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New York State Canal Corporation

EMBANKMENT INSPECTION & MAINTENANCE GUIDE BOOK

November 2022

EXECUTIVE SUMMARY

Public safety is a critical component to the New York State Canal Corporation's (NYSCC) Engineering Operation and Maintenance program and its mission to provide reliable operation of a safe and secure Canal system. The *Guide Book* establishes practices and guidelines for the management of water impounding earthen embankments, focusing on the top priority of reducing risk of embankment failure, while supporting asset preservation, environmental protection and existing community character.

The 130 miles of NYSCC water impounding canal embankments, although distinct from levees and dams, due to the duration and frequency of their water loading, should not be maintained using guidance developed for levees, but rather dams. This is supported by a review of industry and engineering guidance on dam and levee best practices (Section 1).

The NYSCC, a public benefit corporation and subsidiary corporation of the New York Power Authority (NYPA), is organized into engineering regions and maintenance sections in order to maintain canal infrastructure through NYSCC maintenance forces, on-demand contractors, or public bidding of construction contracts (Section 2). Water impounding earthen embankments are prioritized for maintenance by using a matrix based on a hazard classification and a condition rating to arrive at a modified Federal Emergency Management Agency (FEMA) risk urgency scale rating. Bank walk, informal, formal and special periodic inspections of water impounding earthen embankments are conducted at intervals based on hazard classification to identify, review, and program corrective actions (Sections 3 and 4).

Typical dimensions, and the specific outboard and inboard features of canal water impounding earthen embankments are illustrated and explained, embankment zones are illustrated and explained, and structures that are integrated within watered earthen embankments but fall outside the scope of the *Guide Book*, are also explained and illustrated (Section 6).

Embankment maintenance activities (Section 7) are outlined, and the detailed Best Maintenance Practices (BMPs) are provided as an attachment. Definitions for compatible and non-compatible vegetation and a description of goals for vegetation management in each of the five embankment zones are provided. The necessity of embankment maintenance, the scheduling of embankment maintenance, and how non-compatible vegetation is to be safely removed are explained.

Environmental requirements (Section 8) for specific water impounding earthen embankment projects are explained. The SEQR thresholds and mitigation procedures sub-section provides the table of regulatory and community thresholds and the mitigation procedure (a flow chart) that guides the development of specific embankment segment projects. Approaches and methods for essential and effective public relations and community outreach (Sections 9 and 10) are provided for projects where community thresholds are and projects where community thresholds are not exceeded.

The NYSCC Embankment Inspection & Maintenance *Guide Book* establishes the methods and processes necessary for reducing risk of failure of its 130 miles of water impounding earthen embankments, while supporting asset preservation, environmental protection and existing community character.

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REVISION SUMMARY TABLE

This manual shall be updated, at minimum, every 2 years, or as necessary to ensure accurate mapping, procedures, best practices and environmental regulations. The following table describes the revisions of the manual development.

Revision No.	Date	Description
0	November 2022	Issued with Final Generic Environmental Impact Statement
1	To be entered	To be entered

GENERAL LIMITATIONS

This *Guide Book* has been developed by drawing upon current guidance from various groups including both professional societies and regulatory agencies. Note that the Canal is a legacy system that has been built and maintained through a century where the dam safety knowledge base has greatly expanded. Because of this, the conditions of the canal do not always conform to current dam safety best practices in many instances. In some cases, implementing those best practices may be difficult or impossible due to factors outside of the control of Canals. Because of this, compromises must be made in the implementation of the *Guide Book*. Those compromises will be made to prioritize public safety and reduce the inherent risk of the embankments.

As with any operations and maintenance program dealing with infrastructure with an impact on the safety of the public at large, the contents of this *Guide Book* should be overseen by a competent licensed professional engineer with familiarity of the overall system as well as the specific conditions at the location where the maintenance is taking place.

The best practices and suggested details contained within this manual are general and may require modification based on specific site conditions. As such, some of the recommendations, procedures and details must be reviewed by a licensed professional prior to implementation which are noted as such. Other recommendations may be less critical in terms of potential consequence from an engineering perspective; however, there are other important factors such as environmental, health, safety, historic preservation, etc. that must be considered. Impacts of these recommendations must be considered by the individual(s) overseeing and performing the work as not all situations can be addressed explicitly.

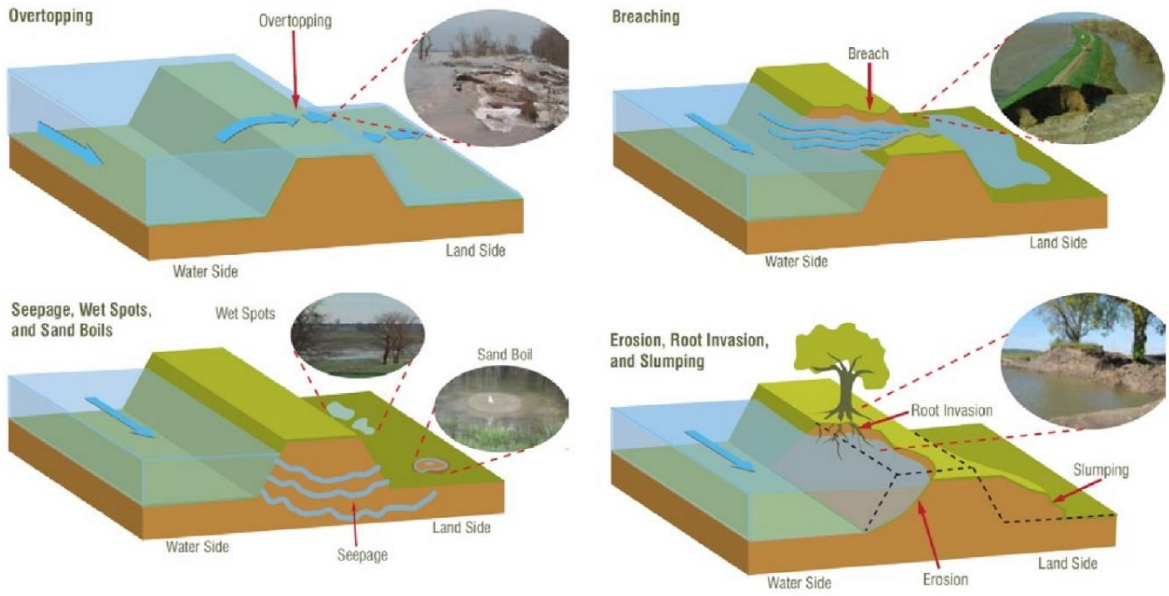
All recommendations herein must be considered as general guidance that may require adjustment depending on actual site conditions.

PREFACE

Public safety is a critical component to the New York State Canal Corporation's (NYSCC) Engineering Operation and Maintenance program and its mission to provide reliable operation of a safe and secure Canal system. This Embankment Management Guide Book (*Guide Book*) establishes good practices and guidelines for the management of water impounding earthen embankments, focusing on the top priority of reducing risk of embankment failure, while supporting asset preservation, environmental protection and existing community character. Both the modernized Erie Canal System (the Erie, Oswego, Cayuga-Seneca, and Champlain Canals) and the feeders and remnant canals have embankments located on one side, both sides or adjacent to the canal to retain water. Although these earthen embankments[1] primarily serve to provide water for navigation, they also provide ancillary benefits including water supply, agriculture, energy and recreation. Should an embankment fail resulting in an uncontrolled loss of water, lives, property and the environment could be at risk. To minimize the risk of an embankment failure, the NYSCC includes the embankments in its water impounding structure and dam safety (Dam Safety) program. A Dam Safety program recognizes the causes and possible impacts related to a dam failure and develops procedures for early identification of these problems. Similar to earthen dams, embankments have the potential to fail in several modes, as illustrated in Figure 0-1, developed by the American Society of Civil Engineers *[ASCE, 2010]*[2].

[1] For the purposes of the Embankment Maintenance Guide Book, the term "embankment" is defined as those earthen embankments that retain or impound water as opposed to earthen embankments constructed for other purposes that do not retain water (e.g. to raise roadways or trails, or to dispose of earth spoil material). The general term "embankment" will be used in lieu of the more specific terms such as "water-impounding embankment" or "earthen embankment" throughout the body of this Embankment Maintenance Guide Book (*Guide Book*) for simplicity.

[2] References are called out with square brackets and italics and full bibliographic listing is provided in Section 12.



Source: ASCE 2010

Figure 0-1: Example Failure Modes for Embankments

The failure modes shown in Figure 0-1 often exhibit early signs that can warn the owner of a potential risk of an embankment failure. Regular inspections and maintenance are integral parts to identifying and remedying the risk to an embankment failure before an uncontrolled release occurs, potentially impacting Canal operations and causing loss of life, property and significant environmental impacts.

The scope of the Earthen Embankment Integrity Program (EEIP) and this *Guide Book* includes water impounding earthen embankments or features that abut and are parallel to the earthen embankments, but not individual structures located along the embankments or under the embankments. Therefore, spillways, waste weirs, fixed crest dams, retention dams, vertical walls, culverts and dive culverts are excluded features. The scope includes all embankment material and impairments, and turf, vegetation, armoring or paving that's parallel to the embankment slopes and surfaces from outside the toe of the outboard slope on one side to the toe of the outboard slope on the other side. It includes water recording and management features used in regulation of water levels in the canal, and geotechnical instrumentation devices. Recognizing that certain areas may have environmental attributes important to nearby residents, the scope also includes identifying means to ensure embankment safety, but where feasible, also preserves existing character through cost-effective alternatives to vegetation removal. Where alternatives to vegetation removal are not feasible, as determined by the Canal Corporation, mitigation such as supplemental vegetation or visual screening may be installed to reduce the community character impacts of the work.

All work covered under the embankment management program and this *Guide Book* will be performed on lands under jurisdiction of the NYSCC or on lands where the NYSCC has permanent easements or permits that allow the work of the *Guide Book* to be carried out. Should temporary easements or permits for

purposes of construction access be required or desired to facilitate the implementation of the embankment management program, they would be obtained on a site-specific basis by the NYSCC or its contractors.

The purpose of this document is to provide a reference to NYSCC staff and consultants to understand the basic components and features of an embankment; the reasons for, and frequency of, inspection surveillance and monitoring of embankments on the NYS Canal System; and to provide direction to staff, consultants, and contractors as to the appropriate measures and actions to address observed deficiencies or concerns. This document is to be used by all NYSCC employees and consultants having responsibility for the maintenance and operation of embankments throughout the NYS Canal System with the understanding that the Canal system includes approximately 130 miles of currently mapped water impounding earthen embankments that exhibit great variance in adjacent land use and community character, which in some specific cases, may require modification of the best management practices described in this *Guide Book*. Modifications should be made only with appropriate approval and should reflect sound engineering judgment.

The embankment maintenance Best Management Practice (BMP) sheets (Attachment 1) are intended to:

- Prevent conditions that could lead to embankment failure;
- Prevent conditions that impair inspections and early identification of hazardous conditions;
- Maintain access to facilitate repairs in case of emergencies; and
- Without compromising safety or regulatory compliance, maintain embankments consistent with existing community character to the maximum extent practicable.

GLOSSARY OF TERMS AND ACRONYMS

ABUTMENT – The interface between two differing components of a dam or embankment system or the dam/embankment and the natural ground surface. Right and left abutments are those on respective sides of the dam when an observer looks downstream (or, more generally, is facing away from the impounded water).

ANTI-SEEPAGE COLLAR – A projecting collar of concrete or other material built around the outside of a tunnel or conduit within an embankment, intended to reduce the seepage potential along the outer surface of the conduit. This type of seepage protection method is no longer recommended for installation within newly constructed dams and embankments.

APPURTENANT STRUCTURE – Any structures built of materials placed and/or maintained, in connection with a dam or embankment. They may include, but are not limited to, such structures as spillways, waste weirs, valves, low level outlet works, fish ladders, and conduits.

AUXILIARY SPILLWAY – See SPILLWAY – AUXILIARY (EMERGENCY).

PLANTING BERM – A nearly horizontal step in the sloping profile of an embankment. Also, a step in a rock or earth cut.

BMP – Best Management Practice – In this document, BMP is used to refer to the embankment maintenance Best Management Practice sheets (Attachment 1)

BOIL – A disturbance in the surface layer of soil caused by water escaping under pressure from behind a water retaining structure such as a dam or levee. The boil may be accompanied by deposition of soil particles (usually sand) in the form of a conical-shaped mound (miniature "volcano") around the area where the water escapes.

BREACH – A break or opening in a dam or embankment which releases impoundment water either deliberately or accidentally. A breached dam (or embankment) permanently lowers the normal impoundment level by the formation of a channel through or around the dam (or embankment).

CHANNEL – A general term of any natural or artificial facility for conveying water.

CIMS – Canal Information Management System.

COMMUNITY CHARACTER – The man-made and natural features surrounding and including an earthen embankment location. It includes the visual character of a town, village or city, and its audio-visual landscape.

CONDUIT – A closed channel to convey the discharge through or under a dam or embankment, typically a pipe or culvert.

CORE – A zone of material of low permeability, within an embankment, the purpose of which is to reduce the quantity of seepage through the embankment.

CORE WALL – A wall of substantial thickness built of impervious materials, usually of concrete or asphaltic concrete, within an embankment to prevent leakage.

CREST OF DAM OR EMBANKMENT – The elevation of the uppermost surface of a dam or embankment, usually a road or walkway (often the canal trail), excluding any parapet walls, railings, etc. Also, the Top of Dam.

CREST LENGTH – The measured length of the dam or embankment along the crest.

CUTOFF WALL – A wall of impervious material usually of concrete, asphaltic concrete, or sheet piling constructed in the embankment or its foundation or abutments to reduce seepage through, beneath or adjacent to the embankment.

CANAL PRISM – A term used to refer to the actual wetted area of the canal in section. This term originates from the fact that the top surface of the canal is wider than at the base making it prism-shaped.

DAM – Any artificial barrier, including any earthen barrier or other structure, together with its appurtenant works, which impounds or will impound waters. By way of example only, waters may be impounded by directly intercepting drainage over land, by placing a structure in or across a watercourse, or by diverting or pumping waters to an impoundment or reservoir. A lagoon or storage facility, with one or more impoundment structures, that stores waste, or that treats, disposes or contains materials, other than waters, is not a dam.

DBH –Diameter at Breast Height – Standard for measurement of trees size defined by the trunk diameter measured 4.5 feet above the ground.

DIVE CULVERT – A culvert structure that conveys a stream or drainage underneath the canal prism.

DRAINAGE AREA – The area that drains to a particular point on a river or stream.

DRAWDOWN – The resultant lowering of water surface level due to release of water from the impoundment.

EEIP – Earthen Embankment Integrity Program.

EM – Engineer Manual – A US Army Corps of Engineers document that provides technical guidance for a specific subject or structure type.

EMBANKMENT – Any form of earthen construction for impounding water. May be constructed of excavated natural materials, such as earth fill and/or rockfill. *More generally, Embankments may also be constructed for the purpose of raising a roadway or other structure above the surrounding terrain and may not impound water*. **This manual only covers embankments that impound water.** Furthermore, for the purposes of this manual, three types of embankments are differentiated:

> **CANAL EMBANKMENT –** A water-impounding earthen structure, usually constructed in a parallel alignment to the Canal, raising the water surface elevation of the Canal above the adjacent land surface elevation. Such embankments can be on one or more sides of the Canal. These embankments may retain water only during the canal operating season for areas where the canal is drained in the winter, or they may retain water year-round in areas where the canal is not drained or only partially drained.
>
> **EMBANKMENT DAM –** A water impounding earthen structure, typically constructed across a waterway or natural valley, to create a raised water surface or reservoir. Dams typically include spillways and outlet works for water level regulation and are permanently watered.
>
> **LEVEES AND OTHER EMBANKMENTS** – Embankments that are only infrequently watered by flood events and are generally associated with rivers and run-of-river portions of canal. Levees typically are meant to protect adjacent areas from flood events.

EMBANKMENT FAILURE – A loss of the integrity of the embankment through any means (slope stability, seepage and piping, or overtopping). A

failure of the embankment may or may not be accompanied by breaching and loss of the impounded water. A failure can be of varying sizes from a minor slough to a complete loss of the embankment.

EMERGENCY ACTION PLAN (EAP) – A dam owner's written plan of methods and procedures pursuant to 6 NYCRR 673.7 that is implemented to detect, identify, mitigate or prevent the causes and consequences of adverse dam incidents, including failures.

ENERGY DISSIPATOR – Any device constructed in a waterway to reduce the energy of fast-flowing water. Typically located at the outfall of a pipe or spillway.

ENGINEER – For the purposes of this document, refers to an individual who is a professional engineer currently licensed and registered to practice engineering under Article 145 of the Education Law of the State of New York and possesses sufficient specific education, training, and experience necessary to exercise professional judgement in the development of opinions and conclusions regarding, and is otherwise competent in areas related to, the investigation, design, construction, operation, and maintenance of a dam or embankment of the type, size, and location that is to be addressed, and in areas related to adverse incidents, failures and the potential causes and consequences of failures related to dams and embankments, sufficient to meet the objectives and performance factors for the areas of practice identified by 6 NYCRR Part 673.

