor's desires and to obtain assurances that the sponsor is capable of, and committed to, the proper maintenance of the vegetation.

b. In certain instances, to further enhance environmental values or to meet state or Federal laws and/or regulations, the local sponsor may request a variance from the standard vegetation guidelines set forth in this ETL. Vegetation variances for either Federal or non-Federal flood damage reduction systems may be permitted. The vegetation variance must meet the following two criteria:

(1) The variance must be shown to be necessary, and the only feasible means, to: (1) preserve, protect, and enhance natural resources, and/or (2) protect the rights of Native Americans, pursuant to treaty and statute.

(2) With regard to flood damage reduction systems, the variance must retain: (1) safety, structural integrity, and functionality, and (2) accessibility for maintenance, inspection, monitoring, and flood-fighting. Note that, as used here, the term "retain" assumes a pre-variance condition that is fully consistent with the requirements set forth in this ETL, and any other applicable criteria.

(3) Some types of vegetation, both woody (trees, shrubs, and vines) and non-woody (grasses and forbs), will be periodically cleared, as needed, to maintain the conditions described in the second criterion. The variance will not be a substitute for poor maintenance practices. See the following references regarding variances to levee vegetation standards: ER 500-1-1, for policy; EP 500-1-1, for the request and approval process; and, any other applicable guidance issued subsequent to this document.

c. Any addition of landscape plantings to existing flood damage reduction systems must comply with the project's O&M manual. New plantings may not be approved without an appropriately detailed and documented engineering evaluation to ensure that design intent and safety criteria are maintained as originally authorized.

1-3. Environmental Quality and Aesthetics. Environmental quality and aesthetics are of special concern. The design and maintenance of flood damage reduction systems must fully consider the environmental implications of the proposed actions and must ensure that they are consistent with the doctrine outlined in the Corps' Environmental Operating Principles. Project design should respond appropriately to the visual character of the project context with respect to the characteristics of both the natural and built landscapes. Landscape planting design should consider both human use and the environmental processes and characteristics of the entire area influenced by the project. While it is seldom feasible to preserve the natural setting intact, design techniques and careful construction methods can protect and perhaps enhance local environmental and aesthetic values.

CHAPTER 2

Landscape Planting: Objectives and Engineering Requirements

2-1. Background.

a. In flood damage reduction projects, the goal of landscape planting is to minimize and/or mitigate negative impacts to aesthetic, environmental, and ecological conditions, such that post-project conditions are equal to, or better than, pre-project conditions. Landscape planting objectives should, minimally:

(1) Provide cover to prevent dust and erosion.

(2) Provide ecological benefits, such as improved water quality and wildlife habitat.

(3) Integrate the flood damage reduction system with the surrounding natural and human environment.

(4) Separate activities.

(5) Define zones of use.

(6) Provide privacy.

(7) Screen undesirable features or views.

(8) Accentuate positive features or views.

(9) Create a pleasant environment for human use and recreation.

b. These and any other project-specific landscape planting objectives must be consistent with both the policy set forth in Paragraph 1-3 and the engineering requirements detailed in this chapter.

2-2. Vegetation-Free Zone.

a. The vegetation-free zone is a three-dimensional corridor surrounding all levees, floodwalls, embankment dams, and critical appurtenant structures in all flood damage reduction systems. The vegetation-free zone applies to all vegetation except grass. Grass species are permitted, as described in Paragraph 4-8, for the purpose of erosion control.

b. The primary purpose of the vegetation-free zone is to provide a reliable corridor of access to, and along, levees, floodwalls, embankment dams, and appurtenant structures. This corridor must be free of obstructions to assure adequate access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting. In the case of flood-fighting, this access corridor must also provide the unobstructed space needed for the construction of temporary flood-control structures. Access is typically by four-wheel-drive vehicle, but for some purposes, such as maintenance and flood-fighting, access is required for larger equipment, such as tractors, bulldozers, dump trucks, and helicopters. Accessibility is essential to the reliability of flood damage reduction systems.

c. The vegetation-free zone must be both wide and tall enough to accommodate all likely access requirements. The minimum allowable dimensions for a vegetation-free zone, for a variety of flood damage reduction system configurations, are based on lessons learned from flood-fighting experience and are illustrated in Chapter 6. The general rule is:

(1) The minimum height of the corridor shall be 8 ft, measured vertically from any point on the ground.

(2) The minimum width of the corridor shall be the width of the levee, floodwall, or embankment dam, including all critical appurtenant structures, plus 15 ft on each side, measured from the outer edge of the outermost critical structure. In the case of a planting berm (Figures A-13, A-14, and A-15), the 15 ft is measured from the point at which the top surface of the planting berm meets the levee section.

(3) No vegetation, other than approved grasses, may penetrate the vegetation-free zone, with two exceptions, as shown in Figure A-2:

(a) Tree trunks are measured to their centerline, so one half of the tree trunk may be within the vegetation-free zone.

(b) Newly planted trees, the crowns of which can be expected to grow or to be pruned clear of the vegetation-free zone within 10 years.

d. The minimum vegetation-free zone dimensions may not be diminished without a formal variance (see Paragraph 1-3b). Due to specific site conditions and project requirements, many levees, floodwalls, embankment dams, and appurtenant structures will be determined, by the project design team, to require a vegetation-free zone larger than the minimum described here.

e. This paragraph has established the minimum acceptable width of the vegetation-free zone at 15 ft. Other than by variance, as described above, the single exception to this 15-ft minimum requirement arises in the case of an existing project where the width of the existing real estate interest for the project is less than 15 ft. In such a case, the vegetation-free zone width shall be the maximum attainable within the existing real estate interest.

2-3. Vegetation-Management Zone.

A recommended alternative to enlarging the vegetation-free zone is adding an adjacent vegetation-management zone (see Figure A-22). A vegetation-management zone provides greater opportunity to include vegetation by reserving the option to manage it selectively, as needed. Two of many possible scenarios are:

a. Several trees, just outside the vegetation-free zone, are inhibiting grass growth, through light deprivation and/or the production of their own natural herbicides that limit competition for moisture and nutrients. These trees should be either removed or modified, as appropriate, to assure that grasses thrive and continue to provide effective erosion control.

b. A large tree, outside the vegetation-free zone, becomes a hazard tree when its root system is severely damaged by construction activity, thereby increasing its susceptibility to windthrow and the associated risk of damage to a floodwall. This tree should be removed.

2-4. Root Impacts.

As stated in Paragraph 2-2, the primary purpose of the vegetation-free zone is access. However, it also serves a secondary purpose: it provides distance between root systems and levees, floodwalls, embankment dams, and appurtenant structures, thereby moderating reliability risks associated with the following two situations: potential piping and seepage due to root penetration; and structural damage (a hole in the ground, surrounded by an area of disturbed earth) resulting from a wind-driven tree overturning. Though not adequate for all situations, this 15-ft zone does provide a measure of risk reduction, as follows:

a. Root size and numbers diminish with distance from the tree trunk.

b. The hole and its surrounding area of disturbed earth, created by a tree overturning, typically has a radius ranging from 6 to 12 ft. This secondary effect of the vegetation-free zone is important to the reliability of flood damage reduction systems; it is not a root-free zone, but it is a zone of reduced root impact.

2-5. Root-Free Zone. Planting design must consider the possible implications to foundation strength and performance. The integrity of the foundation could be compromised if potential seepage paths were created by root penetration and/or root decay. The root-free zone provides a margin of safety between the greatest expected extent of plant roots and the beginning face of any structure that is critical to the performance and reliability of the flood damage reduction system. The list of such structures includes levees, floodwalls, embankment dams, seepage berms, seepage drains, toe drains, pressure relief wells, and cut-off trenches. These critical structures must be root-free, as shown in Figures A-13, A-14, A-15, A-17, and A-19. The rooting habit of each plant selected for use near a root-free zone must be predictably understood with respect to its potential to invade the root-free zone and compromise the reliability of the flood damage reduction system. Landscape planting plans will reflect full recognition of the importance of selecting appropriate plant species and varieties. Root barriers may be used to provide an added measure of assurance, but they should not be a substitute for adequate distance between plantings and root-free zones. Root barriers shall not retard groundwater or seepage flow. Some root barriers include herbicides to enhance effectiveness; in every case, these shall be evaluated before use to prevent negative environmental impacts.

2-6. Water-Current and Wave-Action Barrier. The use of suitable vegetation, such as shrub forms of *Salix* (willow), riverward of the vegetation-free zone, is encouraged as an environmentally beneficial means to moderate the erosive potential of water currents and wave action.

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CHAPTER 3

Treatment of Levees, Floodwalls, Embankment Dams, and Appurtenant Structures

3-1. General.

a. The integrity of levees, floodwalls, embankment dams, and appurtenant structures is paramount to the public health, safety, and welfare. The presence of undesirable vegetation can undermine that integrity and lead to failure if not corrected.

b. Trees and other woody vegetation, such as shrubs and vines, can create both structural and seepage instabilities, prevent adequate inspection, and create obstacles to maintenance and flood-fighting/flood-control activities. Vegetation must be controlled for the following reasons:

(1) To allow proper inspection, surveillance, and monitoring of all structures and adjacent areas for seepage, cracking, sinkholes, settlement, displacement, and other signs of distress.

(2) To allow access for normal and emergency Operations and Maintenance (O&M) activities.

(3) To prevent root-related damage to structures, such as shortened seepage paths through embankments and/or foundations; voids in embankments and/or foundations due to decayed roots or fallen trees; clogged seepage collector systems; and expansion of cracks or joints in concrete walls, spillway floors, and canal linings.

(4) To limit those habitat characteristics that encourage the creation of animal burrows.

(5) To allow full design-discharge capability of waterways, spillway inlet and outlet channels, outlet-works discharge channels, and other open conveyance channels.

(6) To avoid any incidental growth and subsequent presence of endangered species that might prohibit activities necessary for O&M, or access.

c. This document establishes minimum dimensions for both vegetation-free zones and root-free zones; however, for any specific project, those minimum dimensions may be increased by levee and/or dam-safety engineering personnel due to site-specific considerations such as topography, phreatic surfaces within the structure and abutments, geological features, historical embankment and/or foundation seepage or issues, stability issues, and foundation characteristics.

3-2. Levees.

a. Levees are usually constructed of compacted earth fill. In some cases, internal drainage or under-seepage treatment is incorporated into the levee. When a planting berm is used to allow vegetation nearer to the levee centerline, the internal blanket drain and/or toe drain must be extended, as shown in Figures A-14 and A-15. Any such extension must be assessed by the design team for impact to the seepage control system.

b. All levees must have effective and reliable erosion protection. Paragraph 4-8 describes appropriate use of grasses. Where opportunities exist, environmental improvements should be considered. Project design shall address the following criteria:

(1) Urban Levees. Because levee projects have the potential to dominate these high-visibility landscapes, planting is often desirable, particularly in high-visibility locations, such as at and along major thoroughfares, parks, and waterfront developments.

(2) Rural or Agricultural Levees. Although these are typically not high-visibility areas, both human use and environmental needs should be considered during design. Plantings are particularly appropriate for the following areas, provided they are consistent with site-specific engineering requirements: high-visibility pumping installations, public road crossings, locations near residences, and at other project locations where landscape plantings could protect or restore valued environmental characteristics.

c. Minimum vegetation-free and minimum root-free zones are established for levees, as illustrated in Chapter 6.

3-3. Floodwalls.

a. Floodwalls are most often used in urban areas, where land or access is constrained. These walls are subject to hydraulic forces on one side, which may be resisted by little or no earth-loading forces on the other side. Landscape planting should be addressed in floodwall design, particularly where walls encroach on, or change, existing scenic values, e.g., where the wall becomes a visual barrier along a street or near dwellings, parks, and existing or anticipated commercial developments.

b. The minimum vegetation-free zone provides for access. However, two additional areas of concern with respect to floodwalls are:

(1) Large trees can be a threat to project reliability. Planting design and maintenance must take into account the potential for overturning trees to damage floodwalls. The following factors can be used, alone or in combination, to limit potential for such damage:

(a) Ensuring distance between a tree and the wall.

(b) Selecting tree species that have a low potential for breaking and overturning.

(c) Monitoring and performing maintenance to address hazard trees.

(d) Placing intervening obstacles, such as other trees, that would reliably restrain a falling tree. Where other factors are unreliable, the distance between a tree and the wall must be adequate: e.g., a minimum distance of one-half of the mature tree height.

(2) Planting design and maintenance must also take into account the three potential means by which tree roots may damage floodwalls:

(a) Large tree roots can damage concrete structures by jacking (lifting) them, which can cause cracking and separation at joints. Further, if a floodwall is lifted, a seepage path could form along the structure/foundation contact. Smaller (lighter) floodwalls are more susceptible than larger (heavier) structures.

(b) Roots may also grow into and through wall joints, loosening and eroding wall-joint seals, thus damaging the water-proof characteristics.

(c) A floodwall may have a toe drainage system to:

(1) Check and control piping and boils,

(2) Control seepage that may result from roofing, where piles are used, and

(3) Control uplift pressures. These drainage systems must be protected from invasion by roots, which could clog them.

c. Although there are several types of floodwalls, the two most common are the inverted-T type reinforced concrete wall and the cantilever-I type sheet piling wall. The vegetation impact concerns are similar for both types. For all the reasons cited above, minimum vegetation-free and minimum root-free zones are established for floodwalls, as shown in Figures A-16 through A-19.

3-4. Embankment Dams and Appurtenant Structures.

a. Purpose. “Tree and woody-vegetation penetrations of earthen dams and their appurtenances have been demonstrated to cause serious structural deterioration and distress that can result in failure of earthen dams” (Association of State Dam Safety Officials 2002). Proper establishment and control of vegetation is critical to dam safety. This Paragraph establishes minimum requirements for landscape planting and vegetation management at embankment dams (earth fill, rock fill, or earth and rock fill), including multipurpose projects with both concrete and embankment dam structures (wing dams) and perimeter saddle dams (dikes); abutments; and appurtenances, such as spillways, outlet works, and inlet and/or outlet channels.

b. Policy. The following five areas are vegetation-free zones:

(1) The dam or the dam-toe area.

(2) Areas in or around seepage monitoring systems, or critical downstream areas where seepage observation must be vigilant and continuous.

(3) Groin abutments and areas immediately adjacent to groin abutments.

(4) Spillways and spillway channels, including spillway slopes and approaches to spillways where vegetation could, in any way, impede the efficient operation of the spillway.

(5) The outlet-works discharge channel.

c. Vegetation-Free Zones. Vegetation-free zones shall, when dry, be mowed to a height of 3–6 in. at any time the grass reaches a height of 12 in.. Mowing shall be triggered by grass heights of less than 12 in. if important to the health maintenance of the particular grass species. The maximum height of grasses shall be 12 in. The minimum vegetation-free zone requirements for specific structures are:

(1) Embankment Dams. At a minimum, for "dry" reservoirs, the entire dam embankment surface, including upstream impervious blankets and the upstream and downstream areas within 50 ft of the embankment toe, shall be a vegetation-free zone (see Figure A-20). For "normal pool" conditions, the entire embankment surface from the upstream toe of the dam or from the upstream limit of the impervious blanket, as applicable, to a minimum distance of 50 ft from the downstream toe shall be a vegetation-free zone (see Figure A-21).

(2) Dam Abutments. The dam abutment is defined as the part of a natural valley side-wall against which a dam is constructed. At a minimum, the vegetation-free zone shall extend for a horizontal distance of 15 ft beyond the embankment/abutment contact line (i.e., groin).

(3) Spillways. The safety of embankment dams requires the unobstructed operation of spillways. The minimum vegetation-free zone shall include the spillways and spillway channels, including spillway slopes and approaches.

(4) Outlet-Works Discharge Channels. The minimum vegetation-free zone shall include the entire outlet channel, outlet structure headwalls and wingwalls, and surrounding areas to a distance of 50 ft from the top of the bank of the outlet channel.

CHAPTER 4

Design Considerations

4-1. Feasibility Analysis.

During design, an analysis shall be made of the flood damage reduction system to determine if and where landscape planting can be permitted. Not all projects will have a satisfactory combination of conditions to permit planting of trees, shrubs, vines, forbs, and grasses. In some cases, only shrub planting may be feasible. In other cases, planting may be limited to grasses. Site conditions, engineering design criteria, and O&M requirements should determine the appropriate planting scheme. However, environmental objectives shall be considered in all projects and the engineering design should seek to accommodate appropriate plantings. The following paragraphs describe some important site considerations.

a. Types of Construction Material. The type of construction material is an important factor in determining suitability for landscape planting. Rock, sand, and many types of compacted clay embankments are examples of poor plant-growing media. The roots of some plant species, under some conditions, may penetrate a great distance into a sand levee, potentially providing a path for piping through the structure. Plants must be selected very carefully with regard to the type of construction materials used to ensure survival of the plant and prevent damage to the structure.

b. Project Alignment. Project alignment can be a complex exercise involving multiple, often conflicting criteria and requiring a coordinated effort by the project delivery team. The role of the landscape architect is to identify opportunities and constraints to human use relative to project alignment. For example, in an urban area, a relatively minor adjustment to a proposed alignment might allow for plant screening between residences and the structure, or it might provide space for a park or other community green space. Often, those segments of the alignment that are otherwise arbitrary may be turned to advantage with respect to human use.

c. Environmental Factors. The types of vegetation suited to a site are a function of a number of environmental factors. Local climate (precipitation, temperature, dates of earliest and last frost, etc.) can limit the types of vegetation that survive in a particular region. Soil type, pH, nutrient character, exposure to sunlight, flood and drought duration, and depth to groundwater are additional conditions that can influence the potential for a site to support vegetation. Because one important functional characteristic of vegetative groundcovers is their ability to provide erosion control, it is necessary to confirm that the proposed cover can withstand the energy environment under flood conditions. This may require an assessment of local velocities and shear stresses and comparison of predicted values under flood conditions against thresholds for various types of vegetation.

4-2. Planting Berms.

a. Beyond the minimum section needed to satisfy stability requirements, it is sometimes desirable to add additional earth fill to a levee or embankment dam to create a planting berm to

better accommodate differing types of public use and related landscape planting approaches (see Figures A-13, A-14, and A-15). The appropriate dimensions of the planting berm should be determined by the landscape architect in consultation with the design team. Additional rights-of-way may be necessary to accommodate the additional fill material and flatter slopes. Except in approved planters, vegetation is not permitted on any overbuild that has a system-reliability function. Planting berms may be considered for use on the land side only.

b. Planting layout and plant material characteristics shall be coordinated with the design team to assure adequate access between the levee crown and the toe for two purposes: (1) visual access is required for inspection of the toe area, and (2) physical access is required for flood-fighting activities involving personnel and heavy equipment. In all cases, the planting berm must be of sufficient depth to accommodate any proposed vegetation while precluding root penetration into any root-free zone. Design must include adequate consideration of any internal drainage or seepage control system (see Figures A-14 and A-15).

c. Additional design requirements for planting berms include the following. For new projects, engineering and design shall be in accordance with ER 1110-2-1150, Engineering and Design for Civil Works Projects, and all related guidance. For existing projects, engineering and design shall be in accordance with CECW-PB memorandum dated 23 October 2006, Policy and Procedural Guidance for the Approval of Modification and Alteration of Corps of Engineers Projects.

4-3. Planters.

a. In overbuild areas, permanent plant containers, such as concrete planters, may be considered. Planters must not impact the designed dam or levee section, or appurtenant structures such as berms, drains, ditches and wells. Planter design and layout must allow for adequate access up and down the embankment as required for inspection and flood-fighting activities and must be approved by the Dam or Levee Safety Officer.

b. Planters and containerized plants should be used selectively and should be considered only when normal planting is not practical. The initial cost and the ability of the sponsor to maintain this type of planting should be considered during design. Plants selected for use in planters should have mature heights of not more than approximately 20 ft.

4-4. Irrigation Systems. Irrigation systems within the vegetation-free zone pose two potential threats to system reliability: (1) pressurized waterlines may fail, resulting in damage to the engineered embankment section, and (2) irrigation water may impair visual inspection by obscuring wet areas that are actually due to seepage. Any irrigation system that targets the vegetation-free zone shall be engineered so as to address these issues and meet the approval of the District dam or levee safety officer. Designs may include features such as double-walled piping and leakage detection systems.

4-5. Flood-Fighting and Structure Maintenance. Flood-fighting and maintenance operations for levees, floodwalls, embankment dams, and appurtenant structures can be complex. These

operations must not be impacted by the layout and physical characteristics of landscape plantings. Landscape plantings will be designed to permit inspection of structures from moving vehicles. Access requirements for emergency repair and replacement associated with flood-fighting efforts shall also be considered.

4-6. Maintenance of Plantings. Planting designs must be consistent with the capacity of the project sponsor to maintain them. Maintenance shall include the control and/or removal of invasive species. Low-maintenance plant materials are often the most appropriate choice.

4-7. Selection of Plant Material. Plants will be selected from approved plant lists prepared jointly by Division and District landscape architects in conjunction with the local sponsor or resource agencies. The list will include trees, shrubs, vines, forbs, sedges, and grasses that are native to the region and well adapted to the climactic, soil, and hydrologic conditions of the site. Plant lists should be appropriate to the specific structural conditions and requirements of each project. As the project site experiences fluctuations in various environmental conditions over time, such as water level, precipitation, and herbivory, some plants or species will not survive but others may thrive. A diverse array of plant species is essential to a riparian system's resiliency and its ability to provide and sustain a number of functions. A botanist familiar with local flora should be consulted to select those species from the approved list most likely to meet project objectives.

4-8. Appropriate Ground Cover in the Vegetation-Free Zone.

a. The only acceptable vegetative ground cover in the vegetation-free zone shall be perennial grasses. Their primary function shall be to reliably protect against erosion. They shall be maintained as necessary to ensure the health and vigor of the primary species providing erosion protection. The species selected for each project shall be appropriate to the local climate, conditions, and surrounding or adjacent land uses. Preference should be given to the use of native species. Invasive or weed species shall not be acceptable. The species selected must be able to tolerate mowing to heights as low as 3 in. as follows: at least once each year for inspection, and in anticipation of flood conditions and associated monitoring and flood-fighting activities.

b. If the local climate, hydraulic and hydrologic environment, soils, or other conditions will not support such grass species, then non-vegetative means of erosion control shall be employed, e.g., riprap, pavement, articulating concrete mats, or other engineered surface.

c. A maximum grass height is specified for embankment dams and their appurtenant structures (see Paragraph 3-4c, "Vegetation-Free Zones").

4-9. Borrow Sites and Spoil Sites. Borrow sites and spoil sites shall be restored through proper regrading and revegetation.

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CHAPTER 5

Vegetation-Related Maintenance and Repair

5-1. Maintenance of Ground Cover. As ground cover in a system designed to reduce flood damage, the primary purpose of grasses is to effectively prevent erosion. Therefore, maintenance must assure a healthy, vigorous stand of grass that is substantially free of weeds and bare spots. It will generally be necessary to periodically mow, graze, or burn grasses to permit proper inspection, manage pests, inhibit weed growth, or otherwise maintain the health and vigor of the plant stand. The appropriate time of year in which to conduct these maintenance activities will be a function of the species used and of the motivating factor for the maintenance activity itself. For example, mowing to prohibit weed establishment may best be timed to occur before the weed seeds become viable each year. The annual inspection may be scheduled to coincide with this period.

5-2. Operations and Maintenance Manual. For each project, it is important that the O&M manual include an annual maintenance program to control animal burrows and vegetative growth. It is also important that vegetation be managed in such a manner as to avoid the need for mechanized removal and associated embankment repair, and avoid any incidental growth and subsequent presence of endangered species that might prohibit access and activities necessary for O&M.

5-3. Removal of Non-Compliant Vegetation.

a. All vegetation not in compliance with this ETL shall be removed. A detailed removal plan shall be submitted to the local USACE District Levee Safety Officer for review and comment before removal of vegetation. The removal plan shall expand on the following basic requirements.

(1) By excavation, remove the trunk (or stem), stump, rootball, and all roots with diameters greater than ½ in. All such roots in, or within 15 ft of, the flood damage reduction structure shall be completely removed.

(2) Assure that the resulting void is free of organic debris.

(3) Fill and compact the void according to the original soil and compaction specifications: or, if no specifications exist, match adjacent soil and compaction.

b. Removal of non-compliant vegetation can create significant issues for the owner/operator, as maintenance may require environmental permits. The local sponsor must coordinate with the Corps and other appropriate agencies and obtain all the required environmental permits (including Corps of Engineers 404 permits) before conducting work within the levees. Mechanized land clearing below the plane of the “Ordinary High Water Mark” will normally require Clean Water Act permits before work can commence. (Note that “Ordinary High Water Mark” is defined in 33 CFR Part 328.3(e). In this document, see Figure A-23 in

Chapter 6 and the glossary in Chapter 7). In regions with endangered or threatened species, and/or their critical habitat, vegetation removal of any kind may require clearance through the U.S. Fish and Wildlife Service or the National Marine Fisheries Service under the Endangered Species Act.

5-4. Repair of Animal Burrows. For proper procedures for the repair of animal burrows, refer to the latest edition of FEMA Publication 473, *Technical Manual for Dam Owners, Impacts of Animals on Earthen Dams*.

APPENDIX A

Illustrations

A-1. General.

a. The figures presented here are cross-sections and are organized as follows:

(1) Figure A-1 shows the minimum vegetation-free zone required for a basic levee section and serves as an introductory example for use in Figure A-2.

(2) Figure A-2 shows the proper application of the vegetation-free zone with regard to various vegetation types and stages of development.

(3) Figures A-3 through A-23 give additional examples that show the minimum vegetation-free zone required for each of various flood damage reduction system configurations.

(4) Figures A-13, A-14, A-15, A-17, and A-19 show root-free zones.

(5) Figures A-20 and A-21 show vegetation-free zone requirements for embankment dams and their appurtenant structures (presented in greater detail in Paragraph 3-4).

(6) Figure A-22 shows the vegetation-management zone.

(7) Figure A-23 illustrates a levee section with the ordinary high water mark above the riverside toe.

b. For clarity, Figures A-1 through A-23 are not drawn to scale. However, Figures A-24 and A-25 are drawn to scale, using trees in the medium to large size range. The purpose of these two proportionally correct figures is to clearly illustrate realistic spatial relationships between trees (and their root systems) and levees.

c. Note that the minimum vegetation-free zone is not influenced by the type of erosion protection used, so figures are not specific in that regard, e.g., riprap is not shown.

A-2. Figures A-1 through A-25.