ENGINEER OF RECORD – The Engineer responsible for stamping and sealing the design documents pertaining to earthen embankment maintenance repairs under the EEIP.

EP – Engineer Pamphlet – A US Army Corps of Engineers document that provides functional, instructional, or procedural guidance needed to implement programs or systems directed in regulations.

EROSION – Wear or scouring caused by the abrasive action of moving water.

ETL – Engineer Technical Letter – A US Army Corps of Engineers document that Contains advance information on planning, design, engineering, construction, and operations and maintenance projects. ETLs are considered intermediary publications that will eventually be republished in a more permanent form. ETL documents remain active for no more than five years from the date of issuance.

FACE – The external surface of a structure (e.g., the surface of a wall or a dam).

FEMA – Federal Emergency Management Agency – Federal agency that provides guidance for disaster preparedness and reduction. Improving the safety of dams and levees is part of its mission.

FERC – Federal Energy Regulatory Commission – Agency that licenses and regulates hydropower dams.

FILTER (FILTER ZONE) – One or more layers of granular material graded (either naturally or by selection) to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

FLASHBOARDS – Structural members of timber, concrete, or steel placed in channels or on the crest of a spillway to raise the reservoir water level but intended to be quickly removed, tripped, or fail in the event of a flood.

FLOOD – A temporary rise in water surface elevation resulting in inundation of areas not normally covered by water. Hypothetical floods may be expressed in terms of average probability of exceedance per year, such as 1% annual chance (100-year) or expressed as a fraction of the probable maximum flood (PMF) or other reference flood.

FLOODPLAIN – An area adjoining a body of water or natural stream that has been or may be covered by water in the event of a flood.

FOUNDATION – The natural material on which the dam or embankment structure is placed.

FREEBOARD – The vertical dimension between the top of the dam or embankment at its lowest point and the water surface elevation behind the dam or embankment.

GATE – A water barrier for the control of water.

GRAVITY DAM – A dam constructed of concrete or masonry, which relies on its own weight for stability.

GROIN AREA – The area at the intersection of either the upstream or downstream slope of an embankment and the valley wall or abutment.

GULLY – A landform created by running water, eroding sharply and deeply into soil, typically on a hillside, to depths of greater than about 3 ft. See also RILL.

HAZARD CLASSIFICATION – Refers to the damage or hazard that may be posed by the failure of a dam. One of four Hazard Classifications may be assigned to a dam in accordance with 6 NYCRR Part 673.5. The Hazard Classifications are: Class "A" (low hazard); Class "B" (intermediate hazard); Class "C" (high hazard); and Class "D" (negligible or no hazard).

HEIGHT – the measurement of the vertical dimension from the downstream toe of a dam or embankment at its lowest point to the top of the dam or embankment.

INTAKE – Any structure in a reservoir, dam, river, or canal through which water can be drawn from the impoundment or river to a discharge point.

INUNDATION MAP – A map delineating the area that would be inundated in the event of a dam or embankment failure.

LEAKAGE – Uncontrolled loss of water by flow through a hole or crack.

MAXIMO - A work order management system used to manage NYSCC structure assets, create, and fulfill work requests for maintenance and operation work.

MAXIMUM DESIGN WATER LEVEL – The maximum water level, including the flood surcharge, the dam or embankment is designed to withstand.

NAVIGATION SEASON – Period of the year that the water level in the Canal is elevated to allow for boat traffic, generally mid-May to mid-November each year.

NORMAL WATER LEVEL (NORMAL POOL) – Elevation at which the water within the impoundment is normally kept. For a reservoir with a fixed overflow spillway crest, it is the lowest level of that crest.

NYCRR – New York Codes, Rules and Regulations – The Official Compilation of Codes, Rules and Regulations of the State of New York. '6 NYCRR' means Title 6 of the NYCRR.

NYPA – New York Power Authority

NYSCC – New York State Canal Corporation

NYSDEC – New York State Department of Environmental Conservation

NYSDOT – New York State Department of Transportation

OUTLET – An opening through which water can be freely discharged from a reservoir to a downstream channel.

PARGE COATING – A parge coat is a thin coat of a cementitious or polymeric mortar applied to concrete or masonry for refinement of the surface. The typical parge coat is 1/4"-1/2" in thickness; this may be less than the minimum thickness allowed by many mortar types.

PERMEABILITY – A material property which defines the material's capacity to transmit water.

PHREATIC SURFACE – The upper surface of seepage in an embankment. All the soil below this surface will be saturated when the steady-state seepage condition has been reached.

PIEZOMETER – A device used to measure pore water pressure in soil. (See also Standpipe Piezometer)

PIPING – Progressive erosion and removal of soil by concentrated seepage flows through an embankment, dam, or levee, its foundation, or its abutments. As material is eroded, the area of the "pipe" increases and the quantity and velocity of flow increase; these changes in turn result in the erosion of more material. The process continues at a progressively faster rate. Failure can result if the piping cannot be brought under control.

RESERVOIR – An impoundment of water created by a dam.

RETENTION DAM – An impoundment structure used on the Canal system at locations where streams enter the Canal. These structures are used to trap sediments from the stream before they enter the Canal. Retention dams may or may not be classified as dams under 6NYCRR Part 673.

RILL – A shallow channel (no more than a few feet deep) cut into soil by the erosive action of flowing water. Similar but smaller incised channels are known as microrills; larger incised channels are known as gullies.

RIPRAP – A layer of large stone, broken rock, or precast blocks placed in random fashion on the slope of an embankment dam, on a reservoir shore or in a channel as a protection against erosive flows, waves and ice.

SEEPAGE – The slow percolation of water through a dam, its foundation, or abutment. Some amount of seepage will normally occur in any dam or embankment that retains water.

SLIDE – The movement of a mass of earth down a slope. In embankments and abutments, this involves the separation of a portion of the slope from the surrounding material.

SLOUGH – The separation of the surrounding material and downhill movement of a small localized portion of an earth slope. Usually this refers to a shallow earth slide.

SPALLING – Breaking (or erosion) of small fragments from the surface of concrete, masonry or stone under the action of weather or erosive forces.

SPILLWAY – A structure over or through a dam or embankment by which normal or flood flows are discharged.

> **PRINCIPAL –** The principal spillway conveys normal flows, sometimes referred to as service spillway.

AUXILIARY (EMERGENCY) – A secondary spillway designed to operate only during large floods to pass flows and is in addition to a principal/service spillway.

SPILLWAY CHANNEL – A channel conveying water from the spillway crest to the water course.

SPILLWAY CREST – The lowest level at which water can flow over or through the spillway.

STANDPIPE PIEZOMETER – Used to measure saturation levels and hydrostatic pressures to monitor slope stability and seepage.

STORAGE – The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood through a natural stream channel.

TAILWATER LEVEL – The level of water in the discharge channel immediately downstream of the dam or spillway.

TOE DRAIN – A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

TOE OF DAM/EMBANKMENT – The base portion of a dam or embankment which intersects with natural ground.

TOP OF DAM/EMBANKMENT – See CREST OF DAM OR EMBANKMENT.

TOWPATH – A road or trail on the bank of the Canal. The original purpose of which was to allow mules or other animals to tow a boat along the Canal. Current use is often recreational. Paths also allow vehicular access to Canal embankment for maintenance purposes.

TRASH RACK – A device located at the intake of a conduct inlet or waterway to prevent entrance of some floating or submerged debris.

USACE – United States Corps of Engineers

USBR – United States Bureau of Reclamation

VALVE – A device fitted to a pipe or orifice to control or stop flow.

WASTE WEIR – A longitudinal structure used on the Canal, with a crest elevation that is usually lower than the top of Canal embankment, that allows excess water to be discharged from the Canal to streams or other tributaries. These structures often include valves or gates that permit additional water to be drawn from the canal at levels lower than the crest of the waste weir.

WEEP HOLE – A small pipe opening into structures such as concrete abutments, downstream mortared stone wall or concrete aprons to relieve any buildup of water pressure from seepage or groundwater.

WEIR – A type of spillway in which flow is constricted and caused to fall over a crest. Sometimes specially designed weirs are used to measure flow amounts.

1 EMBANKMENTS OVERVIEW

1.1 OVERVIEW AND MANUAL CONTENT

For the purposes of the *Guide Book*, embankments are defined as those earthen embankments that retain or impound water as opposed to earthen embankments constructed for other purposes that do not retain water (e.g. to raise roadways or trails, or to dispose of earth spoil material). The general term "embankment" will be used in lieu of the more specific term "water-impounding earthen embankment" or "earthen embankment" throughout the *Guide Book* for simplicity.

This document, with specific sections and attachments noted in the following list, is intended for use by the New York State Canal Corporation (NYSCC) and its consultants, contractors and other associated parties to:

1. Explain the proper function and features of embankments (Section 1),
2. Provide the risks associated with embankments and ways to mitigate and manage those risks (Sections 3, 4 and 8),
3. Identify the appropriate inspection and maintenance activities to be performed on a regular basis at all NYSCC embankments (Sections 3 and 4),
4. Perform the various inspection and maintenance activities in a uniform and consistent manner throughout the Canal system as defined by the *Guide Book* (Sections 4 – 10),
5. Document the inspections and the performance of maintenance in maintenance logs (Section 4),
6. Clarify the decision-making process for addressing maintenance activities either through in-house maintenance, contract maintenance or capital program maintenance (Section 4),
7. Clarify the roles and responsibilities of various individuals in the organization in relationship to processing of the various types of inspections that are conducted (Section 2 and Attachment 2),
8. Explain the embankment features (Sections 1 and 6),
9. Provide best management practices (Attachment 1),
10. Provide guidance on maintenance activities including isolation and dewatering, environmental considerations, public relations, and community outreach (Sections 5 – 10, and Attachments 1 and 3).

This *Guide Book* applies to all embankments under the jurisdiction of the NYSCC with the following exceptions:

- It does not apply to dams (which are covered by the Guidelines for the Design of Dams [NYSDEC, 1989] and Owners Guidance Manual for the Inspection and Maintenance of Dams in New York State [NYSDEC, 1987]).
- It does not apply to embankments under FERC jurisdiction, which are maintained by other private or public entities (not under NYSCC maintenance jurisdiction).

All sections of the *Guide Book* including the NYSCC embankment maintenance Best Management Practice (BMP) sheets (Attachment 1) are intended to be reviewed and updated as necessary, approximately every 2 years, to reflect the current conditions at each embankment and the current state of practice for dam and embankment maintenance.

The NYSCC is in the process of mapping and completing hazard classifications for all embankment segments. The NYSCC has also developed a multi-level inspection program unique to embankments in the Canal system. Both the hazard classification system and the inspection program are explained in subsequent sections of the *Guide Book*. Lastly, the NYSCC has identified typical embankment repair types, and developed a series of embankment maintenance BMP guides (see Attachment 1 and Section 7.2).

This document is intended to supplement existing structure maintenance and inspection technical documents already in use by the NYSCC.

1.2 CANAL AND CANAL FEEDER EMBANKMENTS

The quintessential example of the "typical" canal embankment would be those on one or both sides of the "60-mile pool" which stretches from Rochester west to Lockport. These embankments vary depending on location and adjacent features but can be up to 65 feet tall in locations such as the Great Embankment, with a typical 16-foot top width, with slopes that vary somewhat depending on location, but typically 1V:2H to 2V:3H (1V:1.5H) both waterside and landside. A typical section, taken from the contract drawings of the 1918 Barge Canal improvement at one specific location in the 60-mile pool, is shown in Figure 1-1 below.

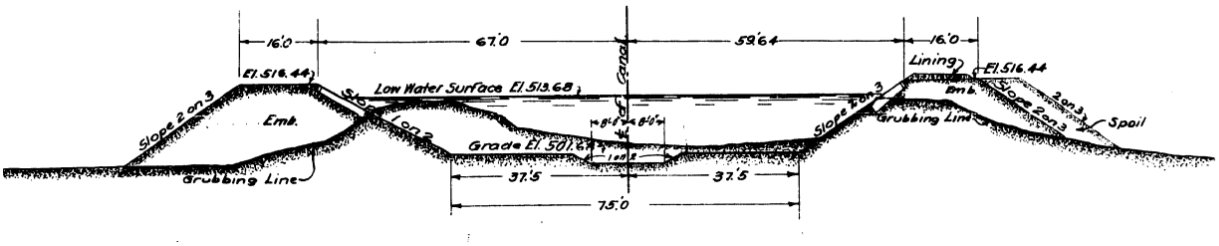


Figure 1-1: Typical Canal Embankment Section – 60 Mile Pool

At some locations along the 1918 Barge Canal improvement, the original designers provided embankment sections that are wider than required for water retention. A typical section of an overbuilt canal embankment taken from the contract drawings of the 1918 Barge Canal improvement at another specific location in the 60-mile pool is shown in Figure 1-2 below. In this case, additional spoil (material excavated from the canal prism) was disposed of landward of the canal embankment. For these situations, it is logical to account for this extra material when evaluating risk and maintenance needs. This is an example of an important factor that reinforces the need for a site-specific evaluation of alternatives instead of a one-size-fits-all approach.

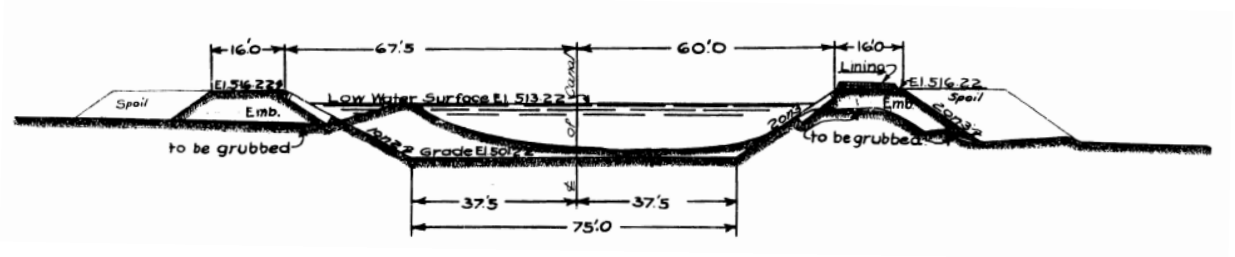


Figure 1-2: Overbuilt Canal Embankment Section – 60 Mile Pool

Feeder embankments are of a similar arrangement to the canal embankments described above except that they are now used on waterways that supply, or at one time supplied water, to a canal or reservoir (feeders). See Section 6 for additional information and details concerning typical canal embankments and details.

1.3 DISTINCTION BETWEEN LEVEES AND CANAL EMBANKMENTS

Water-impounding embankments are typically divided into two main categories: earth dams and levees. The canal embankments do not neatly fit into either category. Although they are similar to levees in some respects, (mainly that they are both linear features that retain water on one side protecting adjacent low ground on the other), there are important differences between levees and canal embankments including:

- Levees are temporary barriers to protect for infrequent, short-term duration rises in rivers and only function with full water loading in high recurrence interval storm events. In contrast to this, the canal embankments perform for the entire navigation season (6 months of the year) year after year. This difference has the following major impacts:
    1. the frequency that the levee embankments function is far less than for the canal embankments, so the risk of failure is correspondingly less (canal embankments function every year, levees may function only once in a period of decades),
    2. the period during which the levees must function is only when the flood waters rise, the canal embankments perform for the entire period when there is elevated water in the canal (roughly 6 months per year from mid-April to mid-October),
    3. because the levees are needed for known storm conditions and for shorter duration, a heightened awareness and increased monitoring of the levees is possible and cost-effective since the period of monitoring is infrequent and short-term (maintaining this heightened awareness and enhanced monitoring for the entire time the canal is watered every year is unrealistic), and
    4. because the period that the levees hold back water is significantly less than for the canal embankments, there is less time for the phreatic surface to develop into a steady-state condition and less time for any flaws within the embankment to be compromised.

The important distinction between relatively infrequently loaded levees is recognized within US Army Corps of Engineers (USACE) guidance (Engineering Monograph [EM] 1110-2-1913 "Design and Construction of Levees") which states the following:

> *Embankments that are subject to water loading for prolonged periods (longer than normal flood protection requirements) or permanently should be designed in accordance with earth dam criteria rather than the levee criteria given herein.*

This distinction is critical. The USACE guidance indicates that the canal embankments should be treated as earth dams. Vegetation management practices for earth dams are universally accepted within the engineering profession with the rule that woody vegetation is not permitted on earth dams.

1.4 VEGETATION MANAGEMENT AND THE EXPERIENCE OF OTHER AGENCIES

The embankment failure risk reduction strategy for earthen embankments that likely has the most beneficial impact on the community, is the management of the vegetation that currently exists on the embankment.