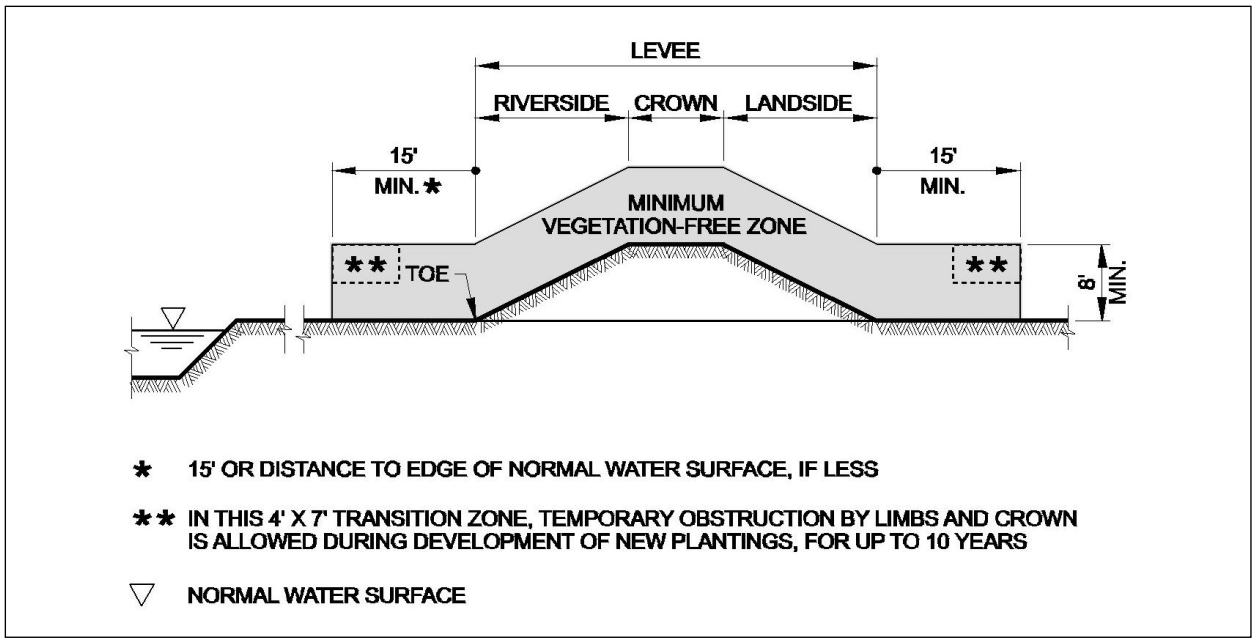


Figure A-1. Levee Section – Basic.

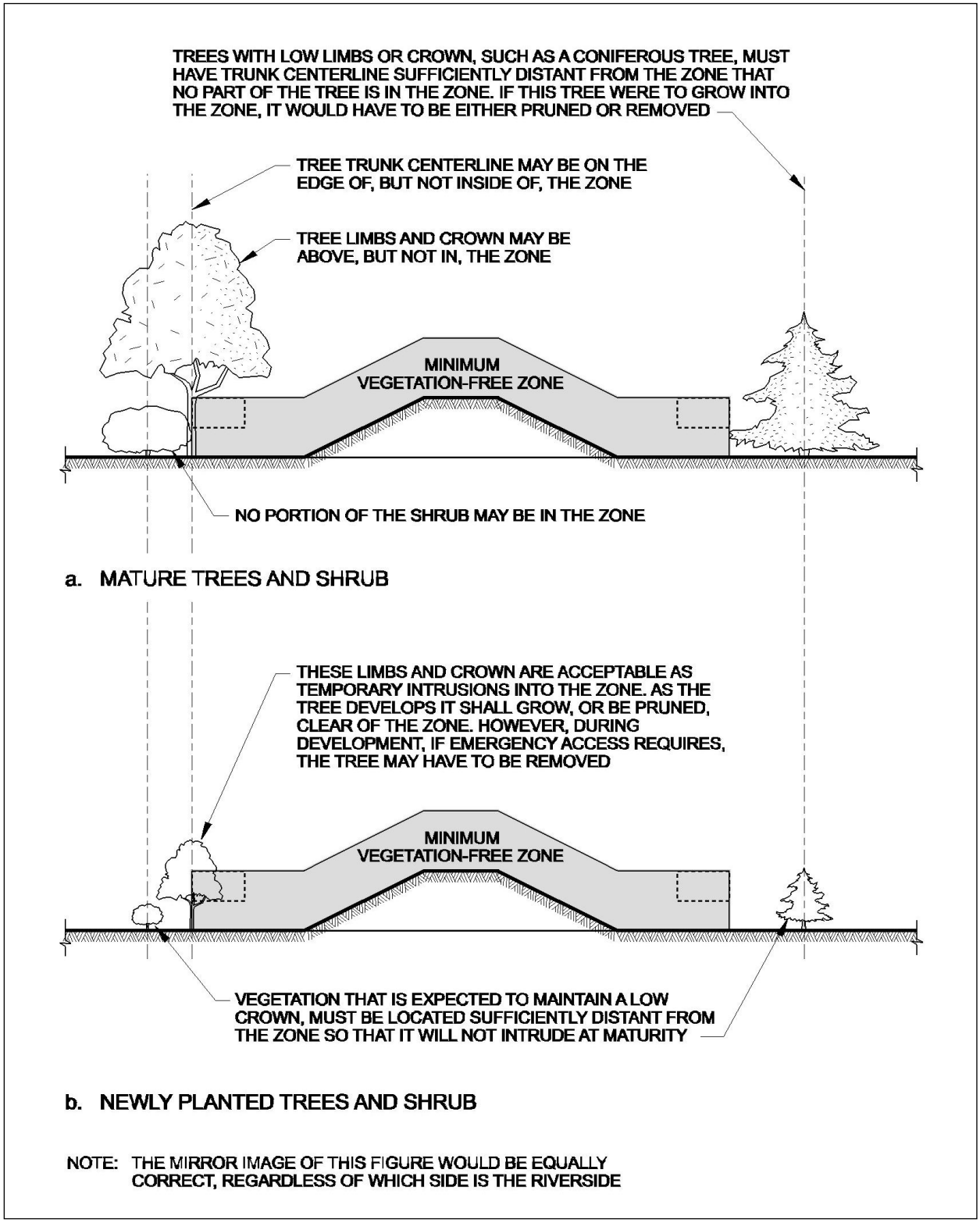


Figure A-2. Proper Application of the Vegetation-Free Zone.

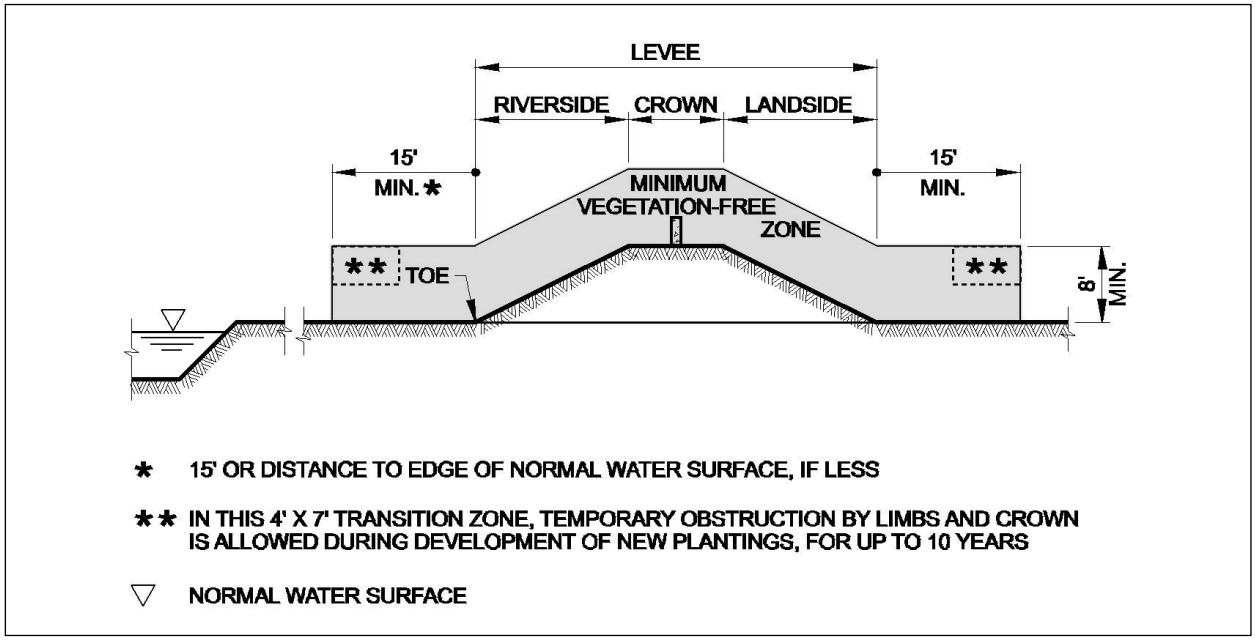


Figure A-3. Levee Section – Basic, with Floodwall on Crown.

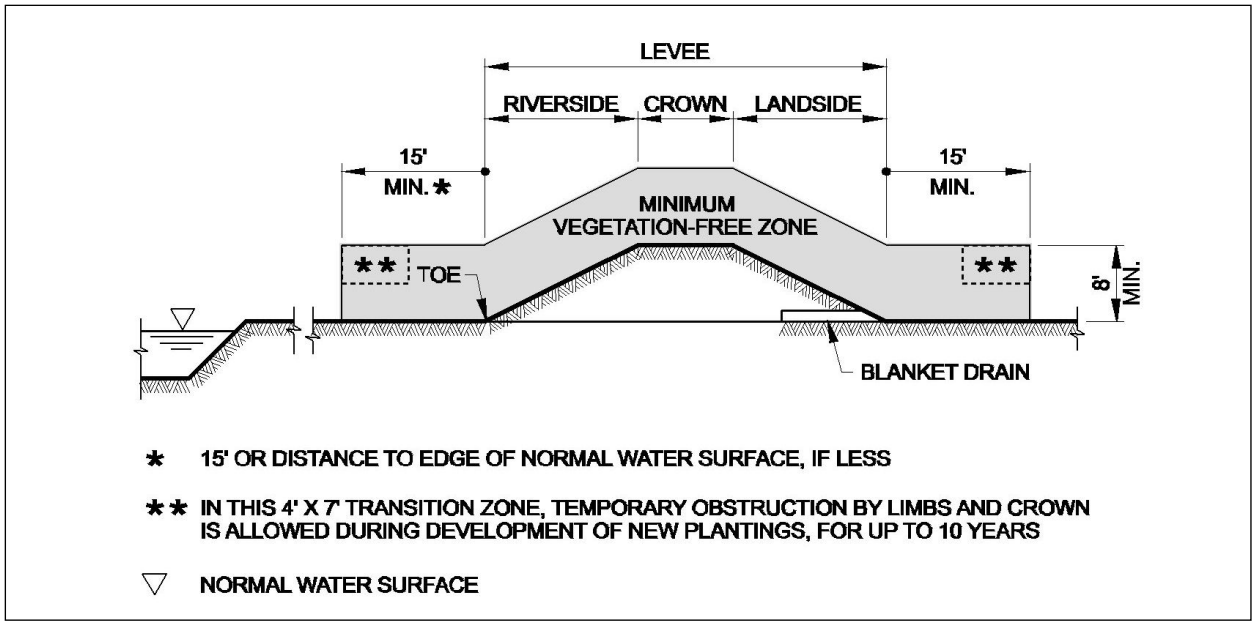


Figure A-4. Levee Section with Blanket Drain.

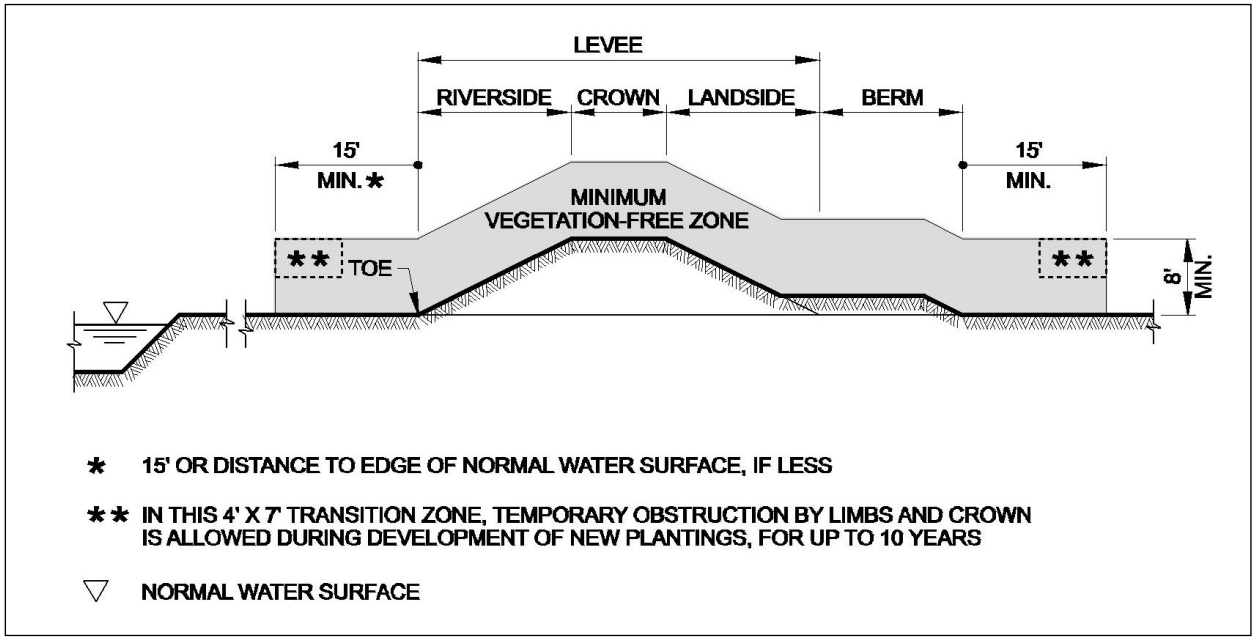


Figure A-5. Levee Section with Seepage or Stability Berm.

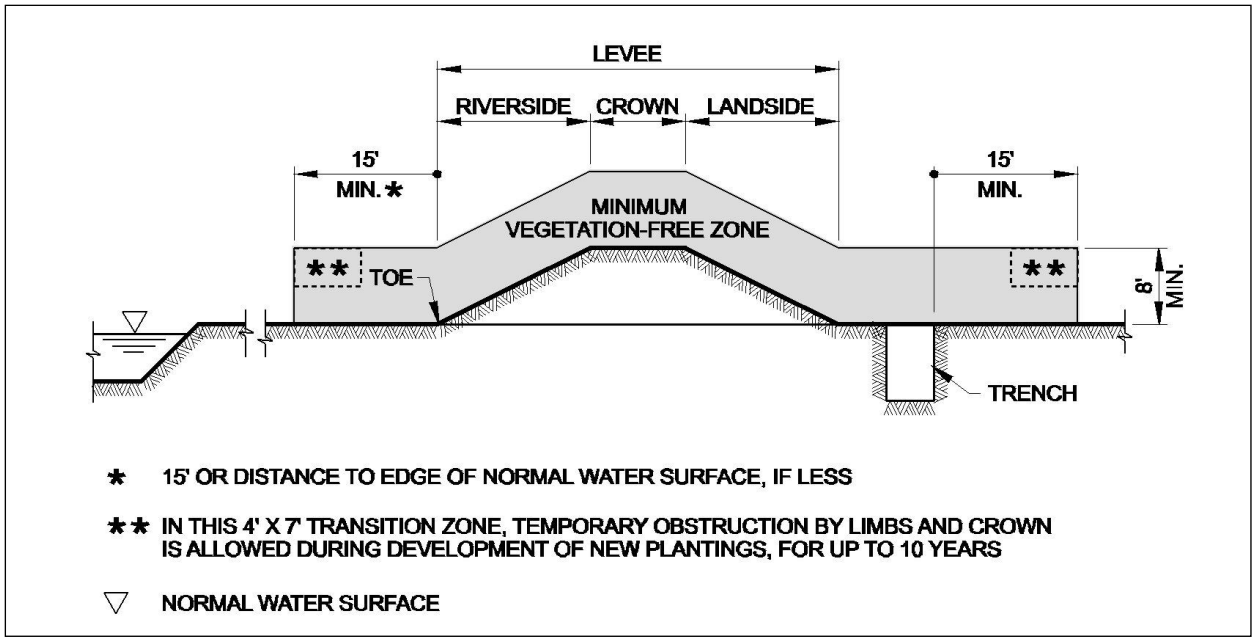


Figure A-6. Levee Section with Pervious Toe Trench.

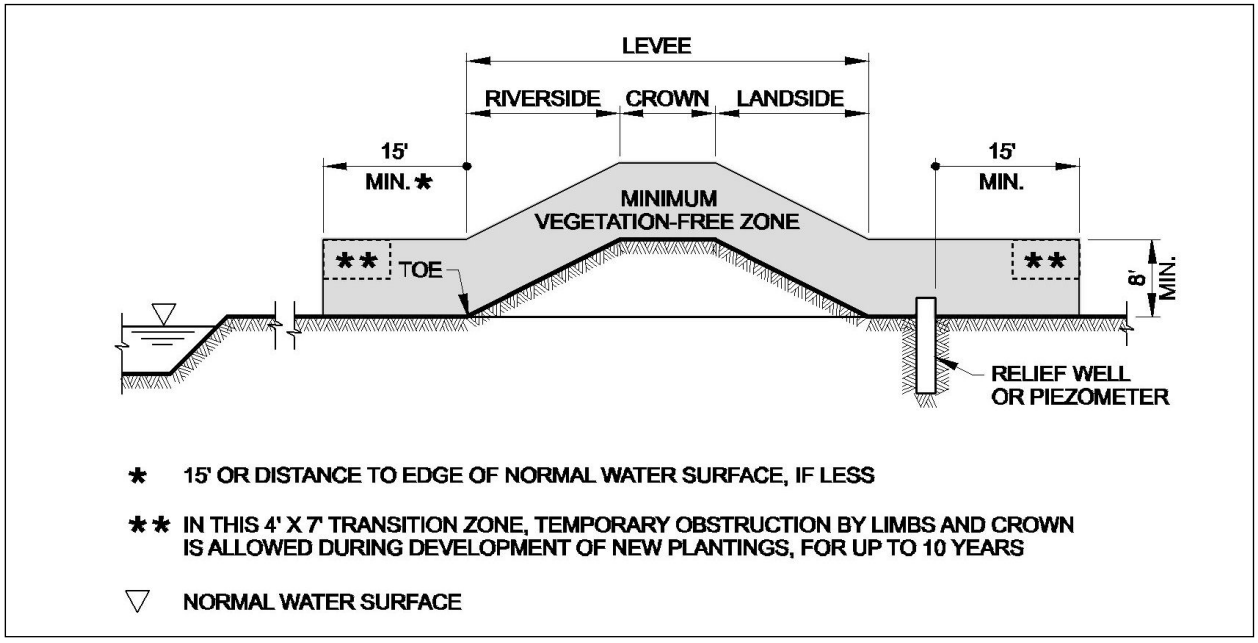


Figure A-7. Levee Section with Relief Well or Piezometer.

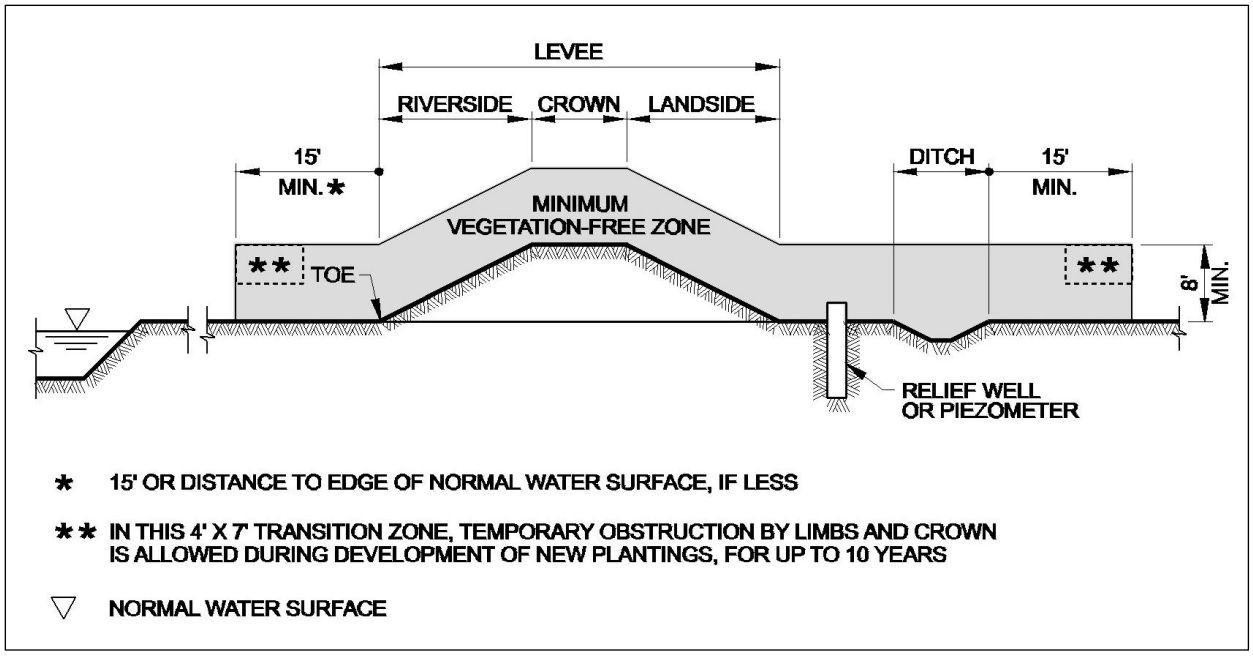


Figure A-8. Levee Section with Relief Well or Piezometer and Seepage Collector Ditch.

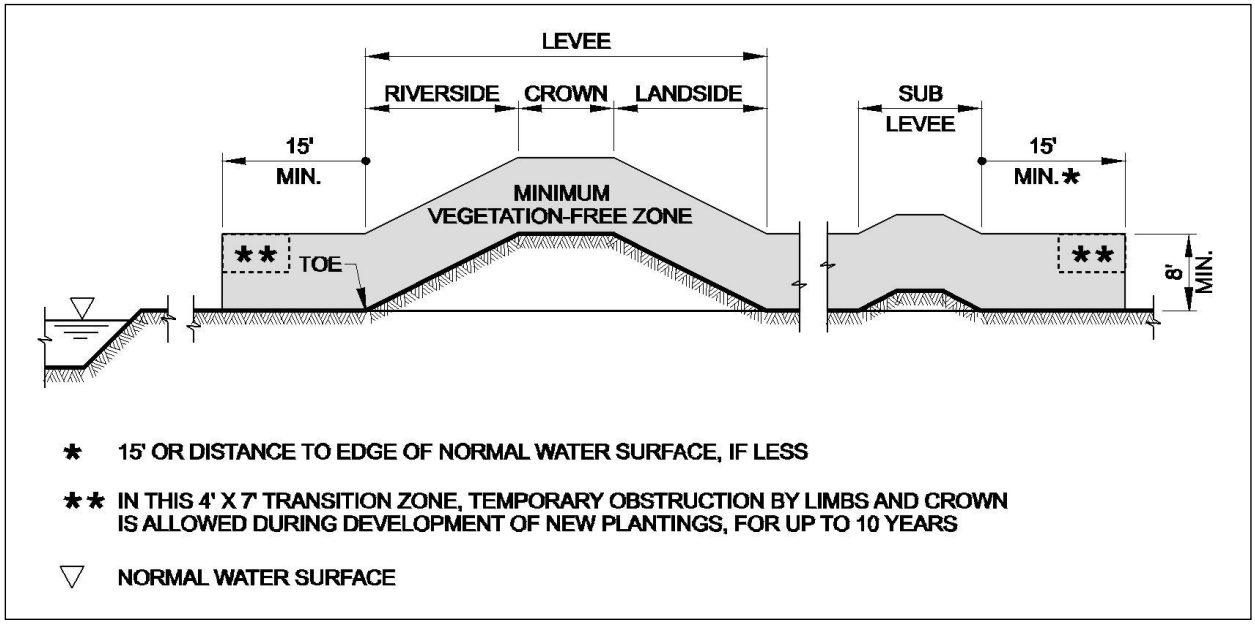


Figure A-9. Levee Section with Sub-Levee.

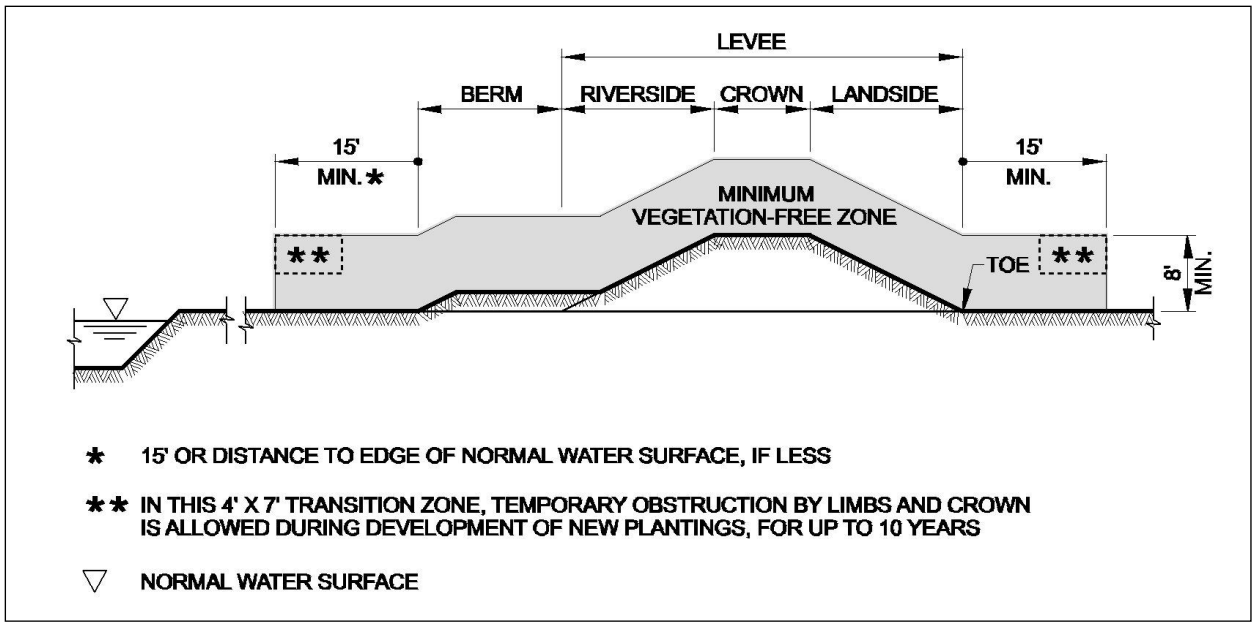


Figure A-10. Levee Section with Stability Berm.