The dam safety engineering profession recommends clearing of all woody vegetation from the embankments to eliminate concerns of seepage paths created by tree roots, the possibility of tree blowdowns creating large depressions that could weaken the embankment or cause a breach and the difficulty the vegetation causes to embankment inspection, among other factors. Adjacent landowners and canal users view the trees and vegetated slopes as beneficial to the canal setting for such things as shade, visual site barrier to adjacent properties, wildlife refuge, and more. Finding a solution that addresses the needs and desires of both sides is critical. Reducing the risk of a catastrophic embankment failure is a clear need. Developing a cost-effective option that allows some woody vegetation to remain is a goal. This same dilemma exists in many other locations where water impounding embankments exist in close proximity to recreational and residential areas. The guidance developed by the governing agencies in those locations can be useful for the canal embankments.

The experience and resulting design criteria from two agencies are summarized in the sections below. The two agencies were chosen because of their specific technical reputation and the similarity of the issues covered. The NYS regulating agency requirements for dam embankments is covered in Section 1.5.

1. The USACE, whose guidance may be considered the best practice relating to vegetation management on embankment dams and levees.
2. The California Department of Water Resources which has dealt with the issue of balancing the risk and benefits of having woody vegetation on their levee embankments, particularly those within urban environments.

1.4.1 US ARMY CORPS OF ENGINEERS

The current guidance for vegetation management on water impounding embankments is contained in EP 1110-2-18 *Guidelines for Landscape Planting and Vegetation Management at Levee, Floodwalls, Embankment Dams and Appurtenant Structures* [USACE, 2019].

The Corps' guidance makes it clear that appropriate landscape plantings may be incorporated into embankment and related water retaining infrastructure projects, provided that "the safety of the structure is not compromised, and effective surveillance, monitoring, inspection, maintenance, and flood-fighting of the facility are not adversely impacted." The guidance also makes it clear that any such landscape plantings must be carefully chosen saying "site conditions, engineering design criteria, and O&M requirements should determine the appropriate planting scheme." The vegetation-free zone, described below, is a key feature of the guidance.

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." No vegetation, other than approved grasses are permitted within the vegetation-free zone. 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."

The vegetation-free zone is required for all levees, floodwalls, embankment dams and appurtenant structures. Variances to this are granted only with a formal variance for 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, under 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 EP, and any other applicable criteria.

The lone exception to the vegetation-free zone is for existing projects where the real estate interests are less than required to meet the entire zone. In such a case, the vegetation free zone width is the maximum attainable within the existing real estate interest.

1.4.1.1 LEVEES

For levees, this vegetation-free zone is indicated in the figure below (Figure 1-3). The Corps also indicates that a secondary benefit of the vegetation-free zone is to provide distance between root systems and the protection structures thereby moderating risks associated with seepage and piping due to root penetration and structural damage from wind-driven tree overturning (windthrow). They note that the vegetation-free zone does not provide adequate protection for all situations. Note that in the case of the typical canal embankment, this vegetation-free zone extends across the entire embankment and a minimum of 15 feet past the toe.

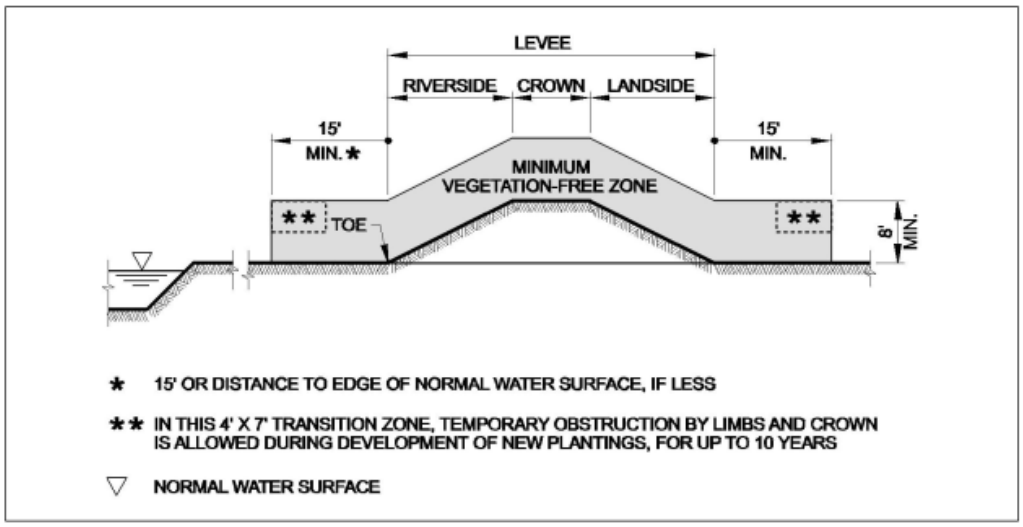


Figure 1-3: Inspection Maintenance and Approval Flow Chart Figure 1.4-1: USACE Guidance – Vegetation-Free Zone (Figure A-1 of EP 1110-2-18)

To provide protection against seepage, piping and concerns with windthrow on levees, the Corps defines a root-free zone. This root-free zone shown in the figure below (Figure 1-4) is used in conjunction with planting berms which are overbuilt levee sections upon which plantings are permitted. Depending on the specific location and embankment characteristics, it could be appropriate to consider the spoil portion of the overbuilt canal embankments as planting berms upon which woody vegetation could be permitted.

Vegetation must be carefully chosen to ensure compatibility. Factors such as vegetation density, size, expected root penetration depth, and location are important factors in the expected performance (i.e. risk) of the embankment.

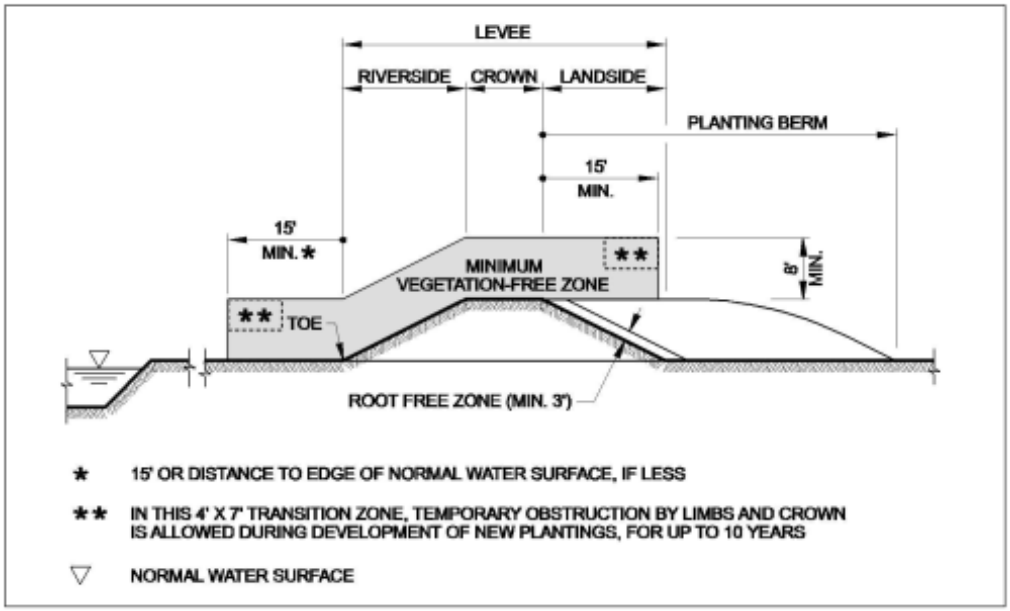


Figure 1-4: USACE Guidance - Levee Section with Planting Berm Showing Root-Free Zone (Figure A-13 of EP 1110-2-18)

1.4.1.2 EMBANKMENT DAMS

The Corps' policy as it relates to embankment dams is clear. The guidelines require the following five areas to be vegetation-free zones:

1. The dam and 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 operation of the spillway.
5. The outlet works discharge channel.

The Corps further clarifies that for embankment dams, the entire embankment surface from the upstream toe of the dam to a minimum distance of 50 ft from the downstream toe[3] shall be a vegetation-free zone.

[3] It should be noted that applying a uniform 50-ft required vegetation-free zone at the toe of all earth dams regardless of size is in all likelihood an over-simplification. Other than the recommendations for an access corridor, the vegetation-free zone should be based on the size of dam and the size of tree. Reducing this 50-ft limit for the canal embankments would seem justifiable.

1.4.1.3 VARIANCES

The Corps also allows for a formal process for requesting a variance from the Guidelines. Any such request must include information to demonstrate the following:

- No significant tree roots (those greater than ½ in. diameter) will enter the levee prism.
- No potential tree overthrow pit will penetrate the levee prism.
- No roots or tree overthrow pit will significantly impact the function of any appurtenant structure, such as those designed to control seepage. Such features include filters and drains.

These three bullets can be considered the guiding principles of when vegetation is permissible on water-impounding embankments from a safety and risk perspective. If vegetation is allowed to remain on the embankments, these principles can be used to help assess and manage the risk.

1.4.2 CALIFORNIA URBAN LEVEE DESIGN CRITERIA

A good deal of information regarding maintenance, inspection and vegetation on water retaining embankments exists for the levee system protecting Sacramento, California and the San Joaquin Valley (the Central Valley Flood Protection Plan). Recent pertinent information can be found dealing with many aspects of risk management relating to maintenance and inspection of the levees. Much of this information has been prepared in response to a reaccreditation process for the federal levee system and the Army Corps of Engineers guidance regarding vegetation management for levees. Like the controversy surrounding the vegetation management on the NYSCC canal embankments, vegetation management on and adjacent to levees became controversial when the Corps released updated guidance for vegetation management for levees in April 2009.[4] Much of the research and lessons learned can be leveraged to develop guidance for the canal embankments.

However, there are important differences between the California levee system and lessons learned and the NYSCC canal embankments. In addition to the differences between canal embankments and levees as detailed in Section 1.3, the Sacramento Levees are constructed with and in sandy soils. The NYSCC canal embankments are constructed of many different material types.

As referenced above, California has dealt extensively with the challenges of balancing the risks associated with vegetation on levee embankments and the detrimental effects of removing vegetation. California's Department of Water Resources published guidance[5] for levee construction and maintenance which strives for a balance between the two goals. Because California's objectives align closely with those of NYSCC, their guidance is generally applicable keeping in mind the important difference that the canal embankments are typically more critical than levees since they function for a 6-month duration every year.

[4] The guidance released was ETL 1110-2-571 *Guidelines for Landscape Planting and Vegetation Management at Levee, Floodwalls, Embankment Dams and Appurtenant Structures* (April 2009). ETL 1110-2-571 was replaced by two subsequent documents having the same title as the original 2009 document – ETL 1110-2-583 (in April 2014) and EP 1110-2-18 (in May 2019). The first two ETL documents are largely the same, and the final EP document is identical to the 2014 ETL except for formatting.

[5] State of California, The Natural Resources Agency, Department of Water Resources, *Urban Levee Design Criteria,* May 2012.

Section 7 of California's *Urban Levee Design Criteria* includes requirements for many aspects of the levee system. The document's relevant sections covering vegetation are summarized below. Other sections covering such things as embankment geometry seepage design criteria, slope stability criteria, and required right of way are included and may be useful for other aspects of the embankment engineering and maintenance program, but they are not directly applicable to this document.

1.4.2.1 VEGETATION [SECTION 7.16]

The California policies have been developed around a commitment to:

> "*developing flood risk reduction solutions that also integrate environmental stewardship. Guidance for levee vegetation management is focused on improving public safety by providing for levee integrity, visibility, and accessibility for inspections, maintenance, and flood fight operations, while at the same time protecting important and critical environmental resources.*"

Section 7.16 of the California guidance says:

> *Policies and criteria regarding removing trees and other woody vegetation that have grown and matured on levees are evolving and will be informed by ongoing and future research. Engineers and levee maintaining agencies are encouraged to consider the results of this research when deciding how to manage trees and other woody vegetation on levees.*

It goes on to say:

> *The criteria provide significant flexibility for engineers and levee maintaining agencies to remove or retain existing trees and other woody vegetation. Because of the importance of these critical resources, it is anticipated that implementation of these criteria will result in near-term retention of the vast majority of existing trees and other woody vegetation that provide important and critical habitat. In the long-term, it is anticipated that the vast majority of trees and other woody vegetation on the lower waterside levee slope*[6] *would continue to grow with little or no management.*

Section 7.16 of the California Urban Levee Design Criteria requires an engineering evaluation to identify unacceptable vegetation and a routine inspection program to identify changes that affect vegetation management. Criteria are provided for vegetation management for new levees and at locations where repairs or improvements are planned. For existing levees with vegetation, a "vegetation management zone" is defined that allows some vegetation to remain subject to trimming and thinning to provide access for maintenance and inspection. The following sections are paraphrased from the California document:

[6] Note that the lower waterside slope is applicable only to levees (this is the portion of the slope that is at or near normal river elevation and then becomes submerged when flood waters rise). It is not applicable to the canal embankments.

1.4.2.1.1 ENGINEERING EVALUATION

The California guidance requires an engineering inspection and evaluation to identify tree and other woody vegetation that pose an unacceptable threat. Any such tree shall be removed along with the root balls and roots. The California guidance requires a minimum of all roots larger than 1.5 inches in diameter that are within 3 feet of the tree trunk be removed.[7] The California guidance varies somewhat from the typical practice for earth dams which is to remove all roots down to 1-inch or even ½-inch diameter. Though not included in the California guidance, it is recommended that the typical earth dam criteria for root removal be followed for the canal embankments.

1.4.2.1.2 ROUTINE INSPECTION

The California guidance dictates that any trees and other woody vegetation that are not removed must be monitored to identify changed conditions that cause any of these remaining trees and other woody vegetation to pose an unacceptable threat to levee integrity.

1.4.2.1.3 NEWLY CONSTRUCTED LEVEES

California requires that new levees be designed, constructed, and maintained according to USACE criteria. These standards limit vegetation to native grass species on levee crown (top), slopes, and within 15 feet of the levee toe. Trees and other woody vegetation may be allowed on portions of the landside slope for a newly constructed levee only if a specially designed planting berm is added. This overbuilt section must be of sufficient size and configuration to mitigate potential negative impacts to levee safety with respect to seepage, stability, and erosion criteria should either windfall or root decay occur.

Trees and other woody vegetation that are within 20 feet of the landside toe should be trimmed up 5 feet above the ground and thinned for visibility and access.

1.4.2.1.4 LEVEE REPAIR OR IMPROVEMENT

The California guidance dictates that vegetation shall be removed as required to meet objectives of the specific project. Any vegetation removed may not be replaced in the vegetation management zone. However, vegetation on other sections of the levee, not affected by the construction activity may remain in place, natural revegetation may be allowed outside of the vegetation management zone, and replanting may be allowed (see Section 1.4.2.1.7); for levees regulated by USACE, their approval is required for planting. Engineers and levee maintaining agencies should also consider preserving trees and other woody vegetation within the vegetation management zone that provide important or critical habitat in consultation with the appropriate resource agencies by including the following root mitigation alternatives as part of any levee improvement program:

- The overall width of the levee is overbuilt landward by at least 15 feet beyond the standard minimum levee dimensions, or

[7] The guidelines point out that more extensive root removal may be required depending on the type of tree; the quantity, size and orientation of roots; the dimensions of the embankment; and the levee features that address seepage.

- An effective root or seepage barrier is installed within the levee to mitigate potential impacts by tree roots.

1.4.2.1.5 LEVEES WITH EXISTING VEGETATION

California's guidance is that levees with existing vegetation are to be maintained according to the bullets below. With respect to California's guidance and its applicability to the NYSCC canal embankments, it is important to consider the differences between levees and canal embankments noted in Section 1.3. In particular, the fact the canal embankments retain water at a frequency and duration that far exceeds ~~s~~ that which levees are considered safe for. This is recognized in the Corps' guidance dictating that canal embankments be designed using earth dam criteria[8]. **Standard guidance and best practices dictate that the levee criteria below are not appropriate for canal embankments.**

- An established vegetation management zone in which trees are trimmed up to 5 feet above the ground (12-foot clearance above the crown road) and thinned for visibility and access (see Figure 1-5).
- Brush, trees and other woody vegetation less than four inches in diameter at breast height, weeds or other such vegetation over 12 inches high are to be removed.
- Trees and other woody vegetation that are within the 20-foot-wide landside right-of-way, but outside of the vegetation management zone, must be trimmed up 5 feet above the ground and thinned for visibility and access.

[8] From USACE EM 1110-2-1913 *Design and Construction of Levees,* April 2000, Section 1-5 a. (1) which states "The term levee as used herein is defined as an embankment whose primary purpose is to furnish flood protection from seasonal high water and which is therefore subject to water loading for periods of only a few days or weeks a year. Embankments that are subject to water loading for prolonged periods (longer than normal flood protection requirements) or permanently should be designed in accordance with earth dam criteria rather than the levee criteria given herein."

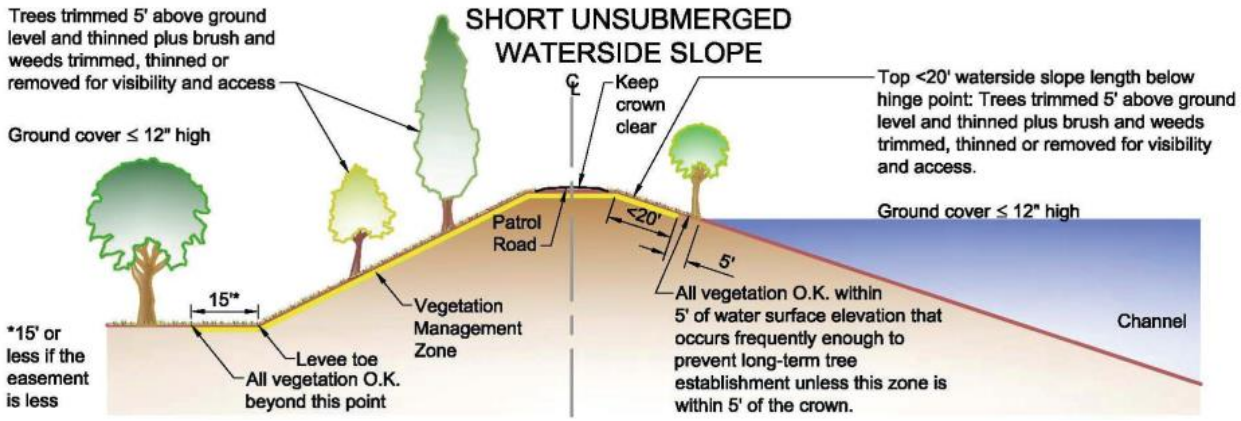


Figure 1-5: California Guidance –Vegetation Management for Existing Levee Section (Figure 7-7 of California Urban Levee Design Criteria)

1.4.2.1.6 LIFE-CYCLE VEGETATION MANAGEMENT

California uses life-cycle management (LCM) to achieve visibility and accessibility criteria while progressing gradually (over many decades) toward the USACE vegetation policy goal of eventually eliminating woody vegetation from the vegetation management zone of levees (landside slope, crown, and upper waterside slope). Life-cycle management on the California levees involves:

- Removal of immature trees and other woody vegetation less than four inches in diameter at breast height.
- Trees and other woody vegetation beyond this size (that do not pose an unacceptable threat to levee integrity) may live out their normal lives on the levee.
- Periodically evaluating the trees and other woody vegetation remaining. Should any of these be found to pose an unacceptable threat to levee integrity, remove them at that time.

1.4.2.1.7 VEGETATION PLANTING (FOR OVERBUILT EMBANKMENTS)

California's guidance for overbuilt embankments states that trees and other woody vegetation may be: (1) planted, and (2) allowed to naturally revegetate on a landside planting berm. Only the portion of the landside planting berm that is both 15 feet or more from the landside levee slope and 15 feet or more from the landward top of the planting berm may be planted or allowed to naturally revegetate. All trees and other woody vegetation in this area of the planting berm must be trimmed up 5 feet above the ground and thinned for visibility. Any landside berm can be a planting berm if its top is more than 30 feet wide (as measured perpendicular to the levee centerline) and the berm is at least 3 feet[9] thicker than required for levee integrity (to account for potential overturning of trees from windthrow) (see Figure 1-6). For levees

[9] The 3-foot thickness is based on research specific to the California soil types and the specific type and size of trees found on the levees and may vary for the soil and tree types found along the canal. This guidance also does not consider the seepage potential caused from roots within the levee embankment (presumably due to the shorter-term duration loading for the levee). Seepage and potential for piping is a major concern for the canal. It is for these reasons that a more conservative depth and distance criteria be used for the overbuilt canal embankments.

regulated by USACE, their approval is required for any plantings on the levee. Before planting, consideration should be given to the possibility that some or all vegetation may need to be removed in the future.

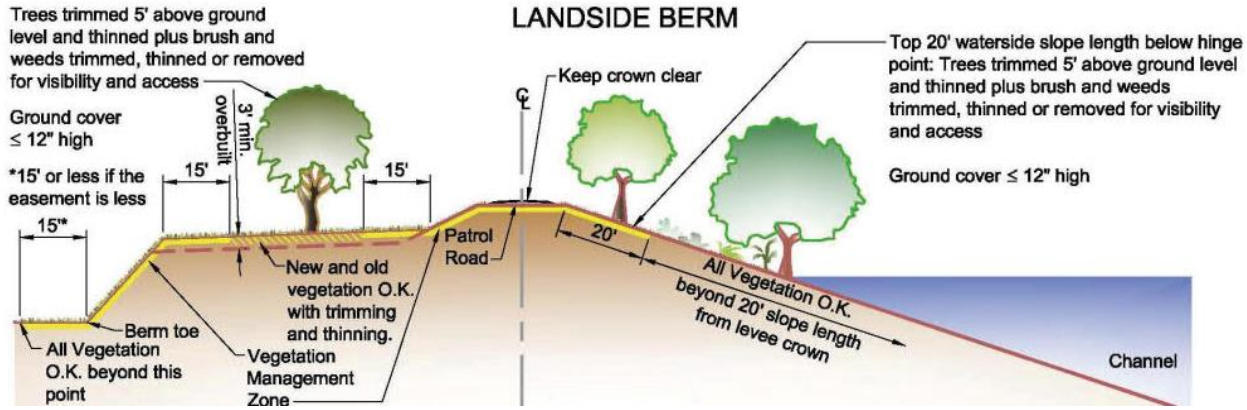


Figure 1-6: California Guidance –Vegetation Management for Existing Levee Section (Figure 7-8 of California Urban Levee Design Criteria)

1.5 NEW YORK STATE REGULATORY RECOMMENDATIONS FOR MAINTENANCE AND DESIGN OF EMBANKMENTS

Today, in New York State, dams that are not otherwise regulated by the FERC or USACE, are regulated by the NYSDEC. Although canal and feeder embankments are not regulated as dams, these embankments do retain water for certain parts of the year and uncontrolled breaches could result in damage to life and property. As such, guidance documents related to earthen dam maintenance and inspections are used by the NYSCC as part of its inspection and maintenance program of these earthen structures and referenced in this *Guide Book*. NYSDEC regulations include requirements for the inspection, operation, and maintenance of dams. The NYSDEC Owners Guidance Manual for the Inspection and Maintenance of Dams in New York State *[NYSDEC, 1987]*, originally published in June 1987 remains the current guidance. This document states:

- The entire dam should be kept clear of unwanted vegetation such as brush or trees.
- When brush is cut down, it should be removed from a dam to permit a clear view of the embankment.
- Stumps from trees or woody brush with a diameter less than 4" diameter may be left in place.
- Following removal of large brush or trees (with a diameter greater than 4"), the left-over root systems should also be removed to a root diameter of 1" or less and the resulting holes filled.

NYSDEC regulations also include requirements for the design of dams. The NYSDEC Guidelines for the Design of Dams *[NYSDEC,1989]* remains the current guidance. Chapter 9, Earth Dams, provides specific guidance in terms of side slopes, top width, seepage control and vegetation management that are required for constructing and maintaining earth dams, including:

- Downstream (outboard) slope of earth dams without seepage control measures should be no steeper than 1 vertical on 3 horizontal;
- Downstream (outboard) slope of earth dams with seepage control should be no steeper than 1 vertical on 2 horizontal;
- Minimum top width of embankment the greater of 10 feet or W = 0.2 H+7 feet, where H is the embankment height in feet;
- Trees and brush are not permitted on earth dams (in practice extends this to a point 15 feet outside the toe of slope where possible) because:
    - Extensive root systems can provide seepage paths for water;
    - Trees that blow down or fall over can leave large holes in the embankment surface that will weaken the embankment and can lead to increased erosion; and
    - Brush obscures the surface limiting visual inspection, provides a haven for burrowing animals and retards growth for grass vegetation.
- Grass vegetation is an effective way to prevent erosion of embankment surfaces and provides a surface that can be easily inspected.

The NYSDEC guidance notes that seepage control is anticipated in locations where the downstream slope is steeper than 3H:1V and/or the top width is too narrow, and NYSCC experience with their earthen embankments indicates this. Where seepage is identified and control measures are needed, the NYSCC, will typically install a filter blanket to safely manage seepage flows. Figure 1-7 and Figure 1-8 are presented to show the variation that is present in the geometry of existing earthen embankments.

A section taken through the northern earthen embankment at Greece Canal Park (Figure 1-7), shows little difference between the NYSDEC embankment design template and the actual embankment geometry. The embankment height is 19 feet, the downstream (outboard) slope is 3H:1V, and top width is 16 feet. The required top width is (0.2 x 19 feet) + 7 feet = 10.8 feet. Therefore, the existing geometry meets NYSDEC Guidelines without seepage control measures.

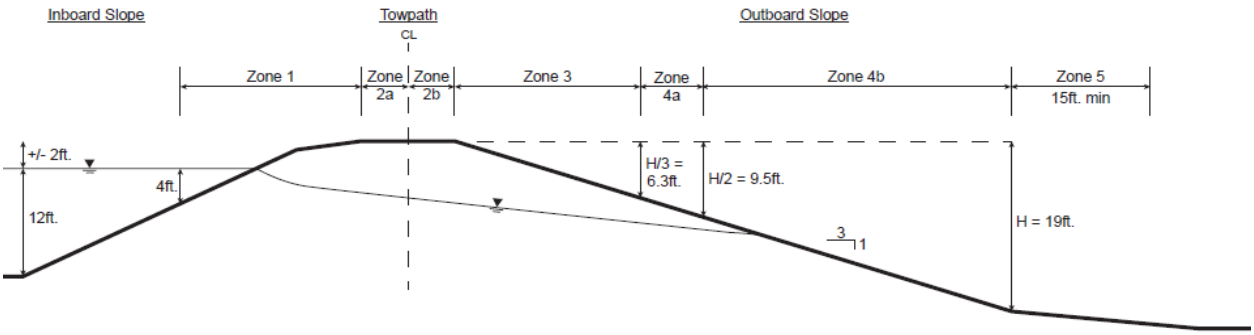


Figure 1-7 Existing North Earthen Embankment Section at Greece Canal Park, Looking West

A section taken through the southern earthen embankment at the Spencerport Village Park (Figure 1-8), shows a significant difference between the NYSDEC embankment design template and the actual embankment geometry. The embankment height is also 19 feet, but the downstream (outboard) slope is 2H:1V, and top width is 16 feet. The required top width is (0.2 x 19 feet) + 7 feet = 10.8 feet. This section

does not meet NYSDEC Guidelines without seepage control because of the steep downstream (outboard) slope.

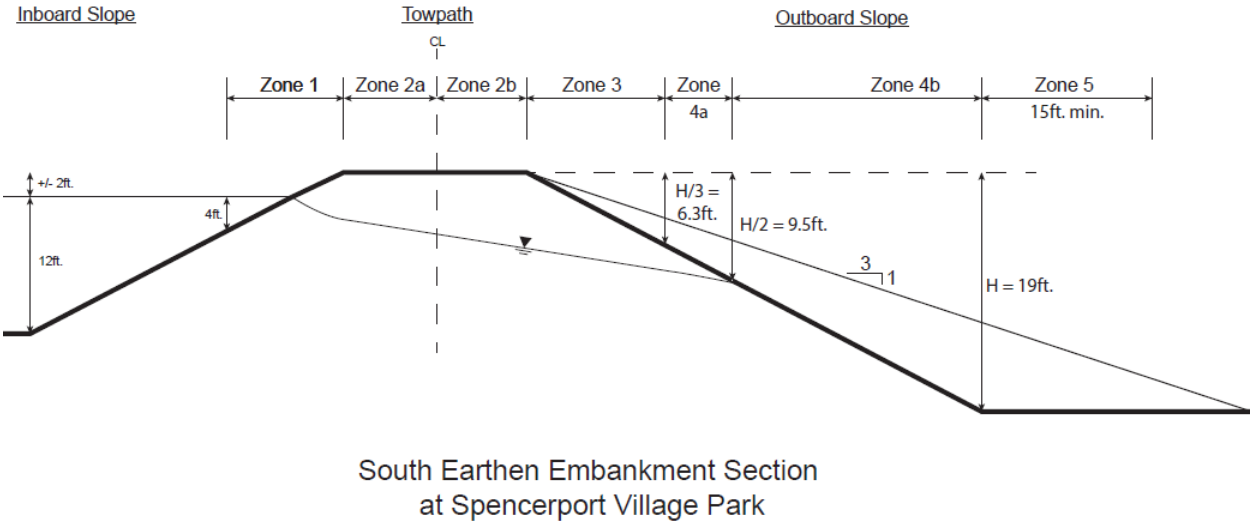


Figure 1-8 South Earthen Embankment Section at Spencerport Village Park

Given that typically the NYSCC right-of-way is close to the toe of slope, flattening of embankment slopes is not an option, and other measures to prevent harmful seepage are required. These are reviewed in later sections of the *Guide Book*.

1.6 SUMMARY

This chapter provided:

- An overall introduction to this *Guide Book* and its objectives.
- Background on the NYSCC canal embankments regarding their construction and configuration.
- A comparison between water impounding canal embankments, earth dam and levees and how that distinction is critical when considering the applicability of regulatory requirements, industry and engineering guidance, and dam and levee best practices.
- Information and background on what other agencies do for their dam and levee assets.

As indicated in the sections above, it is critical to understand the important differences between levees, dams, and canal embankments. As the USACE's guidelines indicate, due to the duration and frequency of water loading, canal embankments should not be maintained using guidance developed for levees.

2 NYSCC DAM SAFETY PROGRAM

2.1 ORGANIZATIONAL STRUCTURE OF NYSCC

Pursuant to Public Authorities Law Section 1005-b, the NYSCC is a public benefit corporation and subsidiary corporation of the New York Power Authority.

The NYSCC operations are divided into two regions: Eastern and Western. Work forces and responsibilities for individual structures are divided into Sections within each Region as follows:

EASTERN REGION

Section 1 - Fort Edward
Champlain Canal between Waterford (junction with Erie Canal) and Whitehall (north end of Lock C12)
[Locks C1 thru C12]

Section 2- Waterford
Erie Canal between Waterford (junction with Champlain Canals) and the East end of Lock E-8 (Rotterdam)
[Locks E2-E7]

Section 3 - Fonda
Erie Canal between and including Lock E8 (Rotterdam) to the east end of Lock E16 (Minden)
[Locks E8-E15]

Section 4 - Utica
Erie Canal from the east end of Lock E16 (Minden) to the west end of the Sylvan Beach breakwater
[Locks E16-E22]

WESTERN REGION

Section 5 - Lysander
Erie Canal from the western end of the Sylvan Beach breakwater to Cayuga/Seneca County line at Montezuma; and the entire Oswego Canal from Three Rivers to Lake Ontario
[Locks E23, E24, & O1-O8]

Section 6 - Lyons
Erie Canal from Cayuga/Seneca County line to the Wayne/Monroe County line; and entire Cayuga/Seneca Canal, from the south end of Cayuga Lake and Seneca Lake to the junction with the Erie at Montezuma
[Locks E25-E30, & CS1 – CS4]

Section 7 - Pittsford
Erie Canal from Wayne/Monroe County line to east end of Ingersol Street Lift Bridge, Albion
[Locks E32-E33]

Section 8 - Lockport
Erie Canal from east end of Ingersol Street Lift Bridge to Tonawanda Creek (500' west of Webster St. Bridge)
[Locks E34/35]

See Attachment 2 for a Map of NYSCC Region and Section boundaries. The inspection and maintenance plans shall be retained by the NYSCC electronically in Canal Infrastructure Management System (CIMS), kept in good order and updated as necessary to reflect any changes in the current condition of the embankments. The following contact information can be used for questions related to the embankment segments.

NYSCC Eastern Region
Regional Canal Engineer
30 South Pearl Street, 5th Floor
Albany, NY 12207
(518) 449-6036

NYSCC Western Region
Regional Canal Engineer
4950 Genesee Street, Suite 190
Cheektowaga, NY 14225
(716) 686-4400

Administrative Headquarters
NYPA Regional Manager – Canals
30 South Pearl Street, 5th Floor
Albany, NY 12207
(518) 449-6000

NYSCC Syracuse Office
Director of Waterways Maintenance
149 Northern Concourse
Suite 400
Syracuse, NY 13212
(315) 423-2081

2.2 GENERAL ORGANIZATIONAL STRUCTURE OF NYSCC OPERATIONS STAFF

The general reporting structure for the Canal Corporation Operations staff in the Regions is as follows (note that not all staff categories are included):

Engineering:

- One Regional Canal Engineer (RCE) per Canal Region. The RCE is a management position requiring a professional engineering license who manages the work in the Canal Region.
- Two Transportation Maintenance Engineers (TMEs) per Region who each oversee two Canal Sections. The TME is a management position requiring a professional engineering license and reports to the Regional Canal Engineer.