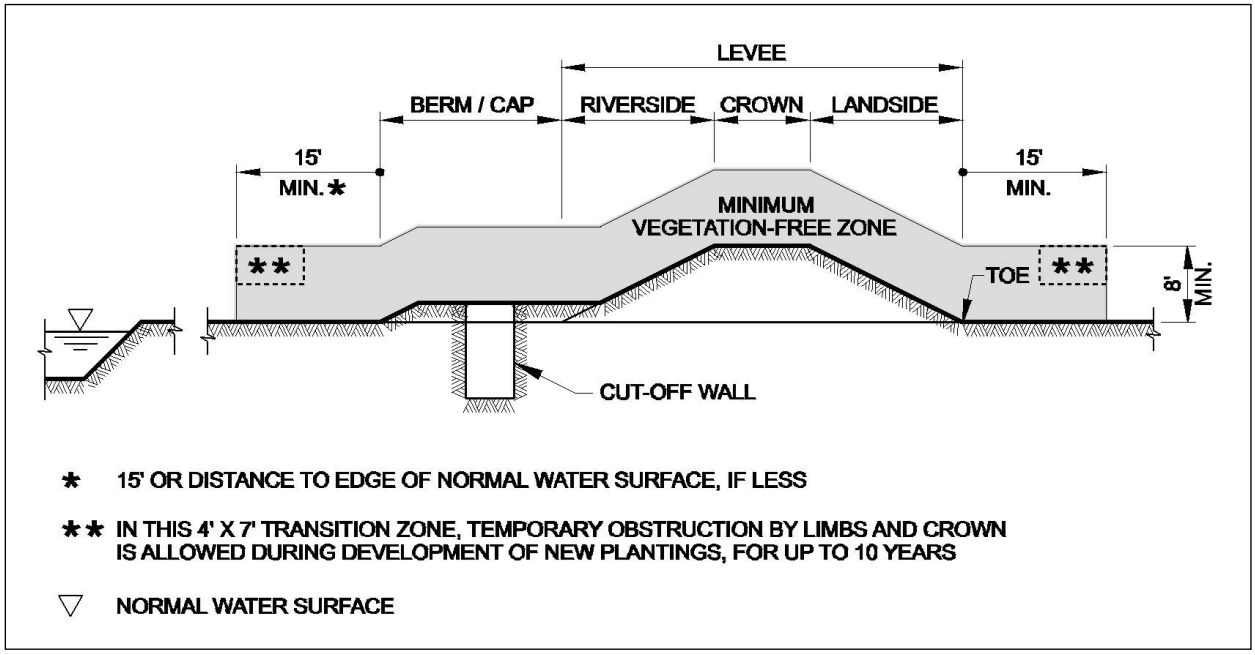


Figure A-11. Levee Section with Cut-Off Wall and Impervious Berm.

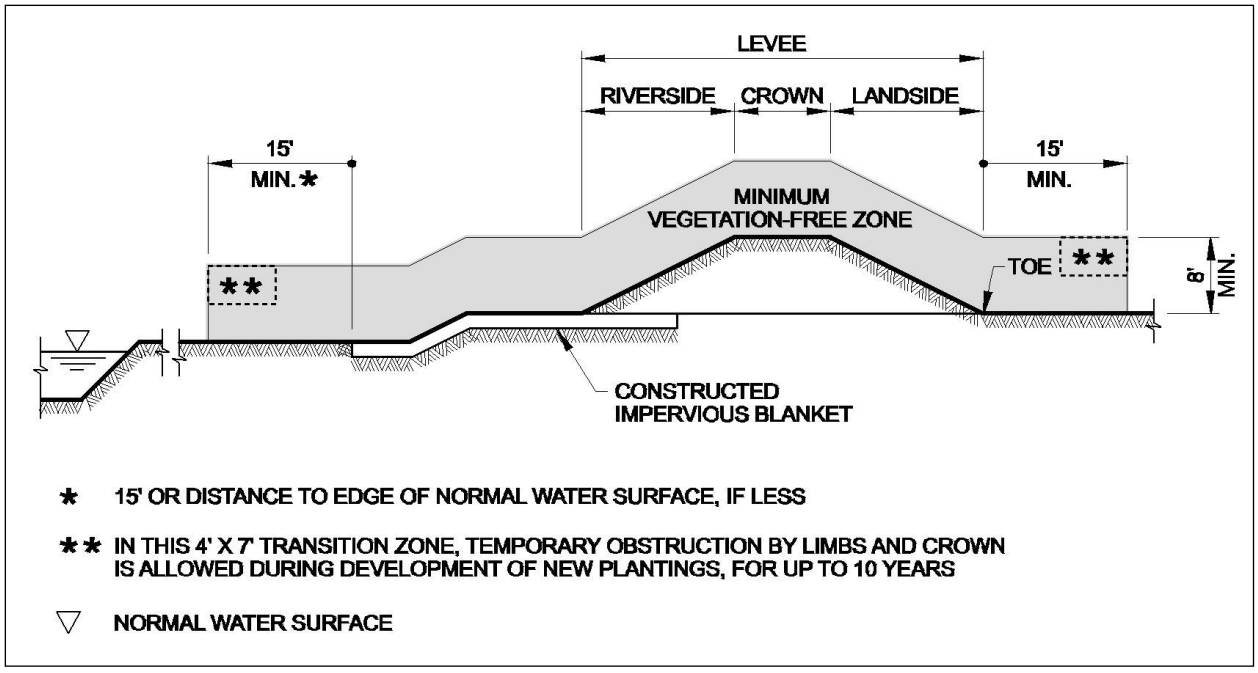


Figure A-12. Levee Section with Constructed Impervious Blanket.

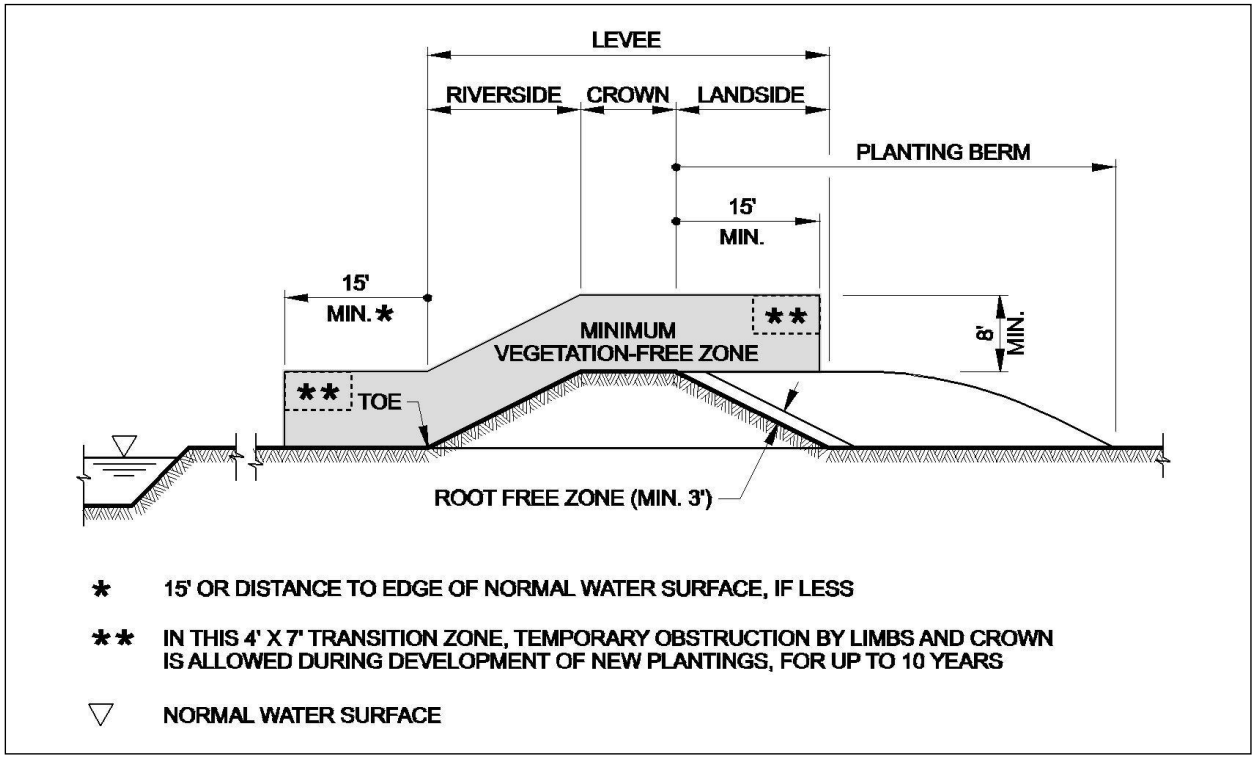


Figure A-13. Levee Section with Planting Berm.

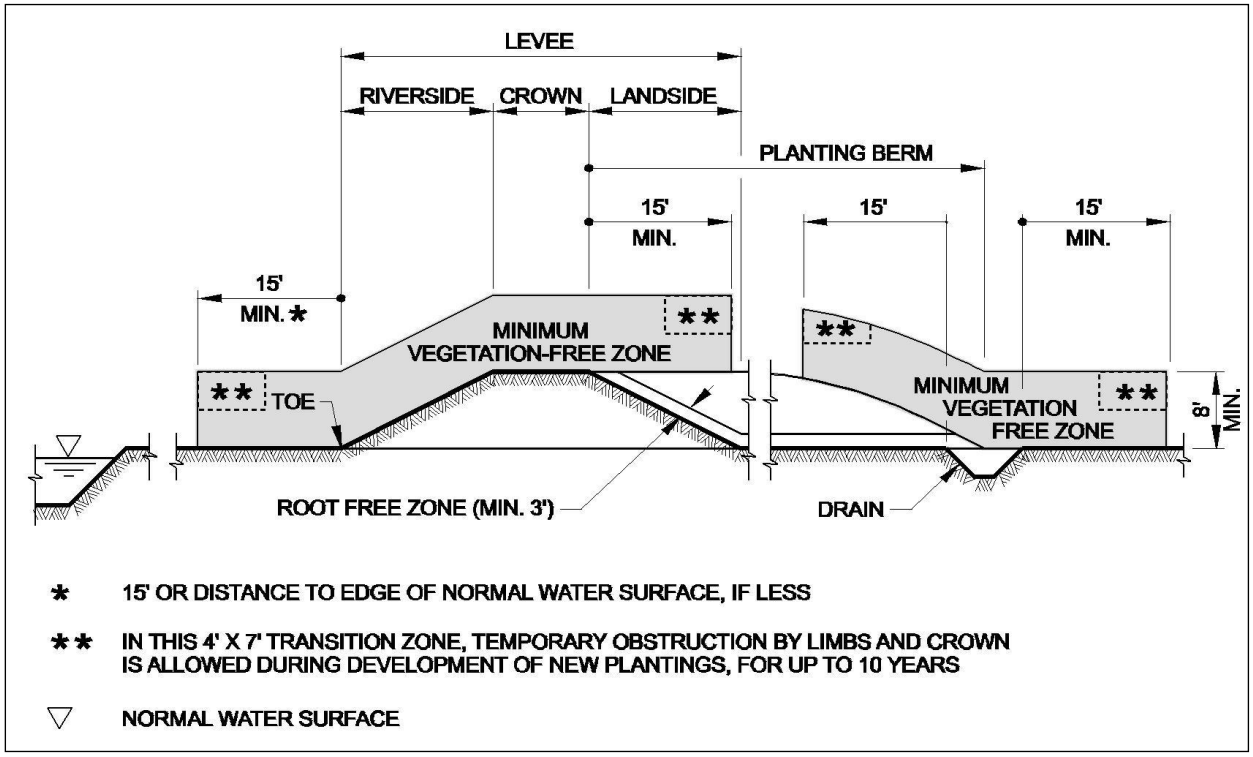


Figure A-14. Levee Section with Planting Berm and Collector Drain.

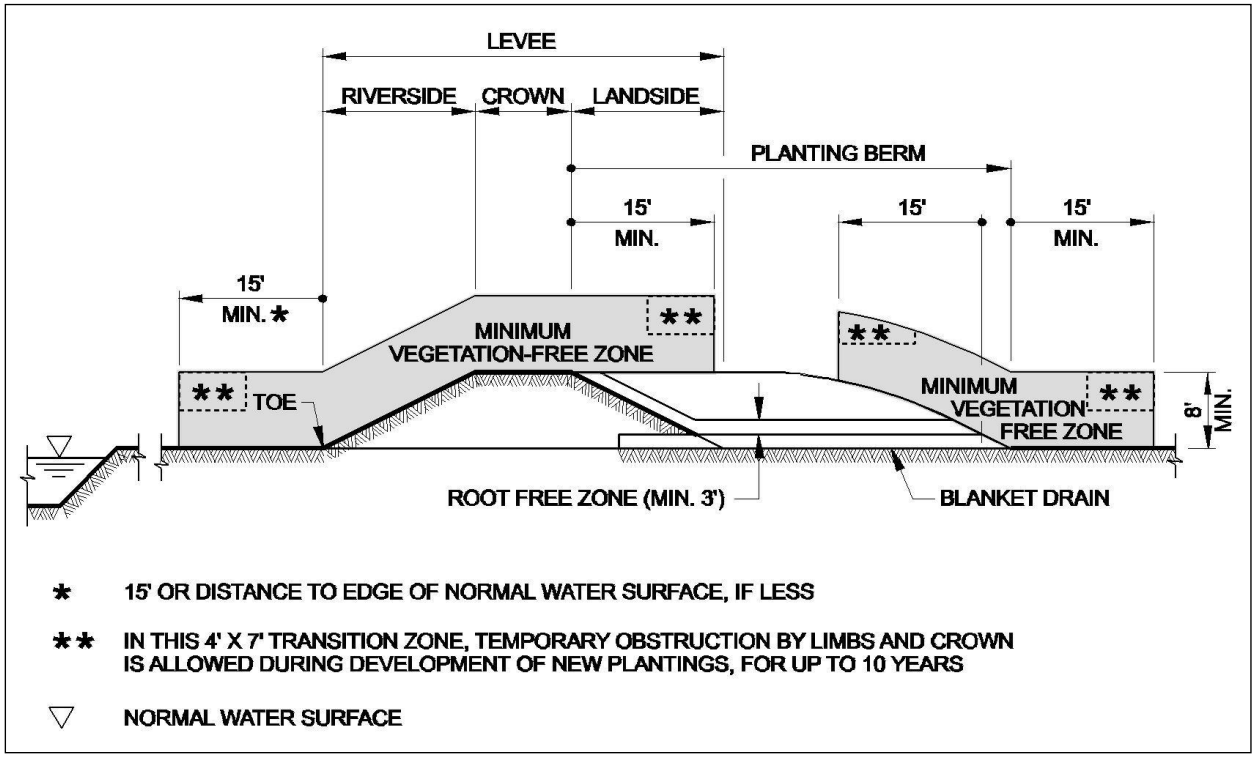


Figure A-15. Levee Section with Planting Berm and Blanket Drain.