Operations:

- One Section Superintendent per Canal Section who is in charge of the entire section including maintenance, operations, and the Section maintenance shop. The Section Superintendents report to the TMEs.

- Canal Maintenance Supervisor 2 (CMS2) who functions as a maintenance general foreman and is the senior maintenance supervisor in the Canal Section. The CMS2 reports to the Section Superintendent.
- Canal Maintenance Supervisor 1 (CMS1) who functions as a maintenance foreman responsible for a single work crew.

2.3 SUMMARY

The NYSCC is a public benefit corporation and subsidiary corporation of the New York Power Authority. It is organized into an Eastern Region (comprising Sections 1 through 4) and a Western Region (comprising Sections 5 through 8). Engineering is organized by Region with each Region having a Regional Canal Engineer (RCE) supported by two Transportation Maintenance Engineers (TMEs). Operations is organized by Section with each Section having one Section Superintendent supported by one Canal Maintenance Supervisor 2 (CMS2) and one Canal Maintenance Supervisor 1 (CMS1).

3 EMBANKMENT RATING SYSTEM

With approximately 130 miles of embankment presently identified in the Canal system, it is necessary to identify and prioritize those sections most in need of maintenance. In order to create a prioritization, a matrix was developed based on two metrics: hazard classification, and condition rating to assign a resulting risk urgency rating. The matrix prioritizes risk urgency by assigning the highest risk urgency to those segments with the highest hazard classification and lowest condition rating.

Sections 3.1 through 3.4 describe the three classifications and ratings used to classify the embankment sections.

3.1 HAZARD CLASSIFICATION

The NYSCC uses the following hazard classifications for embankments, based on NYSDEC and FEMA guidelines *[NYSDEC, Undated; FEMA, 2004]*.

Table 3-1: NYSCC Hazard Classification for Embankments

Class "A" or "Low Hazard"		An embankment failure is unlikely to result in damage to anything more than isolated or unoccupied buildings, undeveloped lands, minor roads such as town or county roads; is unlikely to result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise unlikely to pose the threat of personal injury, substantial economic loss or substantial environmental damage.
Class "B" or "Intermediate Hazard"		An embankment failure may result in damage to isolated homes, main highways, and minor railroads; may result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise likely to pose the threat of personal injury and/or substantial economic loss or substantial environmental damage. Loss of human life is not expected.
Class "C" or "High Hazard"		An embankment failure may result in widespread or serious damage to home(s); damage to main highways, industrial or commercial buildings, railroads, and/or important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; or substantial environmental damage; such that the loss of human life or widespread substantial economic loss is likely.

3.2 CONDITION RATING

Periodic inspections have been performed for some of the Canal embankment sections. Inspections were performed by NYS Department of Transportation (NYSDOT) personnel in 2015 and prior years. Starting in 2017, the Canal Corporation and its consultants took over the inspection program. Minor revisions to the rating system have been made over time to include dam safety best practices and risk reduction measures.

Table 3-2: NYSCC General Condition Rating for Embankments

1 - SERIOUS/EMERGENCY		Serious Deficiencies Exist, Repairs Needed Urgently, Consider Emergency Remedial Action. Dam Safety Review Warranted to Determine the Embankment Integrity. Enhanced Monitoring Required
2 - VERY POOR		Advanced Safety Deficiencies Exist. Begin Monitoring and Consider Interim Stabilization Measures.
3 - POOR		Safety Deficiencies Exist that Signify Potential Progression of Deterioration under Existing or Increased Loading Conditions. May Need Condition-Based Preventative Maintenance. Place in Priority Scheduling for Improvement.
4 - FAIR		Moderate Safety Deficiencies Exist. Improve as Part of Normal Scheduling.
5 - GOOD		Minor Safety Deficiencies Exist. Satisfactory but Shows Signs of Aging.
6 - VERY GOOD		Normal Aging.
7 - EXCELLENT/NEW		No Appreciable Deterioration or Deficiencies Exist.

Key elements that are examined in the inspection include:

- the presence of embankment seepage (including standing water and other indicators such a lush vegetation or even the presence of wetland vegetation),
- the presence of vegetation on the embankment including trees or other vegetation that can negatively affect the embankment or hinders the inspection (refer to Section 7.3),
- geometry of the embankment including height, top width, and inboard and outboard slope,
- embankment settling or slope failure,
- presence of animal burrows,
- missing or deteriorated inboard slope protection (riprap) with erosion potential, and
- the presence of development or residential properties near the embankment (an indicator of hazard class).

3.3 FEMA RISK URGENCY RATING SYSTEM

The FEMA risk urgency system assigns different levels of urgency to dam corrective actions. It reflects an assessment of the likelihood of failure with five risk categories. Risk urgency classifications listed below are as defined in the FEMA publication P-1025 *Federal Guidelines for Dam Safety Risk Management [FEMA, 2015]*.

Table 3-3: FEMA Risk Urgency Rating

I - Very High Urgency		CRITICALLY NEAR FAILURE: Direct evidence that failure is in progress, and the dam is almost certain to fail during normal operations if action is not taken quickly. OR EXTREMELY HIGH RISK: Combination of life or economic consequences and likelihood of failure is very high with high confidence.
II - High Urgency		RISK IS HIGH WITH HIGH CONFIDENCE OR IT IS VERY HIGH WITH LOW TO MODERATE CONFIDENCE: The likelihood of failure from one of these occurrences, prior to taking some action, is too high to delay action.
III - Moderate Urgency		MODERATE TO HIGH RISK: Confidence in the risk estimates is generally at least moderate but can include facilities with low confidence if there is a reasonable chance that risk estimates will be confirmed or potentially increase with further study.
IV - Low Urgency		LOW TO MODERATE RISK: The risks are low to moderate with at least moderate confidence, and there is a potential for the risks to increase with further study.
V - No Urgency		LOW RISK: The risks are low and are unlikely to change with additional investigations or studies.

Depending on the urgency of the risk, remedial actions may range from routine risk management measures to heightened monitoring and evaluation, up to immediate action to avoid failure and implementing the emergency action plan. FEMA Risk urgency ratings for NYSCC embankment sections began in 2016. It is the intent to assign Risk Ratings to all embankments as part of the inspection program.

3.4 MODIFIED RISK URGENCY RATING SYSTEM FOR USE ON CANAL ASSETS

The NYSCC uses a modified FEMA risk urgency scale which includes one additional urgency classification to better fit with the General Condition Rating and Hazard Class system that has been established. The new rating of "Va - Very Low Urgency" is used in between FEMA's IV and V classifications. This new rating is beneficial to differentiate between a classification of "Low Urgency" and a classification of "No Urgency."

The NYSCC uses the General Condition Rating and Hazard Class to develop a preliminary Risk Urgency Rating as per the matrix below. This matrix has been established to prioritize the risk urgency of the various assets according to their condition and the consequence of the asset's failure. Higher hazard structures generally receive a higher preliminary Risk Urgency Rating for the same condition. This ranking matrix places the highest priority to the structures that would have the greatest consequence of failure and exhibit the worst condition. The preliminary Risk Urgency Rating assigned by the matrix is reviewed by the inspecting engineer for appropriateness considering the actual observations made prior to assigning a final Risk Urgency Rating. Allowing the engineer to apply judgment in assigning the final Risk Urgency Rating allows for consideration of factors that are difficult to quantify in the general matrix and eliminates the "black box" assignment of the final Risk Urgency Rating.

Table 3-4: NYSCC Risk Urgency Rating for Embankments

GCR\Hazard	Low Hazard	Intermediate Hazard	High Hazard
7 - Excellent/New	V - No Urgency	V - No Urgency	V - No Urgency
6 - Very Good	Va - Very Low Urgency	Va - Very Low Urgency	Va - Very Low Urgency
5 - Good	Va - Very Low Urgency	IV - Low Urgency	IV - Low Urgency
4 - Fair	IV - Low Urgency	III - Moderate Urgency	III - Moderate Urgency
3 - Poor	III - Moderate Urgency	III - Moderate Urgency	II - High Urgency
2 - Very Poor	II - High Urgency	II - High Urgency	I - Very High Urgency
1 - Serious/Emergency	I - Very High Urgency	I - Very High Urgency	I - Very High Urgency

3.5 SUMMARY

The 130 miles of presently identified water retaining embankments in the NYSCC system are prioritized for maintenance using a matrix based on two metrics: hazard classification, and condition rating to assign a resulting risk urgency rating. NYSCC uses a modified FEMA risk urgency scale that is presented in Table 3-4.

4 EMBANKMENT INSPECTIONS

NYSCC is responsible for periodically inspecting embankments under its jurisdiction. Inspections and maintenance are important to the ongoing serviceability and operability of embankments, the safety of people and facilities downstream of the embankments, and the continued operation of the Canal System. Identifying signs of failure early is critical to the prevention of hazardous situations for the surrounding people and infrastructure as well as aiding the NYSCC in gauging risks and priorities when planning and scheduling maintenance activities and capital improvements. Annual embankment inspection training is provided to Canal staff who perform embankment inspection work. Additional training, such as seepage monitoring and dam safety training, is provided annually to Maintenance Supervisors and staff who are licensed professional engineers. Training requirements are evaluated annually and revised as needed.

4.1 SUMMARY OF INSPECTIONS

The NYSCC performs various types of inspections at its embankments. Further description of the inspection requirements is included in the following sections. The frequencies identified below are targets NYSCC strives to meet based on resource availability. Additional inspections for appurtenant structures including spillways, weirs, sluice gates and culverts are coordinated by the Asset Management & Inspection Engineer separately from the embankment inspection program.

4.1.1 BANK WALK INSPECTIONS

Bank Walk Inspections are routine scheduled inspections performed by NYSCC staff. It is also the minimum level of inspection to be performed any time staff visits an embankment site. The inspection consists of visually identifying areas of immediate concern for the functionality of the embankment. The primary focus of the visual inspection is the embankment and its appurtenant structures to observe defects and changes in condition.

Items to Monitor:

- Crest alignment
- Seepage
- Reservoir pool
- Wet areas
- Slides/sloughs
- Cracks
- Toe drain flow
- Trash rack debris/ culvert flow
- Condition of any appurtenant or adjacent structures (e.g., spillways, dive culverts, waste weirs)

Minimum Frequency:

- Assigned by the Regional Canal Engineers or Transportation Maintenance Engineers based on the embankment's condition and hazard class
- Typically performed on a more frequent interval as often as weekly to bi-monthly

Inspection Personnel:

- NYSCC Section Staff

Responsible Reviewers:

- Canal Maintenance Supervisor 1,
- Canal Maintenance Supervisor 2, and/or
- Section Superintendent

4.1.2 INFORMAL INSPECTIONS & ENHANCED EMBANKMENT MONITORING

Informal Inspections and Enhanced Embankment Inspections are conducted to monitor any devices or conditions related to seepage at the embankment in addition to the normal requirements of a Bank Walk Inspection. Previous observations should be compared to current observations to determine if there are any significant changes in conditions at the embankment. All changes in condition, changes in readings from instrumentation devices, and maintenance practices implemented since the previous inspection are documented. Informal Inspection may also document any new deficiencies, instabilities, or notable conditions.

Items to Monitor

- Areas of Concern (AOCs) identified in Safety Inspections
- Monitoring wells (level)
- Piezometers (level)
- Observation manholes (level)
- Outfalls (discharge)
- Monitoring Devices
- Monitoring Weirs (discharge)
- Rodent activity
- Vegetation
- Concrete surfaces
- Vandalism

Minimum Frequency:

- Enhanced Embankment Monitoring intervals vary and are assigned by the Regional Canal Engineers based on the embankment's condition, hazard class, and specific areas of concern being monitored
- Informal inspection frequencies are completed according to the Dam Safety Program Policy CC-POL-DS as follows:

Hazard (See Section 3.1)	Inspection Interval[1]
Class A	Semiannually
Class B	Quarterly
Class C	Monthly

[1] Inspection intervals are applicable only during periods when embankment retains water)

Inspection Personnel:

- NYSCC Engineering Staff
- Licensed Professional Engineers

Responsible Reviewers:

- Regional Canal Engineer
- Dam Safety Engineer

4.1.3 FORMAL INSPECTIONS

Formal Inspections are conducted regularly by qualified licensed engineers. A report is generated by a Licensed Professional Engineer in the State of New York experienced in dam safety. The report compares conditions of the embankment to previous conditions assigns a condition rating, performs a visual assessment of apparent hazard class, assigns a risk urgency rating, and provides recommendations for necessary maintenance.

Items to Monitor:

- The formal inspection is a detailed inspection of all aspects of the embankment including general condition, apparent hazard classification and overall risk.

Minimum Frequency:

- Minimum frequency for formal inspections is set by Dam Safety as follows:

Hazard (See Section 3.1)	Inspection Interval
Class A	Every 5 years
Class B	Every 3 years
Class C	Every 2 years

Inspection Personnel:

- Licensed Professional Engineers trained in dam safety

Responsible Reviewers:

- Dam Safety Engineer

4.1.4 SPECIAL INSPECTIONS

Refer to NYSCC Post Event Inspection Procedures; K118-EMP-0008 *[NYSCC, 2018]* for instructions on post event or emergency (earthquake, flood) inspection criteria.

4.2 IDENTIFICATION, REVIEW, AND PROGRAMMING OF CORRECTIVE ACTIONS

Figure 4-1 summarizes the means by which embankment safety issues are identified, and corrective actions are reviewed, approved and programmed for implementation. Embankment safety issues may be identified through the inspections discussed in Section 4.1. Other sources of information may come from boaters, trail users or residents along the canal who observe seepage, sloughing or other anomalies. The recommendation of corrective actions is initiated by the reviews of inspection reports by one or more NYSCC leadership team members. These include: Section Superintendent, Regional Canal Engineer, Dam Safety Engineer, and Asset Management & Inspection Engineer.

The Regional Canal Engineer, Dam Safety Engineer, and Asset Management & Inspection Engineer determine the appropriate vehicle for implementing the corrective actions. In making their determination, they shall consult with Environmental Health & Safety (EH&S) for required maintenance work. The Regional Canal Engineer will determine when consultation with and/or involvement of the Public Information Office, Legal and/or Real Property is also required. Such instances include when corrective actions may require mitigation to address environmental impacts. Corrective actions that can be performed as in-house or contract maintenance are then progressed back through the appropriate Regional Canal Engineer and Section Superintendent for implementation via generation of work orders in NYSCC's work order management system Maximo.

When programming corrective actions, the property ownership rights of the NYSCC must be confirmed to determine whether sufficient space to perform the maintenance work or to provide sufficient access to perform the required maintenance work described in this *Guide Book*. When corrective actions result in ground disturbance, a review of potential sources of contamination (e.g. State Superfund sites, etc.), as further described in Section 8, should also be performed. Presence of contaminated soils could significantly

extend timeframes for action or trigger special material handling requirements. For this reason, the limits of NYSCC property, or rights to access the property to perform maintenance work must be confirmed. Access to adjacent lands to perform maintenance work, or to provide access, may be obtained through a Site Access/Vegetation Management Permit or permanent easement. Refer to Section 8.13 – Access, Easements and Temporary Workspace for more information.

Figure 4-1 depicts a flow chart for the inspection review, maintenance recommendation and approval process for embankment maintenance activities.