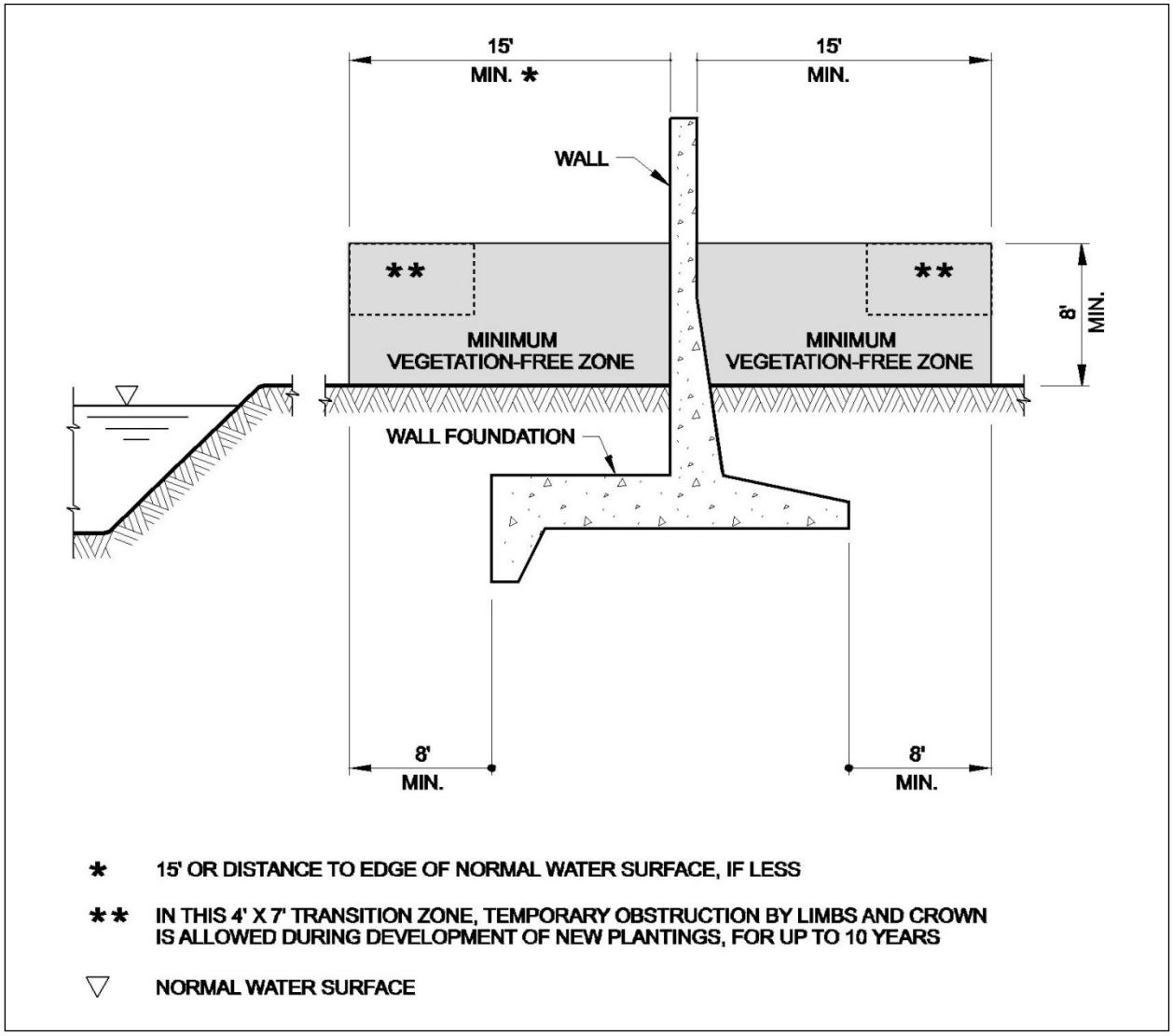


Figure A-16. Inverted-T Type Floodwall.

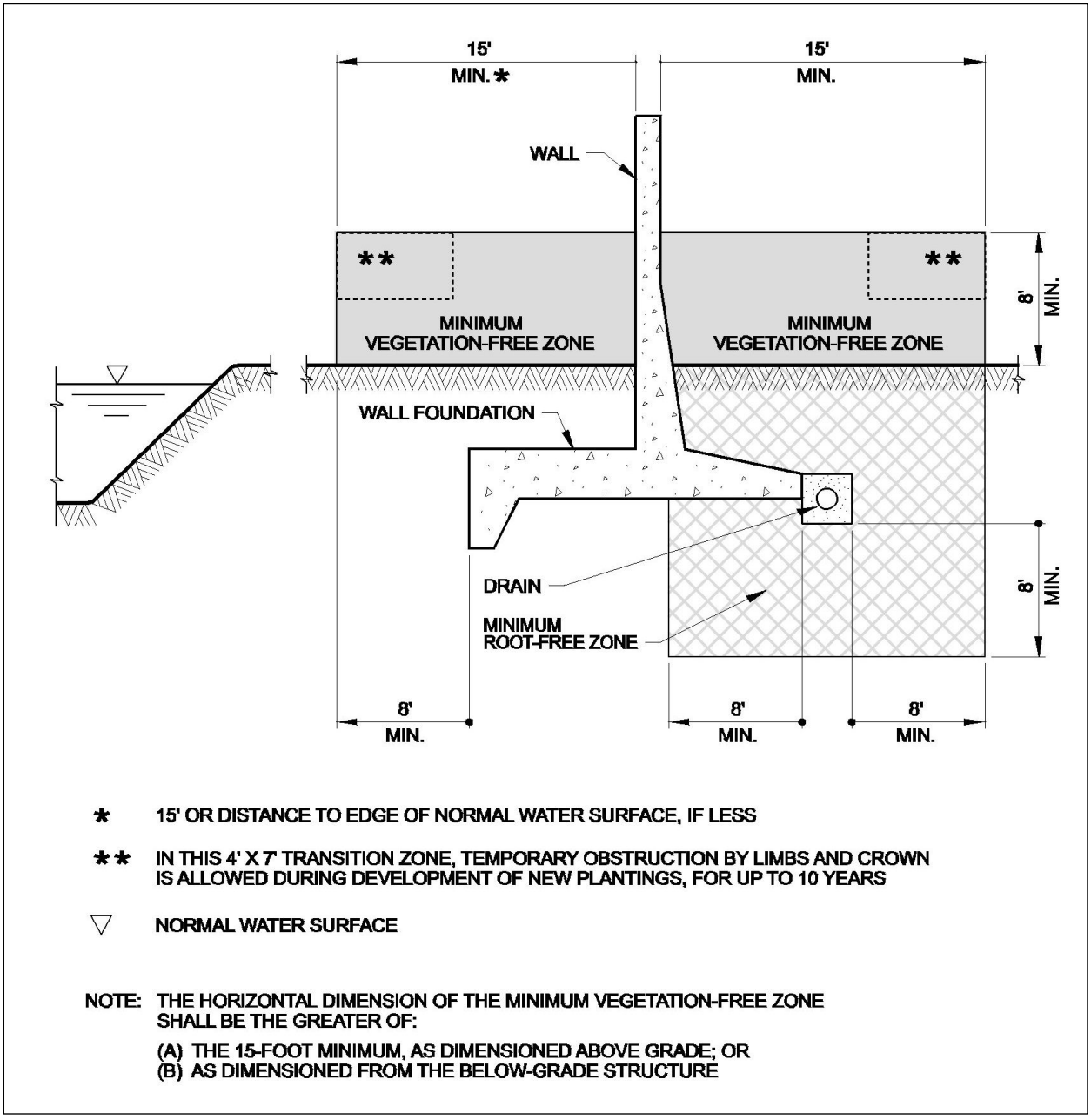


Figure A-17. Inverted-T Type Floodwall with Drain.

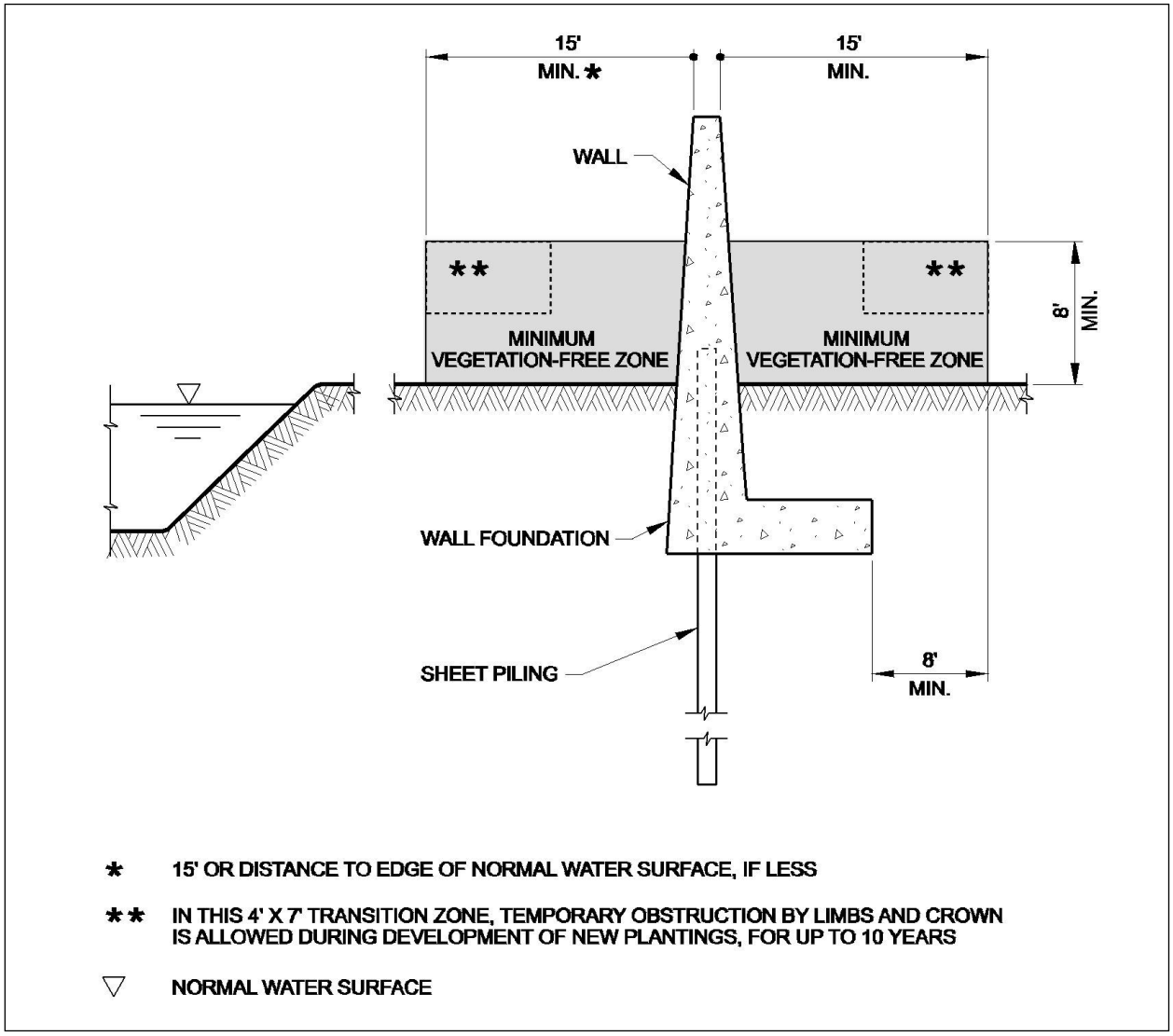


Figure A-18. Cantilever-I Type Sheet-Piling Floodwall.