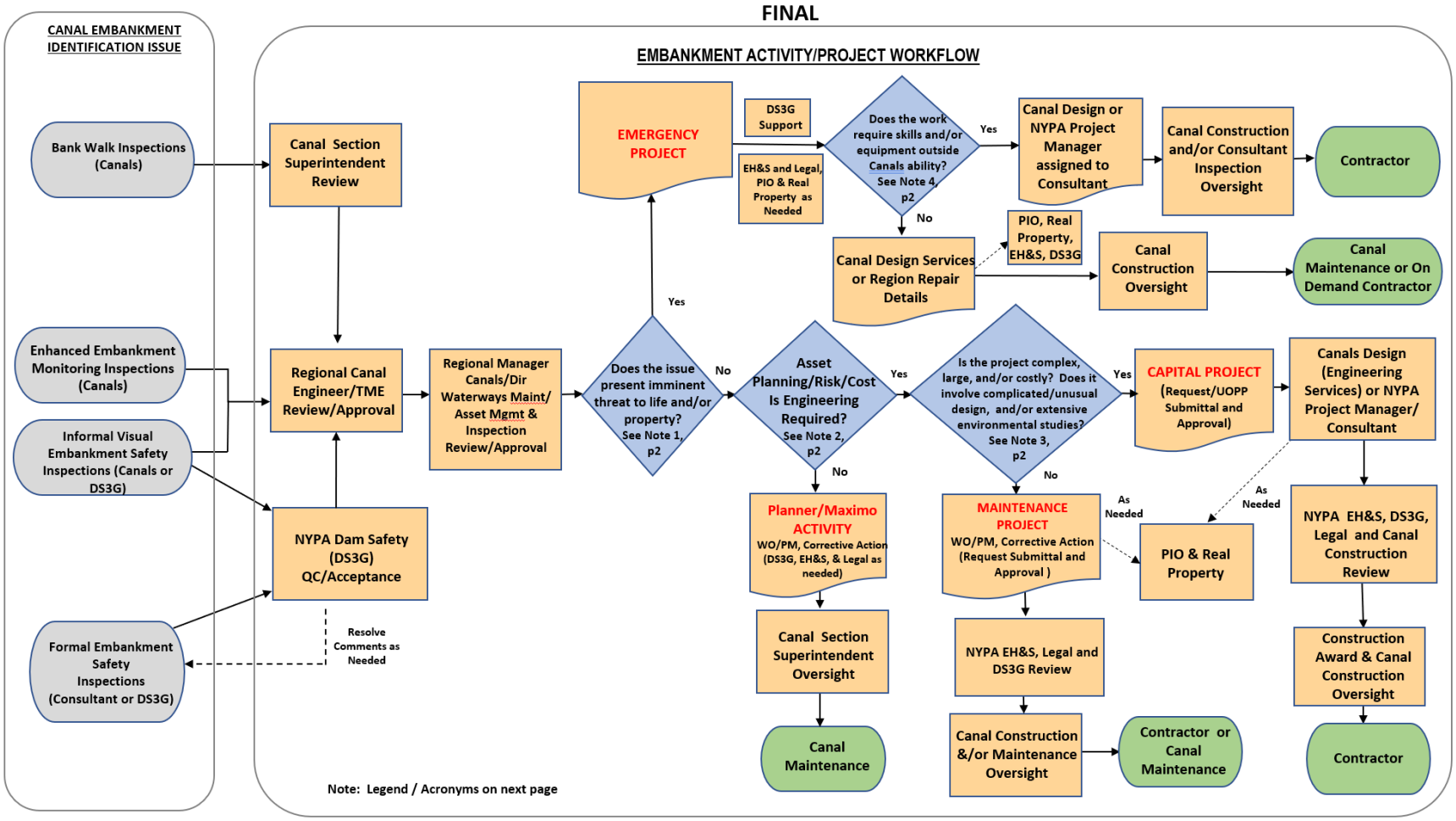
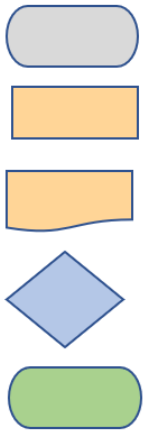


Figure 4-1: Inspection Maintenance and Approval Flow Chart

LEGEND /ACRONYMS



Terminal Point - Start

Action or Process

Document

Decision

Terminal Point - End

Canals	NYS Canal Corporation
EH&S	NYPA Environmental Health and Safety
DS3G	NYPA Dam Safety
PIO	Public Information Officer

NOTES: TEAM INLCUDED FOR DECISION MAKING

Note 1: Decision team may include: Regional Manager Canals; Director, Waterways Maintenance; Regional Canal Engineer; Director, Asset Management and Inspection Bureau; Manager – Dam Safety

Note 2: Decision team includes: Director, Asset Management and Inspection Bureau; Director, Design Bureau; Regional Canal Engineer

Note 3: Decision team includes: Director, Design Bureau; EH&S

Note 4: Decision team may include: Regional Manager Canals; Director, Waterways Maintenance; Regional Canal Engineer; Director, Design Bureau

4.3 RELATED ITEMS CONCERNING INSPECTIONS

Inspection records and log readings are kept in CIMS and Dam Safety files.

The Regional Canal Engineer, Asset Management & Inspection Engineer, and Dam Safety Engineer shall receive copies of inspection reports for Enhanced Embankment Monitoring and Dam Safety Inspections. The Regional Canal Engineer, Asset Management & Inspection Engineer, and Dam Safety Engineer shall be contacted with any relevant findings (e.g. new or suspected seepage, settlement, sinkholes, sloughing, etc.) from Bank Walk Inspections and Informal Inspections.

4.4 EMERGENCIES

In the event that an emergency condition is observed that appears to imminently jeopardize the integrity of any of the NYSCC's embankments, the observer should call the Canal Emergency Dispatch at 1-833-538-1042 immediately to begin the duty notification process.

4.5 SAFETY REQUIREMENTS

All NYSCC employees are required to follow the appropriate safety procedures while engaged in work related to embankment inspections and maintenance activities.

Procedures and Policies relating to health and safety include, but are not limited to, those listed below. Refer to the Canals Intranet: "Publications" → "Environmental, Health and Safety" → "Safety" for a listing of all current safety policies and procedures.

- Canal Corporation Safety Rules; CCHQ-1000.04 R01
- Canal Corporation Employee Safety Policy; 25-2-23C
- Confined Space Entry & Permit Program; 322-0-01
- Safety-Toe Footwear; SP-00 2018 R03
- Lockout/Tagout Program; SD 90-4

4.6 SUMMARY

NYSCC performs bank walk, informal, formal and special periodic inspections of their water retaining embankments at intervals based on hazard classification. NYSCC then identifies, reviews and programs corrective actions following the Embankment Activity/Project Workflow (Figure 4-1). Inspection records and log readings are kept in CIMS and Dam Safety files. An emergency contact number is provided, and safety requirements are listed and available on Canals Intranet.

5 ISOLATION AND DEWATERING OF EMBANKMENT SEGMENTS

Maintenance activities associated with embankments are preferentially performed under dewatered conditions. Dewatering embankment segments prior to conducting excavation work is a risk-reduction practice to limit both the likelihood and resultant consequence of an embankment failure. During the non-navigation season, many embankment segments are dewatered when water levels are drawn down. However, dewatered access to an embankment area occasionally may be required during the navigation season and some embankments may be located within segments that are not dewatered or where the water level is not fully lowered during non-navigation season.

Notifications to internal business units prior to raising or lowering water elevation in the canal systems shall be made in accordance with EMB-2020-003.

5.1 ISOLATION OF CANAL AND FEEDER SECTIONS

During the navigation season it is a priority to maintain the navigable pool in the operating canal segments adjacent to a required dewatering. Sections of the canal can be isolated for dewatering between existing structures. The primary limits of dewatered sections are provided by the existing guard gates and navigation locks on the canals. See the Isolation and Dewatering Tables in Attachment 3 for listings of sections of the canals between guard gates and locks and their associated dewatering features in each segment. During the non-navigation season, isolation points may be constructed in the canals away from existing structures by using cofferdams. In an emergency, cofferdams may be installed during the navigation season, however, additional evaluation would be required to ensure maintenance pools in adjacent segments are unaffected.

The feeders and remnant canals have water depths typically between 4 and 6 feet, and most lack control structures like guard gates and frequent outlets. Isolation of these sections would typically require installation of cofferdams and potential pumping or siphoning after identifying permissible discharge locations other than adjacent segments, if needed. See the Isolation and Dewatering Tables in Attachment 3 for listings of sections of the feeders and remnant canals with the associated water control and dewatering features in each segment.

5.2 LOCATIONS OF EMBANKMENT SEGMENTS

Identification and mapping of embankment segments is an ongoing process. Embankment maps are updated as new embankment segments are identified. In the NYSCC's asset portfolio, there are two categories of embankments as described below.

Canal Embankments – Embankments that are associated with portions of the modern Erie Canal System (Erie, Champlain, Cayuga-Seneca, and Oswego). Only man-made water-retaining embankments whether on natural riverine sections or the artificial canal sections of the waterway are included in this category. The portions of the canal system that traverse lakes, such as Onondaga, Oneida, Cayuga and Seneca Lakes do not include man-made water retaining embankments and are therefore not included.

Remnant Canal and Feeder Embankments – Embankments that are associated with feeders and remnant canals. The natural streams and rivers that convey water from feeders and remnant canals and that were not modified by construction of embankments, are not included.

5.3 DEWATERING

Most sections of canal between identified isolation points include one or more water outlet structures to discharge water from the canal. Canal locks may be used to dewater by cross feeding.[10] These features have limited capacity and will generally perform best in sections where flows are small, and where the canal is not combined with river flows. Sluice gates and valves in waste weirs and drains in the bottom of the canal which outlet into culverts under the canal also provide drainage points in some sections, again typically away from canalized river sections. At some locations, powerhouses may also be used to provide additional outflow from an isolated section; however, coordination with other owner-operator entities would likely be required.

Many sections of remnant canals and feeders have limited existing infrastructure to allow isolation of segments. Generally, dewatering will require closure of inflow at headworks control structures and either installation of cofferdam systems or longer extents of dewatering beyond the location of interest. In some instances, it may be necessary to provide downstream cofferdams to prevent backflow from the downstream canal being fed.

If an event occurs at a location that prevents the operation of a usual dewatering feature, alternate points in the same segments may be used and/or supplemental methods such as pumping or siphoning may be considered. Breaching is not considered a safe or effective means to dewater as it could result in release of flow to undesirable areas away from usual canal discharge or stream flows.

When dewatering of sections of canal between identified isolation points is planned, the community and public will be provided advance notification in accordance with the provisions of Section 9 or 10 of this document.

5.4 SUMMARY

This section, along with Attachment 3, explains the necessary isolation and dewatering of canal embankments that's required to safely perform many of the embankment maintenance activities.

[10] Cross feeding is a method that involves passing flow through a lock using the filling and emptying system. Cross feeding is accomplished by opening the upper valve on one side of the lock and the lower valve on the opposite side of the lock. Specific procedures and functionality may vary by lock and should be done only in consultation with staff experienced with the procedures at the particular lock.

6 EMBANKMENT FEATURES

Figure 6-1 and Figure 6-2 help identify the various parts of an embankment. The figures identify common elements of embankments; however, each embankment is unique and many of NYSCC's embankments have elements that may differ from what is shown.

This manual and the figures focus on the earthen portion of the canal embankments. There are many other types of structures that may be inline or adjacent to these earthen features, however, they are not represented here. Items such as concrete spillways, waste gates, waste weirs, dive culverts, and concrete or masonry walls are not shown nor described in this manual.

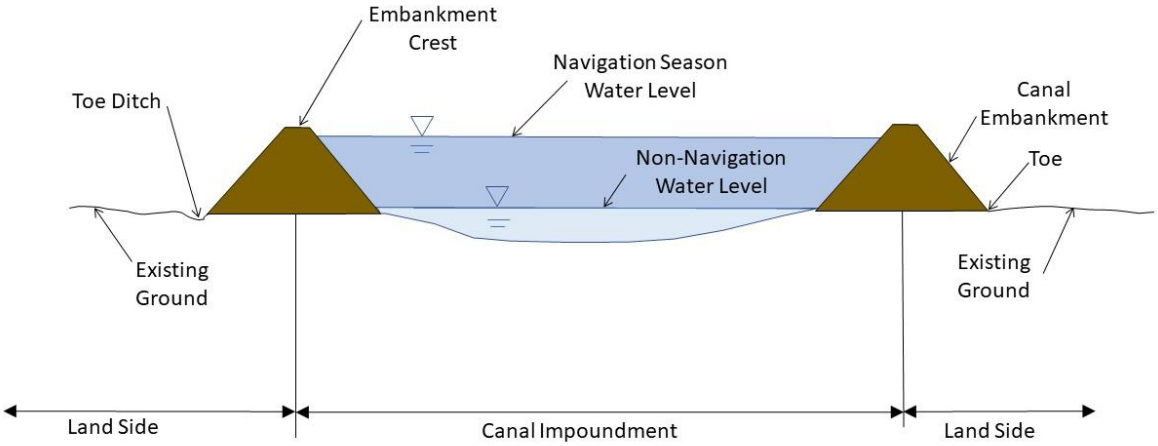


Figure 6-1: Parts of an Impounded Canal (Revised)

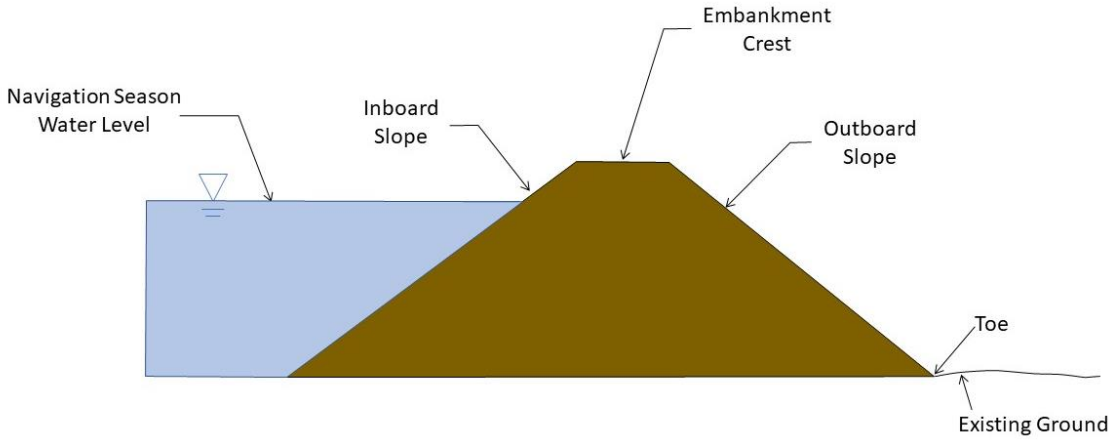


Figure 6-2: Embankment Features (Revised)
Typical Canal Embankment Sections

6.1 TYPICAL CANAL EMBANKMENT SECTIONS

There are two typical canal prisms in the modern Erie Canal system. The size of the canal prism has an obvious impact on the required embankment dimensions (a deeper canal requires higher embankments).

On the Erie Canal from Waterford to Three Rivers (where the Oswego, Seneca and Oneida confluence), the typical canal prism and generalized embankment section is shown in Figure 6-3. [11]

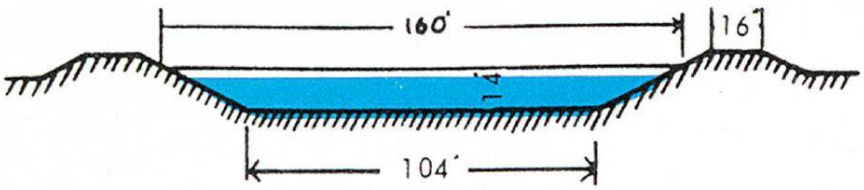


Figure 6-3: Earthen Embankment Canal Section: Erie Canal – Waterford to Three Rivers

On the Erie Canal from Three Rivers to Tonawanda, and on the Champlain Canal, the typical canal prism and generalized embankment section is shown in Figure 6-4.[12]

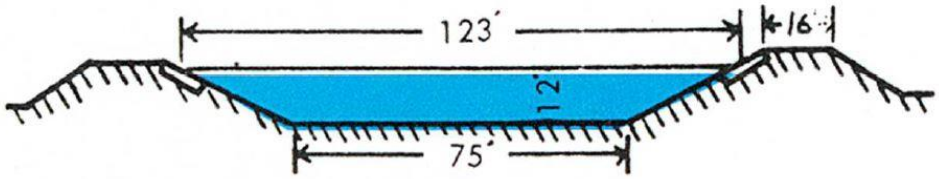


Figure 6-4: Earthen Embankment Canal Section: Erie Canal – Three Rivers to Tonawanda and Champlain Canal

The typical inboard slope of the canal prism as shown on Figure 6-3 and Figure 6-4 are 2H:1V. The outboard slopes are variable. There are locations where the embankment is much wider than 16 ft. due to material disposal requirements during construction.

6.2 EMBANKMENT FEATURES

There are three main parts to an earthen embankment. These features are also shown in Figure 6-2 above.

Outboard Slope: This refers to the landward side of the embankment beginning at the top, landward crest edge.

Inboard Slope: This refers to the water-ward side of the embankment, beginning at the top, water-ward crest edge.

Crest: This refers to the top, typically flat portion of the embankment.

[11] From "New York's Canals & Connecting Waterways" Published by New York State Department of Transportation. Circa 1992
[12] Ibid.

6.2.1 EMBANKMENT ZONES

Five dam safety inspection and evaluation zones have been identified within the geometric configuration of a typical earthen embankment. The delineated zones, illustrated in the figure below, have been numbered from upstream (inboard side) to downstream (outboard side). These zones have been delineated based on typical seepage characteristics. Descriptions of the zones, as adapted from and outlined in *FEMA 534 Technical Manual for Dam Owners – Impacts of Plants on Earthen Dams* and *FEMA 473 Impacts of Animals on Earthen Dams* and accompanying Figure 6-5 are listed below (zone designations have been modified slightly from the FEMA references to simplify and reduce overlap of some zones).

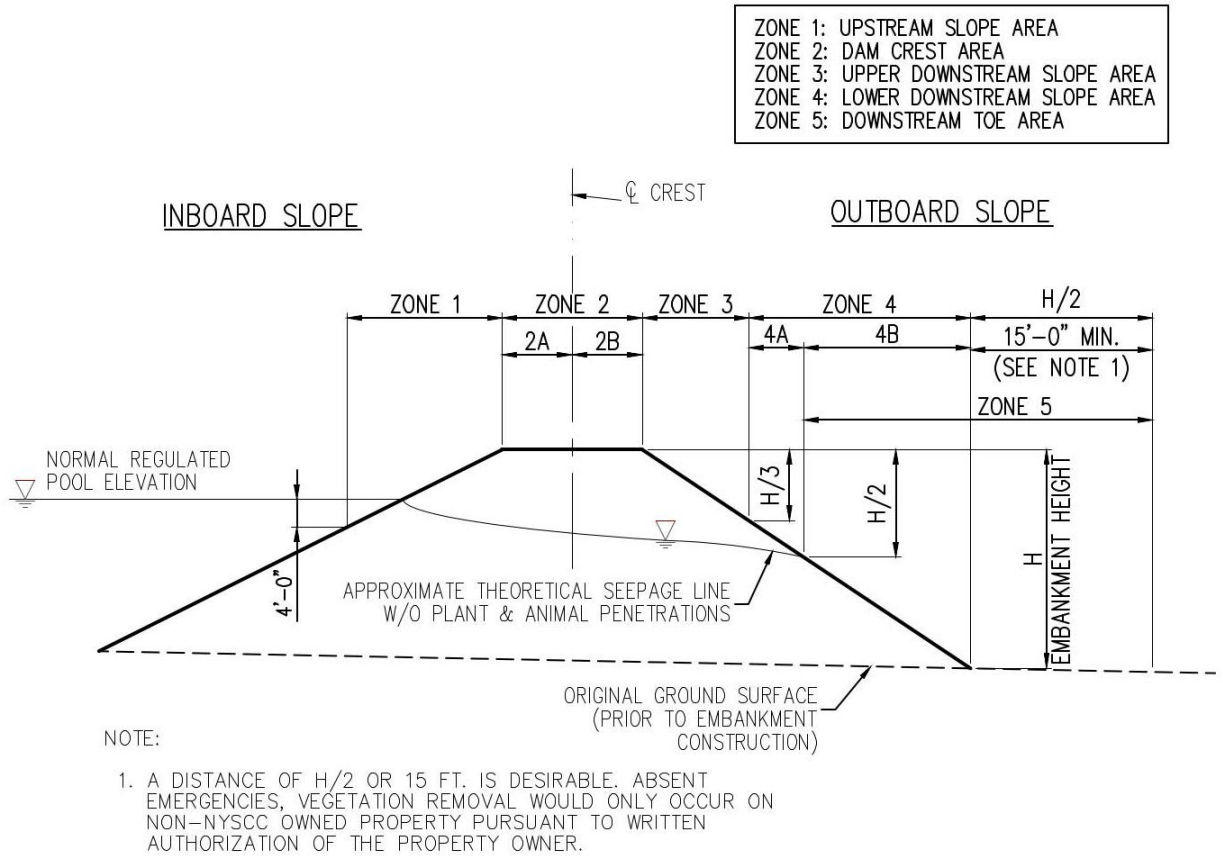


Figure 6-5: Embankment Zones

EMBANKMENT ZONE DESCRIPTIONS:

Zone 1: Zone 1 begins on the upstream slope (inboard slope) of the earthen embankment at about four feet below normal pool elevation and extends to the embankment crest.

Zone 2: Zone 2 includes the entire width of the crest of the embankment and is subdivided into equal length zones - Zones 2A and 2B by the centerline of embankment.

Zone 3: Zone 3 extends from the outboard edge of the crest of the embankment to a point on the downstream (outboard) embankment slope that is about one-third of the structural height below the crest of the embankment.

Zone 4: Zone 4 extends from a point on the downstream (outboard) embankment slope that is about one third the structural height of the embankment to the toe of the downstream embankment slope. Zone 4 is subdivided to more clearly differentiate the portion that overlaps Zone 5, designated as Zone 4B, which is the most critical area of the zone.

Zone 5: Zone 5 extends from the mid-height of the downstream (outboard) embankment slope to a distance of one-half the structural height or a minimum of 15 feet beyond the toe of the downstream embankment slope, but work shall not occur beyond the NYSCC property limit without an easement or access agreement (refer to Section 8.13).

For land not currently owned by Canals but where best practices dictate that the work on the property is recommended (vegetation clearing, filter and toe drainage installation, etc.), Canals will endeavor to work with those landowners to accomplish the dam safety best practices to the greatest degree practical.

6.3 OUTBOARD SLOPE EMBANKMENT FEATURES

The following describes some of the features either present from the original construction or rehabilitation, or enhancements added to maintain the embankment in a safe condition on the outboard slope of the Canal embankment.

6.3.1 EROSION AND BANK PROTECTION

Filter Blankets: A blanket of granular material, sometimes on a granular bedding, placed on the slope in the location of a known seep through the embankment. Filter blankets allow for water to continue to flow through the seep but prevents transport of the smaller grain embankment materials (piping). This filter blanket is typically covered with either riprap protection or vegetation.

Riprap Protection: In some instances, the outboard slope is protected by riprap stone protection. One such example is where the canal is adjacent to a pond, ditch, stream or other waterbody. Erosion can occur from these water sources due to high velocity/shear stress conditions or wave action. Riprap, large diameter, angular, quarried stone, may be placed in these locations to protect the embankment from erosive forces.

Vegetated Slopes: The majority of the embankment outboard slopes are vegetated with turf grass. Some locations may have additional reinforcement including rolled erosion control products or turf reinforcement matting. For the reasons set

forth in Section 7.3, woody vegetation should not be present on embankment slopes.

6.3.2 DRAINAGE CHANNELS AND DITCHES

Toe Ditch: A drainage swale running parallel to the embankment at the toe, where the embankment meets original ground. The ditch allows for collection and conveyance of seepage and surface drainage.

Toe Drain/Rock Toe: An area of stone material at the toe of the embankment. The stone allows seepage to be directed to the toe of the embankment.

6.4 INBOARD SLOPE EMBANKMENT FEATURES

Riprap Protection: Riprap is angular, quarried stone of varying sizes. Typically, NYSDOT standard specifications for Stone Fill are used. The riprap should be placed on a layer of smaller grain filter material. The size of the riprap should be designed to accommodate the canal flow and potential boat and wind generated waves at the site.

Concrete Linings: Concrete linings are located on some sections of embankment covering a portion of or the entire wetted perimeter of the canal. This concrete lining can serve multiple functions including water cutoff of varying degrees or erosion protection.

Wave Wash Protection: Wave wash protection is a general term for materials placed to prevent erosion of the embankment resulting from the wake of passing vessels. Concrete, riprap and stone linings all can be used for this purpose.

Stone Paved Linings: Stone paved linings consist of laid up stone or mortared stone. These are typically installed to address erosion, flow velocities, and waves.

6.5 CREST EMBANKMENT FEATURES

Geometry: The crest top width varies. Often the crest is crowned (nearly flat with a slight high point in the center) or sloped to one edge to promote drainage.

Surfacing: The crest surface is normally turf with asphalt paving or stone dust path.

6.6 STRUCTURES INTEGRATED WITHIN THE EMBANKMENT

Structural features are located adjacent to and within the embankment. The maintenance of these features other than cleaning debris, is outside of the scope of this *Guide Book*. These structural features are described below in the context of the embankment systems. Detailed inspection of these features is also outside of the scope of this *Guide Book*; however, descriptions of the features is included so that their function is understood. Often, failures initiate at the interface of the embankment with other features. Detailed

investigation and careful maintenance of the interface areas is crucial to embankment performance. Cursory inspection of the features and the interface with the embankment should be included in all categories of embankment inspections. Depending on the structure type, detailed inspection of the structures is conducted under the auspices of either the Canal Structure Inspection program or the Dam Safety Inspection program, and the results coordinated between the Asset Management & Inspection Engineer and the Dam Safety Engineer.

Dive Culverts/Culverts: When the Canal crosses over natural channels, culverts or dive culverts are installed to pass the stream flow underneath the canal and its embankments. Dive culverts and culverts have a variety of shapes, sizes and construction materials. Inspection relating to the embankment would be to look for flow condition (color or flow rate) in the culvert that appear inconsistent with general conditions at the inlet (if observable), the presence of sinkhole in the embankment near the culverts, any signs of whirlpooling in the canal, or any unexplained flow at or in the vicinity of the culvert. Figure 6-6 shows a profile of a dive culvert in the Western Embankment section of the Erie Canal.

Waste Weirs/Spillways: In general, the Canal's water surface elevation is relatively constant between locks. It is regulated by a series of dams and locks across the state. In the event additional flow enters a segment of the Canal and the water surface rises, there are waste weirs and spillways located along the Canal embankment that allow water to flow out of the impoundment and into adjacent streams. The waste weirs / spillways are typically concrete or stone and in-line with the earthen embankment. Some of these features have sluice gates or valves that can be used to lower the Canal pool level below the crest of the weir. Figure 6-7 shows a view of a waste weir in the Village of Albion.

Concrete / Masonry Walls: Portions of the impounded sections of the Canal include concrete or masonry walls with the embankment or in lieu of embankment. Masonry walls consist of stacked stone with a mortar binder. Concrete walls may be reinforced or unreinforced concrete. Figure 6-8 shows a view of a concrete retaining wall on the canal.

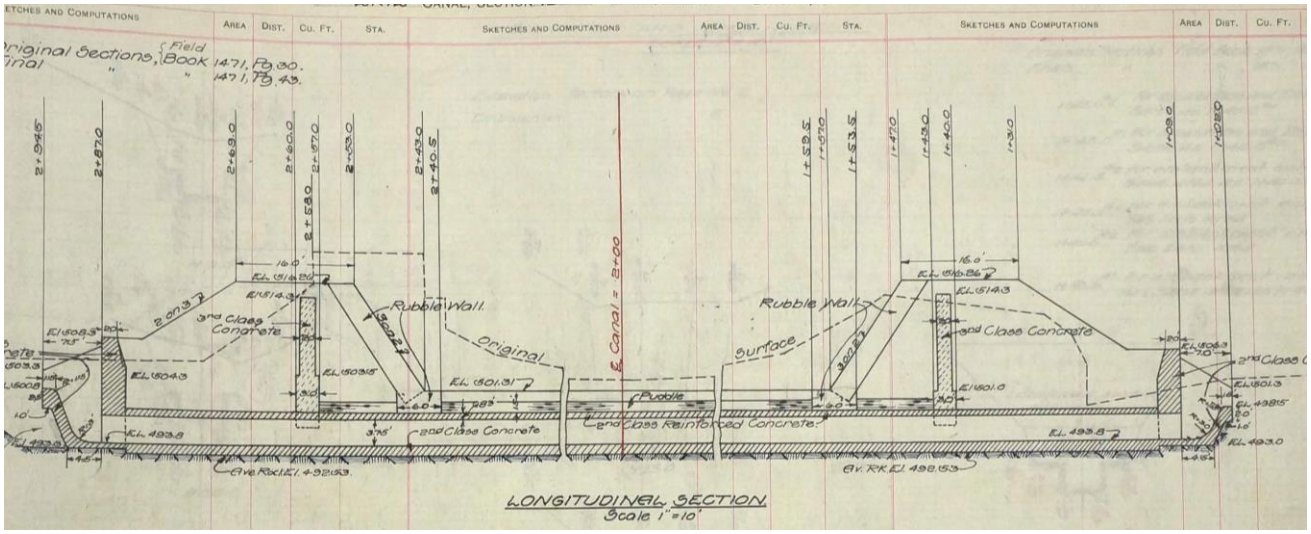


Figure 6-5: Western Embankment Dive Culvert Profile

Figure 6-6: Erie Canal Waste Weir (and Sluice Gates) at Albion, NY

Figure 6-7: Concrete Wall along Canal at Little Falls, NY

6.7 SUMMARY

Typical watered embankment dimensions, and the specific outboard and inboard features of canal watered embankments are illustrated and explained. Embankment zones, adopted from FEMA 534, are illustrated and explained. Structures that are integrated within watered embankments, the maintenance of which falls outside the scope of the *Guide Book*, are also explained and illustrated.

7 EMBANKMENT MAINTENANCE

Maintenance of embankments is necessary to protect against the embankment's deterioration, to prolong its service life and to reduce the risk of failure. A proper maintenance program is essential when considering the potential loss of life, property, economic and environmental damage, and major repairs required to mitigate the impacts that can occur from a failure.

Public safety shall be considered for all rehabilitation or water impounding structure construction projects in accordance with EMB-2021-011.

7.1 MAINTENANCE CATEGORIES

Table 7-1 below identifies common maintenance tasks associated with embankments as well as their general frequencies of occurrence, the risk priority as compared to other maintenance tasks in need of attending to, and the maintenance category. Many of these maintenance tasks are capable of being completed by NYSCC in-house staff as part of their normal workload. Other items that require special equipment, staff or larger work force or allocation of funds are recommended to be completed by either contractual agreement with an outside entity or through capital improvements. The table categorizes maintenance items; however, it should be noted that the scale and complexity of many of these items could alter their predicted funding source. All maintenance plans should be developed by the Regional Planners and Section Superintendents to ensure the most effective use of time and proper prioritization of work.

Table 7-1: Frequency, Risk Priority, and Category for Typical Maintenance Tasks

Common Problem, Maintenance Task or Embankment Feature	Frequency of Operation	Risk* (E, H, M, L)
Embankments		
Vegetation		
Establishing Turf Grass	As Needed	L
Maintenance of Vegetative Screening Plantings	As Needed	L
Pollinator Plantings	As Needed	L
Mowing	2X per year, minimum[13]	L
Control/Removal/Disposal of Japanese Knotweed	As Needed	L
Tree and Brush Removal	As Needed	M
Aquatic Vegetation	As Needed	L
Debris Collection & Removal	As Needed	H
Erosion, Settlement, & Effects of Animals		
Gullies / Rilling	As Needed	L
Sloughs/Sliding	As Needed	H
Settlement Voids/Sinkholes/Subsidence	As Needed	H
Embankment Cracks	As Needed	H
Rodent Burrows	As Needed	H
Beaver Dams	As Needed	H
Upstream Slope Protection (Inboard Side)	As Needed	M
Rutting Along Crest	As Needed	L
Isolated Settlement	As Needed	L
Paved Path / Roadway Along Crest	As Needed	L
Seepage		
Boils in the Foundation	As Needed	E
Seepage from Embankment Contacts	As Needed	M
Wet Bulging on Embankment	As Needed	H
Whirlpools	As Needed	E
Drainage Blanket/Filter	As Needed	M
Toe Drains	As Needed	M
Cut Off Walls	As Needed	M
Monitoring Devices		
Piezometers / Wells / Standpipes	As Needed	L
Flow Measurement	As Needed	L
Staff Gauges	As Needed	L
Concrete Repairs		
Concrete Spalling	As Needed	L
Concrete Joint Seepage	As Needed	M
Concrete Joint Vegetation	Annually	L
Concrete Cracking	As Needed	L
Masonry Repairs		
Joint Vegetation Removal and Repointing	As Needed	L
Parging	As Needed	L
Displaced Stones	As Needed	L

*Depending on the severity of the issue, the risk prioritization [Emergency, High, Medium, Low (E, H, M, L)] can vary. Serious issues may require more urgent response and an immediate supervisor should be contacted when encountered. **In the event of an emergency condition that appears to imminently jeopardize the integrity of an embankment, the observer should call the Canal Emergency Dispatch at 1-833-538-1042 immediately to begin the**

[13] Mowing twice per year is intended to prevent establishment of woody vegetation and provide minimum standard for visual inspection. In areas of high importance (e.g., high hazard embankment, poor condition, known seepage, etc.) mowing at a more frequent interval may be required to allow for periodic inspection.

duty notification process. Such issues include whirlpools; boils in the foundation; seepage from embankment contacts and others as noted in the embankment maintenance Best Management Practices (Attachment 1).

7.2 BEST MANAGEMENT PRACTICES

To help standardize certain maintenance activities, various embankment maintenance Best Management Practice (BMP) sheets have been developed. These BMPs are to act as the NYSCC standard for in-house or contract maintenance activities. Activities that cannot be conducted as directed in the BMP sheets should be put forth for special consideration as an item needed for contract or capital improvements.

Common maintenance activities have been categorized by the type of embankment feature (vegetation, erosion, etc.) and detrimental issue (trees and brush, cracks, etc.). Each BMP has been developed to cover generic repair needs that should accommodate most embankments. At any time, if the work cannot be done in accordance with the BMP sheets, consultation with the Section Superintendent and Regional Canal Engineer will be required.

Any maintenance activities conducted during each embankment visit should be recorded and reviewed by the appropriate reviewer (See Section 4 for a full list of reviewer responsibilities). The entire collection of BMP sheets is included in Attachment 1.