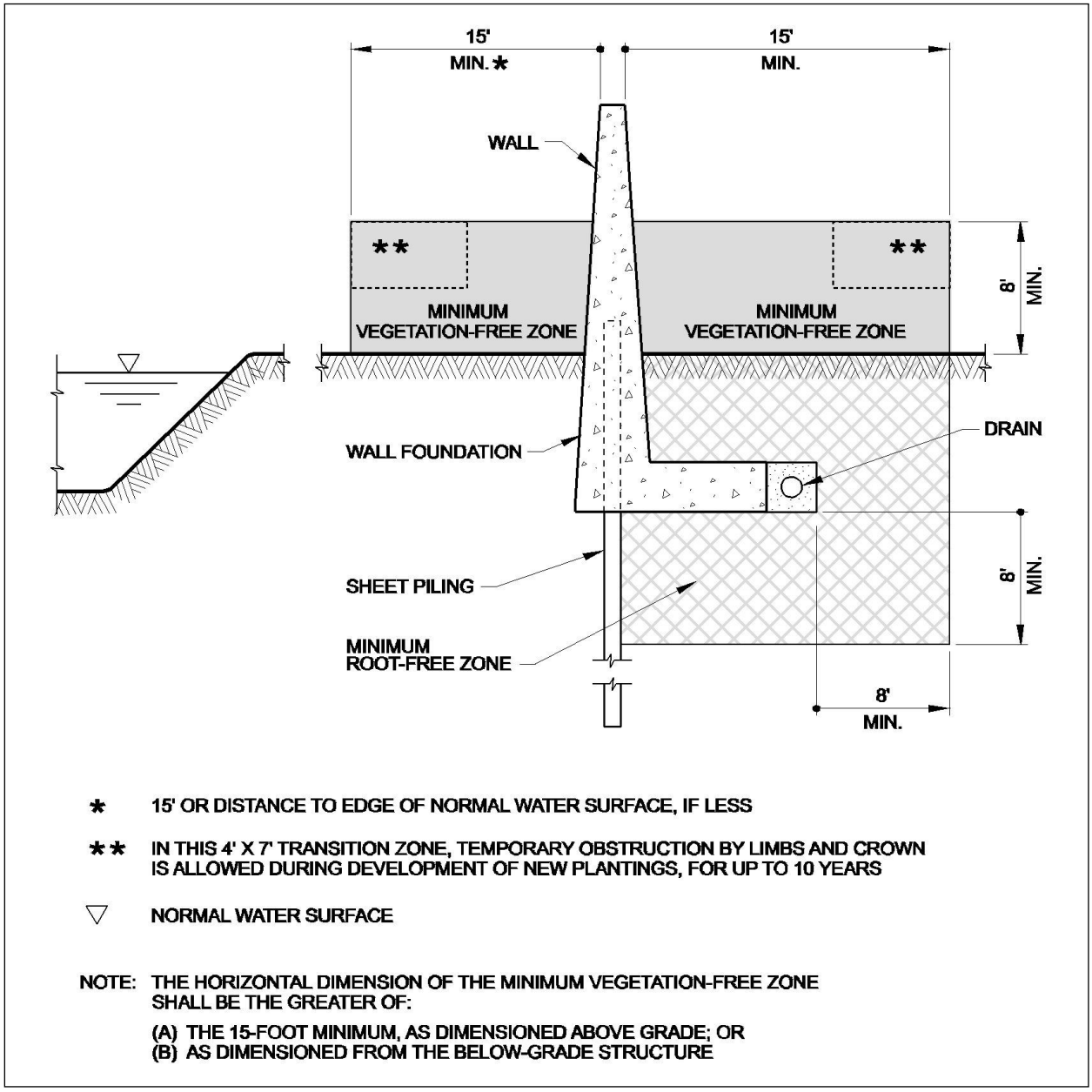


Figure A-19. Cantilever-I Type Sheet-Piling Floodwall with Drain.

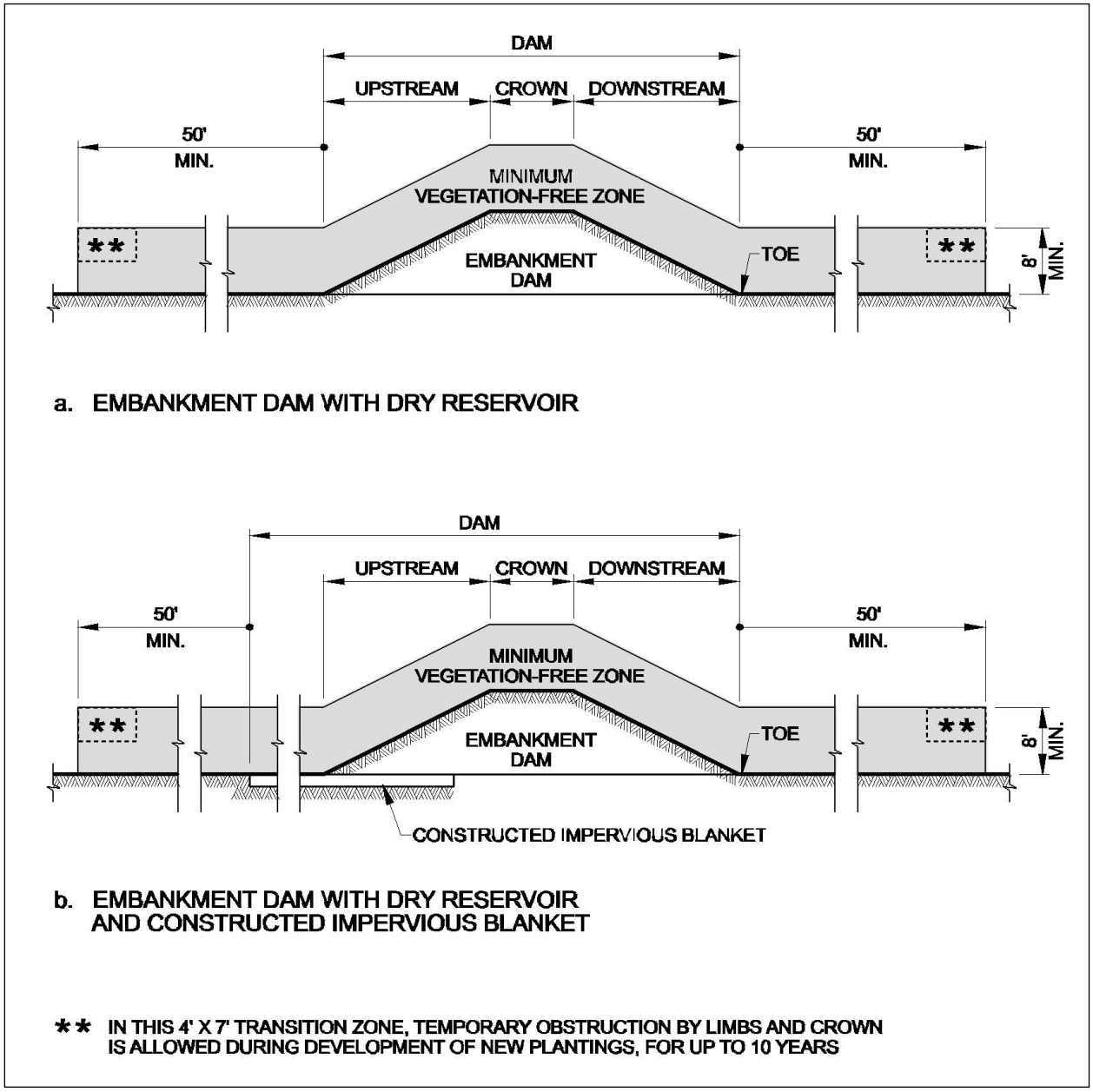


Figure A-20. Embankment Dam (Earth Fill, Rock Fill, or Earth and Rock Fill).

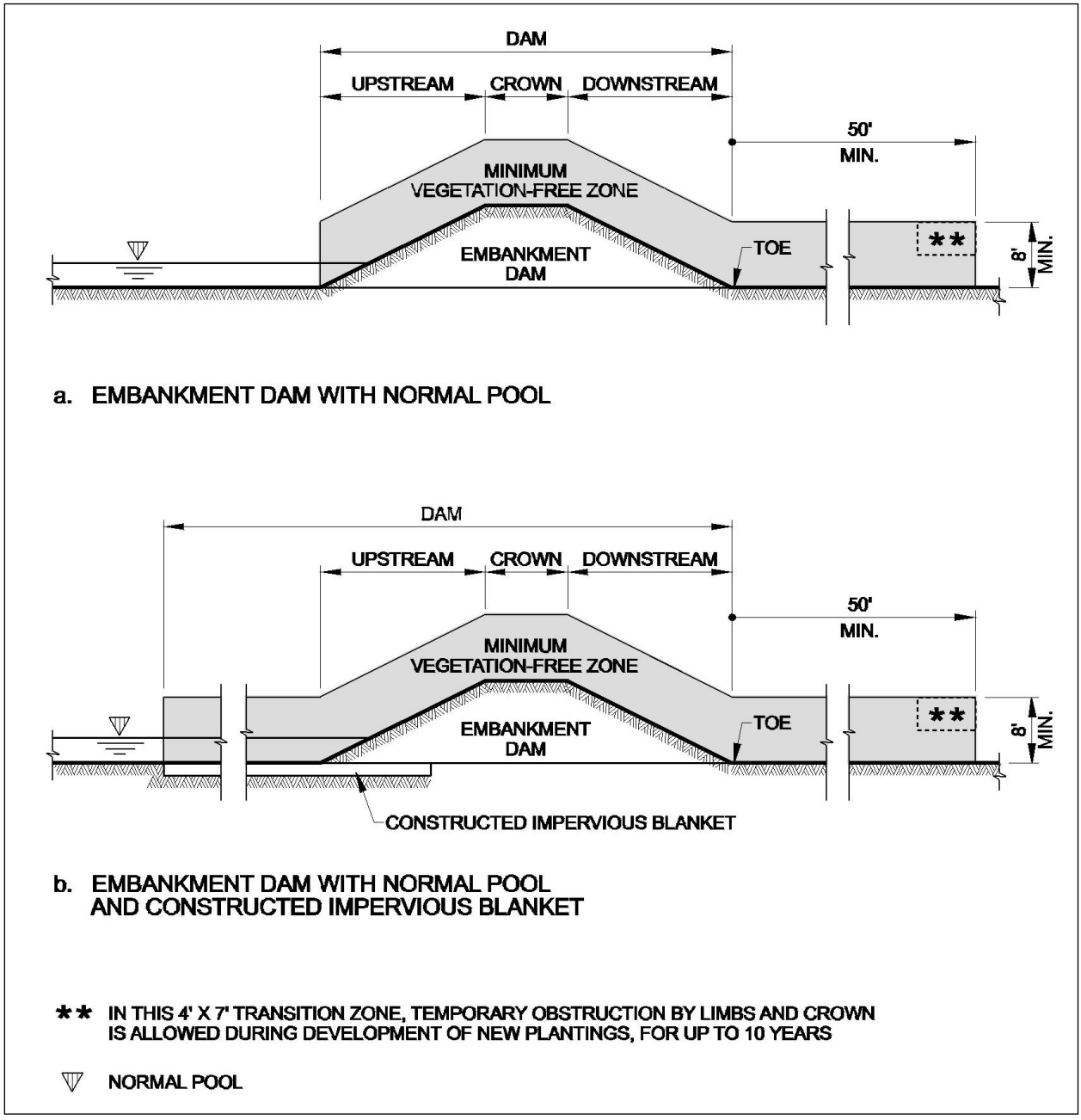
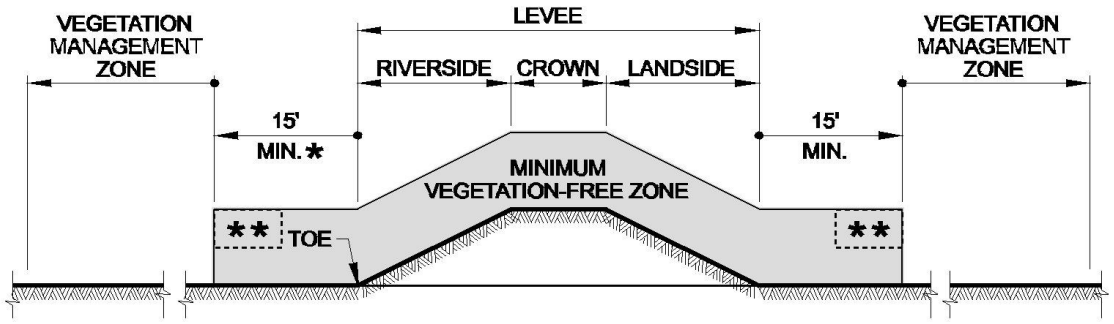


Figure A-21. Embankment Dam (Earth Fill, Rock Fill, or Earth and Rock Fill).



* 15' OR DISTANCE TO EDGE OF NORMAL WATER SURFACE, IF LESS

** IN THIS 4' X 7' TRANSITION ZONE, TEMPORARY OBSTRUCTION BY LIMBS AND CROWN IS ALLOWED DURING DEVELOPMENT OF NEW PLANTINGS, FOR UP TO 10 YEARS

▽ NORMAL WATER SURFACE

NOTES:

1. THE VEGETATION-MANAGEMENT ZONE ALLOWS FOR ACCESS, FOR THE PURPOSE OF INSPECTION, AND MODIFICATION OR REMOVAL OF ANY PLANT WHOSE LIMB, FOILAGE, OR ROOT BEHAVIORS BECOME A THREAT TO PROJECT RELIABILITY.
2. THE APPROPRIATE WIDTH OF THE VEGETATION-MANAGEMENT ZONE SHALL BE DETERMINED BY THE DESIGN TEAM: 35 FEET WILL BE SUFFICIENT IN MOST CASES.
3. THE VEGETATION-MANAGEMENT ZONE MAY BE ESTABLISHED BY EASEMENT.
4. THIS FIGURE SHOWS THE VEGETATION-MANAGEMENT ZONE IN THE CASE OF A LEVEE; HOWEVER, IT IS EQUALLY APPROPRIATE IN THE CASE OF ANY OTHER FLOOD DAMAGE REDUCTION STRUCTURE OR APPURTENANCE: IT'S USUAL RELATIONSHIP IS TO THE VEGETATION-FREE ZONE.

Figure A-22. Vegetation-Management Zone.

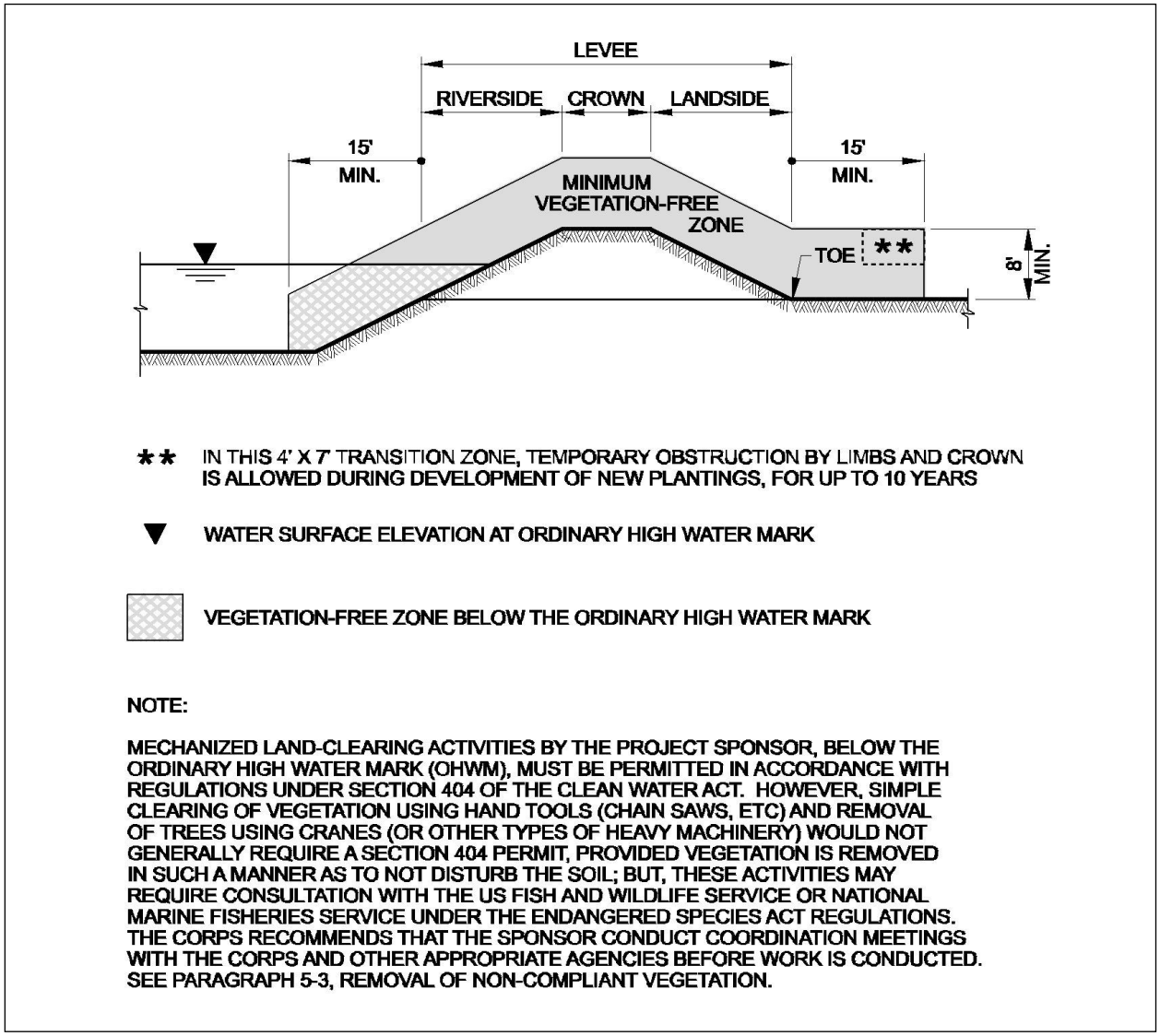


Figure A-23. Levee Section with Ordinary High Water Mark above the Riverside Toe.

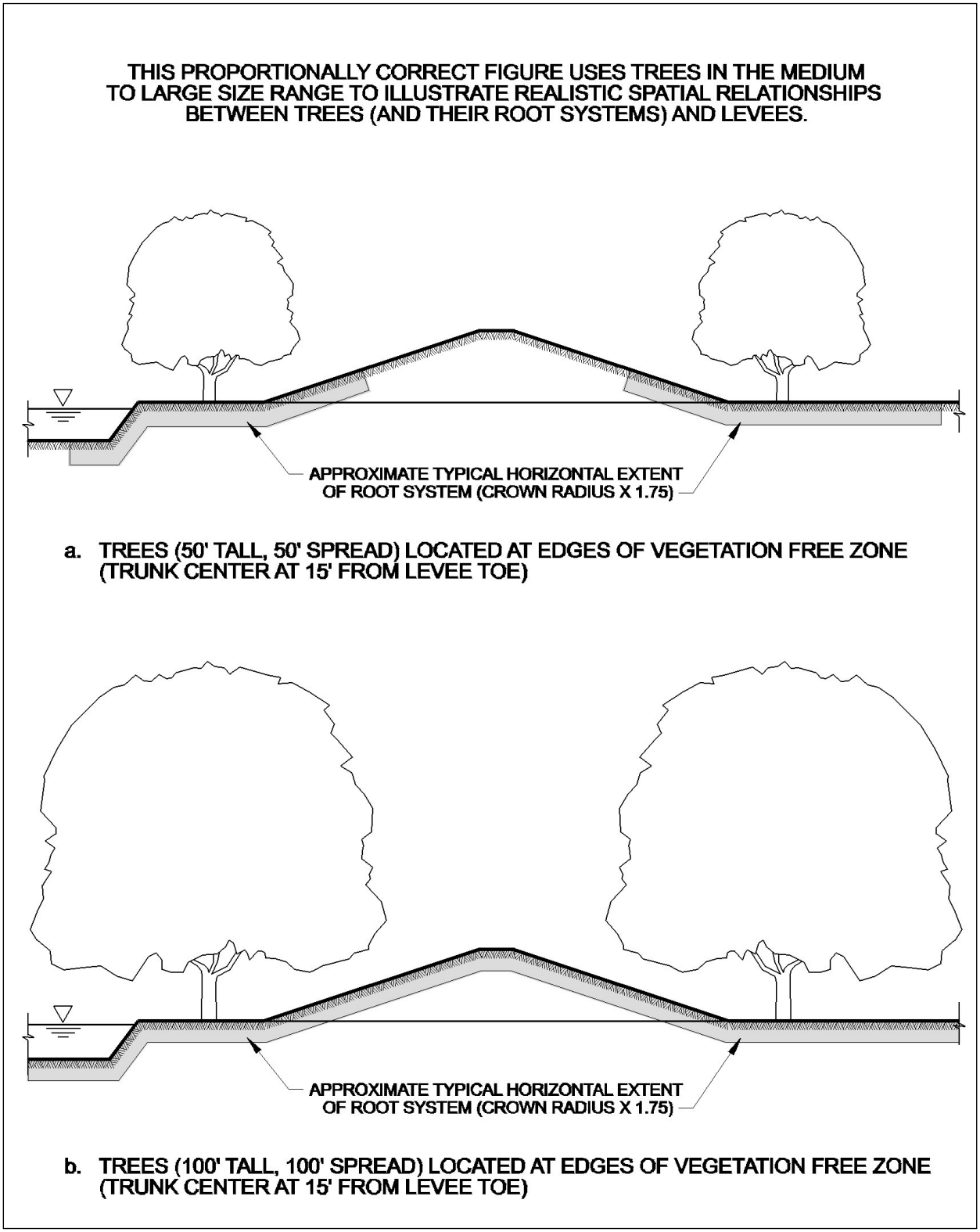


Figure A-24. Levee (20 ft tall, 3:1 side slopes) with Trees, as Noted Above.

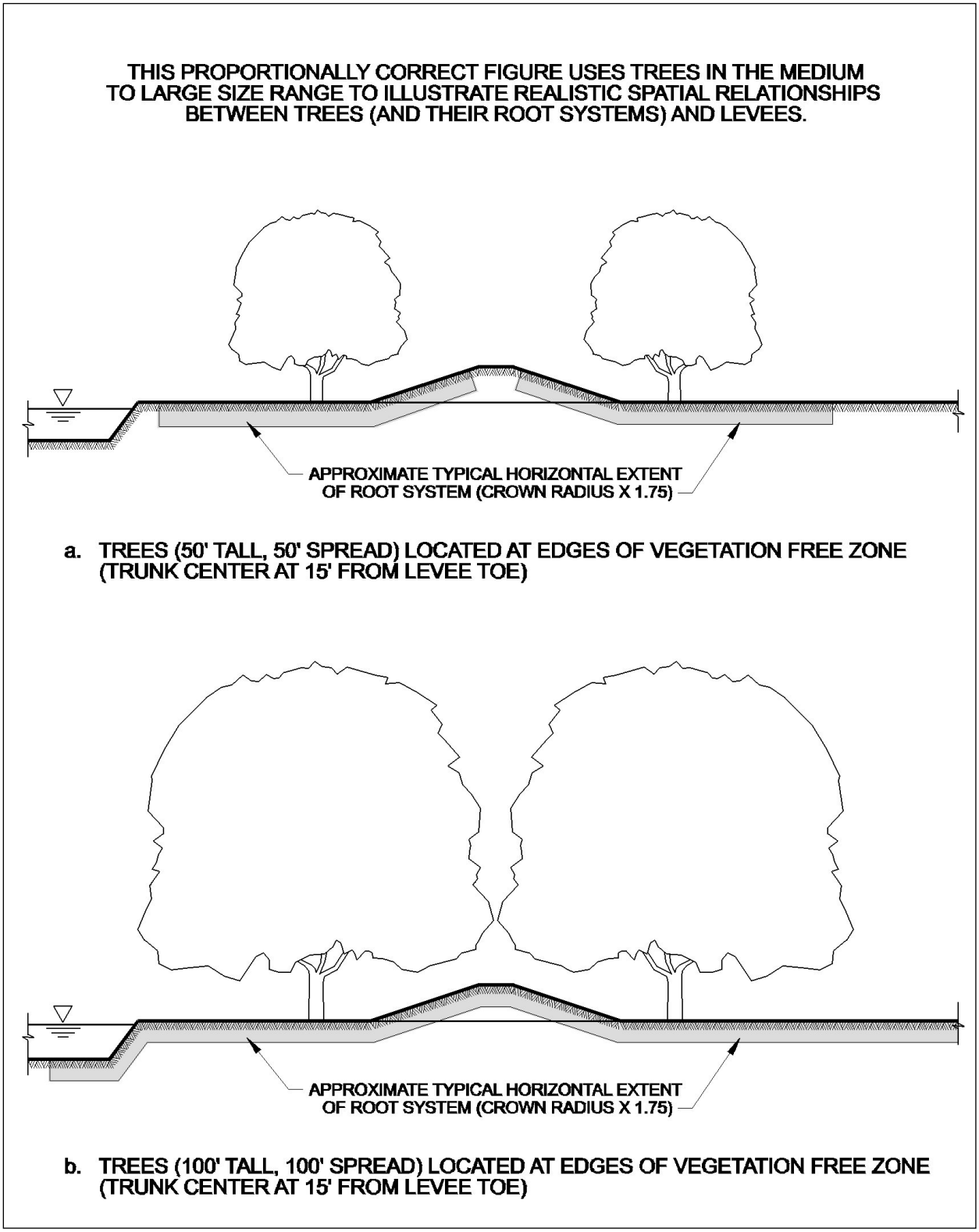


Figure A-25. Levee (10 ft tall, 3:1 side slopes) with Trees, as Noted Above.

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APPENDIX B

Acronyms, Abbreviations, and Glossary of Terms

B-1. Acronyms and Abbreviations.

Term	Definition
ASDSO	Association of State Dam Safety Officials
CECW	U.S. Army Corps of Engineers, Directorate of Civil Works
CFR	Code of the Federal Regulations
EC	Engineer Circular
EM	Engineer Manual
EOP	Environmental Operating Principles
EP	Engineer Pamphlet
ER	Engineer Regulation
ETL	Engineer Technical Letter
FEMA	Federal Emergency Management Agency
NFIP	National Flood Insurance Program
O&M	Operations and Maintenance (O&M)
SES	Senior Executive Service
USACE	U.S. Army Corps of Engineers

B-2. Glossary of Terms.

Critical Structure. A critical structure is any component of a flood damage reduction system that contributes to system reliability.

Flood Damage Reduction (FDR) System. A flood damage reduction system is made up of one or more flood damage reduction segments that collectively provide flood damage reduction to a defined area. Failure of one segment within a system constitutes failure of the entire system. Failure of one system does not affect another system.

Forb. A forb is an herbaceous (non-woody) annual, biennial, or perennial plant, other than grass, sedges, and rushes (e.g., alfalfa, clover, vetch).

Herbivory. Herbivory is the consumption of vegetation by animals.

Ordinary High Water Mark (OHWM). The Regulatory definition of the OHWM is provided at 33 CFR Part 328.3(e), which states that:

The term 'ordinary high water mark' means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.

The OHWM determines the lateral extent of the jurisdiction of the Corps within Waters of the United States (see Figure A-23, [p A-19]).

Overbuild. Beyond the normal engineered cross-section of a levee, dam or appurtenant soil structure, overbuild is additional soil mass, fulfilling flood-damage-reduction design criteria and therefore subject to vegetation-free and root-free requirements.

Variance. A variance is a Corps-approved exemption from compliance with specific standards.