TABLE OF CONTENTS OF EMBANKMENT MAINTENANCE BEST MANAGEMENT PRACTICES (BMPs)

7.3 VEGETATIVE MAINTENANCE

Of particular importance for safety is the proper maintenance of vegetation on embankments. For embankment maintenance, vegetative cover is divided into two general categories:

- Compatible vegetation – this includes grasses and other similar plant cover. This vegetation is low growing, is easy to mow, and develops shallow root systems.
- Non-compatible vegetation – this category includes most brush, bushes and trees. This vegetation can develop deeper root systems and is typically prevented by regular mowing, after initial removal by clearing and grubbing.

While there are some positive benefits of woody vegetation and tree cover, these benefits do not outweigh the substantial risks associated with embankment failure that could be initiated by the presence of the vegetation such as flooding, property damage, environmental damage and loss of life. In contrast, grass or "soft" vegetation is beneficial to the embankment. The grass and its root system prevent erosion damage from rain events, foot traffic, and even from minor overtopping events that are small and of short duration.

7.3.1 WHY IT'S NECESSARY

Proper maintenance of embankments and their ancillary features is of utmost importance in protecting lives and reducing the flood risk of adjacent communities. This includes the proper maintenance of vegetation on embankments and ancillary structures. Non-compatible vegetation can harm the structural integrity of these impoundment structures, obscure visibility of the ground surface (necessary for inspections for other types of failures), impede access for maintenance and inspection, and encourage burrowing by rodents by providing habitat. Woody vegetation with robust root systems can disturb the soil structure in the embankment. Roots that penetrate the phreatic surface in the embankment increase the risk of internal erosion known as piping, the early stages of which can go undetected for decades resulting in a sudden failure of an earthen embankment. Animal burrows pose a similar piping potential – the animal burrow shortens the seepage path potentially leading to piping at the burrow location. Additionally, shade caused by woody vegetation can impede growth of more compatible grassy vegetation. Furthermore, large trees can be uprooted by winds/erosion and leave large holes in the embankment, root systems can decay and rot creating passageways for water through the embankment. Once a significant seepage pathway is initiated, catastrophic embankment failure could be expected to occur within one to two hours. The presence of brush and trees can also hinder critical emergency responses to flooding or repair operations.

The proper maintenance of vegetation for water impounding structures is well understood and accepted by the dam safety community and the various regulatory and advisory agencies tasked with dam safety including the USACE, FERC, USBR and FEMA. In addition, all federal flood protection projects including embankment dams and levees in New York State must maintain a woody vegetative free zone on the embankment.

The woody vegetative free zones for the Canal System embankments, are based on Figure 6-5, adopted from FEMA 534 *[FEMA, 2005]*. All woody, non-compatible vegetation should be removed in Zones 1, 2A, 4 and 5 of the embankment including to a distance of H/2 (where H is the height of the embankment from

its outboard toe to the crest) but not less than 15 feet from the toe of the embankment. In Zones 2B and 3, only turf grass, pollinators, and vegetative screening plantings meeting *Guide Book* BMPs may be planted. Existing non-compatible, woody vegetation > 3" DBH may only remain with approval by the NYPA Regional Manager – Canals or designee. New vegetative screening plantings approved by the NYPA Regional Manager – Canals or designee shall be allowed.

Refer to Section 8.8 for information regarding potential reasons to retain or install vegetation and types of compatible vegetation.

In many cases, the ownership rights of the NYSCC do not include the full area in Zone 5 described above, or do not include sufficient space for access to perform the required maintenance work described in this *Guide Book*. For this reason, **the limits of NYSCC property must be confirmed prior to performing any vegetation maintenance or other work on the embankments or beyond the toe of the embankments**. Access to adjacent lands to remove woody vegetation or to perform other maintenance activities, or to provide access, may be obtained through a Site Access/Vegetation Management Permit or permanent easement (refer to Section 8.13).

7.3.2 HOW IT'S DONE SAFELY

The NYSDEC Owners Guidance Manual for the Inspection and Maintenance of Dams in New York State *[NYSDEC, 1987]*, originally published in June 1987 is still referred to by dam safety experts and dam owners. It states that:

- The entire dam should be kept clear of unwanted vegetation such as brush or trees.
- When brush is cut down, it should be removed from a dam to permit a clear view of the embankment.
- Stumps from trees or woody brush with a breast height diameter (DBH) less than 3" may be left in place.
- Following removal of large brush or trees (with DBH equal to or greater than 4 3"), the left-over root systems should also be removed to a root diameter of 1" or less and the resulting holes filled.

The NYSDEC guidance is specific to dams. More recent guidance for vegetation maintenance that has been developed for longitudinal embankments such as levees, canals and feeders, is found in:

- FEMA 534, Technical Manual for Dam Owners Impacts of Plants on Earthen Dams *[FEMA, 2005]*; and
- USACE EP 1110-2-18, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures, *[USACE, 2019]*.

The FEMA document, in addition to espousing that woody growth should be prevented on dams and water retaining embankments in the first place, provides good information on the considerations and general processes to follow in order to remove woody vegetation once established.

The Association of State Dam Safety Officials (ASDSO) surveyed dam safety officials in all 50 states and determined that there was agreement on problems caused by tree and woody plant growth on embankment dams including:

- Interfering with dam safety monitoring for seepage, cracking, sinkholes, settlement and other signs of embankment distress
- Uprooted trees producing large voids in the embankment
- Tree root growth loosening previously compacted soil
- Decayed roots creating preferential seepage paths and internal erosion
- Clogging embankment underdrains
- Providing cover for burrowing animals

The USACE Engineer Research and Development Center (ERDC) prepared *Literature Review – Vegetation on Levees* (USACE, 2010), an extensive review of topics related to vegetation on levees with the objective to better assess if woody vegetation compromises levee integrity. In this document, woody vegetation (trees, bushes and shrubbery) was distinguished from non-woody vegetation (brush, shrubs, herbs and grasses). More than 200 documents were reviewed and 61 addressed some aspect of woody vegetation. The report defines levees as "an embankment whose primary purpose is to furnish flood protection from seasonal high water and, which is therefore subject to water loading for periods of only a few days or weeks in a year." Thus, woody vegetation on levees presents a significantly lower risk than woody vegetation on canal embankments that are subject to a water load for 6 months of the year. A few items from the Summary and Recommendations that highlight the most prevalent issues and data gaps found in the literature reviewed, and uncertainties involved included:

- The influence of woody vegetation on habitat (i.e., animal burrows), and the interaction of these specific habitats on levee integrity should be studied,
- The effect of woody vegetation on maintenance, inspection and flood-fighting access should also be considered.
- Research should include a system-wide approach to better understand the interaction of woody vegetation with different components of the levee system, environment and river community,
- Scientific and engineering principles should support guidance addressing woody vegetation on levees.
- Another topic that should be further investigated is the effect of tree root decay and tree throw-down on seepage and levee stability.

While some research involving tree roots in embankments indicates that tree roots stabilize the soil mass, research involving tree roots in water retaining embankments have consistently shown that tree roots destabilize water retaining earthen embankments. Canal and other water retaining embankments must be designed and constructed under engineering supervision using moisture-controlled inorganic, graded soil materials and be properly compacted to reduce soil voids to a minimum. Tree root development that is necessary to provide nutrients for tree growth and stabilize the tree actually loosens the dam soil mass reducing the stability of the compacted embankment dam.

The location of the woody vegetation on the embankment (see Figure 6-5) dictates different methods of removal. Due to the general characteristics of seepage through the embankment, each zone of the embankment has somewhat different characteristics. Therefore, the criticality of the removal procedures and the extent of removal required varies by zone (e.g. requiring removal of the entire root system or just the portion above ground). One of the major concerns with tree and brush cover is the potential for a piping failure. Those zones that intersect the phreatic surface of the water within the embankment are the most critical with respect to maintenance and removal techniques. It is recommended that any excavation work

on Canal embankments occur once the embankment segment is dewatered and no longer retaining water. Since the majority of the Canal embankments are (or can be) dewatered in the non-navigation season, it is possible in most cases to do earthwork (such as stump removal and regrading) when the embankment is not retaining water. **ANY EMBANKMENT EARTHWORK SHOULD BE PERFORMED ONLY UNDER THE GUIDANCE OF A LICENSED PROFESSIONAL ENGINEER AND WITH THE APPROVAL OF THE DIRECTOR OF WATERWAYS MAINTENANCE, REGIONAL CANAL ENGINEER, OR TRANSPORTATION MAINTENANCE ENGINEER.** Referring again to Figure 6-5 the following applies to all earthen embankment segments where **regulatory or community thresholds are not exceeded**. If regulatory or community thresholds are exceeded, the process in Section 8.15 applies.

Zone 1: Tree and woody vegetation growth in Zone 1 is more critical relative to embankment safety in the case of embankments having a narrow crest width than those with a wide crest width. Zone 1 also includes that area subject to damage resulting from wave erosion and frequently recurring rapid drawdown events. **NYSCC goal is to remove all woody vegetation growth located in Zone 1**.

Zone 2: Zone 2 is typically considered to be one of the least critical zones relative to embankment safety issues associated with tree and woody vegetation growth. However, careful inspection of Zone 2 often reveals evidence of serious safety issues such as tension cracks, slope failure, scarps, and erosion features that may or may not be related to tree and woody vegetation growth originating in other embankment safety inspection and evaluation zones. Maintaining vegetation such that inspection is not hindered is critical. Ideally this is low grass or other similar materials. Isolated plantings with shallow root systems may be permissible on a case-by-case basis. On the Canal System, Zone 2 contains access roads and recreational trails, both of which must be considered when managing existing vegetation and providing replacement vegetation. Zone 2 extends across the entire top of embankment from shoulder break to shoulder break and is further subdivided into equal length zones - Zones 2A and 2B by the centerline of embankment. **NYSCC goal ~~policy~~ is to remove all woody vegetation growth located in Zones 2A and 2B. In areas where there is a very wide Zone 2B relative to embankment height, vegetation should be preserved to the greatest extent possible.**

Zone 3: Zone 3 is typically considered the least critical zone relative to embankment safety issues associated with tree and woody vegetation growth. The seepage line and zone of saturation in this portion of an earthen embankment are typically far enough below the surface to allow excavation of tree root balls on the downstream (outboard) slope of the embankment without installation of a drain or filter system. Maintaining vegetation such that inspection is not hindered is critical. Ideally this is low grass or other similar materials. Isolated plantings of compatible vegetation with shallow root systems may be

permissible on a case-by-case basis. **Due to the relatively small dimensions of the canal embankments in relationship to the size and influence of root penetration,[14] NYSCC goal ~~policy~~ is that all woody vegetation in Zone 3 shall be removed.**

Zone 4: Zone 4 is one of the two most critical zones relative to embankment safety issues associated with tree and woody vegetation growth as well as other potential embankment safety issues. This zone typically contains the interceptions of both the zone of saturation and the seepage line with the downstream slope. The close proximity of the zone of saturation and seepage line to the surface of the downstream (outboard) slope in this zone causes there to be a heightened risk of piping in this area. This increased risk is a critical factor to relative embankment safety issues associated with tree and woody vegetation growth. ***Tree and woody vegetation growth in Zone 4 creates a major concern regarding the safety of an earthen embankment and must be evaluated carefully.*** **NYSCC goal is to remove all woody vegetation growth located in Zone 4.**

Zone 5: This zone typically contains the interception of the seepage line with the downstream (outboard) slope and there is potential for boiling (soil piping) action beyond the toe of the downstream embankment slope. As such, this zone is critical relative to long-term, steady-state seepage and stability considerations. Tree and woody vegetation growth in this zone rapidly develops into serious conditions that directly affect the safety of an earthen embankment. Zone 5 is one of the two most critical zones relative to embankment safety issues associated with tree and woody vegetation growth. ***Tree and woody vegetation growth in Zone 5 creates a significant concern regarding the safety of an earthen embankment. Maintenance must be undertaken if tree and woody vegetation growth is significant within Zone 5.*** **NYSCC goal is to remove all woody vegetation growth located in Zone 5.** For the proper control of vegetation growth, the landward extent of Zone 5 should extend a distance of half the embankment height (H/2) or 15 feet minimum whichever is greater, but not beyond the NYSCC property limit without easement or access agreement (refer to Section 8.13). Control of tree and woody vegetation growth well beyond the toe of the downstream embankment slope cannot be over-emphasized. This area of an earthen embankment is critical to overall stability and potential embankment safety issues associated with embankment and foundation seepage. ***Because the Canal property line is often located in this***

[14] Based on an embankment height of 15 feet (which is common for the 60-mile pool between Rochester and Lockport) leads to a 5-foot depth for the Zone 3 area. The zone of influence from trees and other mature woody vegetation far exceeds this 5-foot area of lower risk.

zone, it is essential to verify property limits prior to performing maintenance in this zone.

Detailed vegetation maintenance measures are outlined in the BMP Sheets (Attachment 1). The general procedure for tree and brush removal is outlined below:

Problem Identification and Preparation of Removal Plan – where a segment has been identified containing trees with a size equal to or greater than 3″ DBH, a removal plan is developed and prioritized with other canal embankment work. The plans must be reviewed and approved by the Dam Safety Engineer. Plans must include a sketch identifying tree(s) to be removed. In areas with high seepage rates and where filter blankets are to be constructed, tree removal will ~~may~~ be necessary to avoid interference with placing the filter blankets.

Prior to starting work, conduct community notification/outreach (Section 9 of the *Guide Book*) and coordinate with Environmental Health and Safety (EH&S) on environmental review as outlined in Section 8 including work within Emerald Ash Borer Restricted Zone.

Tree Removal Work – Schedule the work for non-navigation season when the canal section is drained. To avoid problems with proper soil compaction in the winter, schedule the work to be done soon after the canal water level is lowered in the late fall or spring when the weather warms up just before re-watering the canal.

Excavate to allow removal of all roots greater than 1″ in diameter and backfill the hole with suitable approved embankment material to 95% compaction per ASTM D-698 (Standard Proctor).

Where the stumps and rootballs are to be removed, a Professional Engineer (P.E.) must be present during removal. Remove the stump and root ball by pulling the stumps or extracting with a track-mounted backhoe. Remove the remaining root system down to 1/2″ diameter roots (Zone 1) and 1″ diameter roots (Zone 2-5). Remove loose soil from root ball cavity by excavating the sides no steeper than 1H:1V and the bottom of cavity approximately horizontal. Backfill the excavation with compacted soil in maximum loose lifts of 8″. Sand and stone filter material design for seepage areas should be performed by a P. E.

Post – Construction Monitoring – an Informal Inspection (Sec. 4.1.2 of the *Guide Book*) should be conducted at the repaired area at the start of re-watering and again within one week after completion of Canal re-watering at the site. The inspector should evaluate the condition of the repaired area and compare the repair sketches and construction details to conditions noted at the site. Seepage at the repaired area, changes in seepage quantity or seepage that appears to be transporting sediment should be reported to the **Regional Canal Engineer** and **Dam Safety Engineer** immediately for further evaluation.

7.3.3 SCHEDULING CONSIDERATIONS

The NYSCC will endeavor to plan and schedule individual EEIP projects so that they would be constructed within as short a duration as reasonably possible. In general, a one-year project duration is the goal to minimize temporary impacts and so that the work of stabilizing the embankment (tree, stump and root

removal, backfilling, and construction of seepage and stability controls) would be completed prior to the start of watering up the canal for the navigation season. The NYSCC will make particular efforts towards this end for individual EEIP projects where community thresholds (Table 8-7) are exceeded so that the duration of any potential temporary impacts on the community thresholds are minimized. However, the NYSCC will work within the constraints imposed by bat habitat tree cutting, turf establishment, shrub planting and other construction quality, community engagement and permitting requirements. These factors could result in project timelines beyond one year. Depending on the three alternative ways an embankment maintenance project could be progressed (Figure 8-1), the following schedules would be followed as practicable:

When Community Thresholds Are Not Exceeded

- Late October - Temporary erosion and sediment control measures in place. Wetlands marked/protected in field.
- Early November - Brush removal, tree cutting, and removal starts, while still watered up.
- 3rd week of December - Stump removal and embankment excavation begins immediately following emptying of the canal.
- January thru April - Stump removal, embankment excavation, embankment grading, drainage systems/filter blanket installation, etc. continued through the winter months (as weather allows).
- May 6 - All excavation and backfill operations would need to be complete, just prior to "watering up" for the next navigation season.
- May 6 thru June - Topsoil and grass seeding completed while watered up, with full lawn establishment by end of June.

Projects would have to be "sized" (based on acreage) appropriately, making sure the work could be completed within the timeframe provided. Early closure and/or late opening of canal sections would need to be discussed.

When Community Thresholds Are Exceeded and Embankment Restoration Alternative Is Selected

- Early March - Temporary erosion and sediment control measures in place. Wetlands marked/protected in field.
- Late March thru April - Brush removal, trees (< 3" DBH), and dead, diseased, imminently dangerous trees >3" DBH completed.
- Late April/early June - Tree inventory and identification of Zone 2B and 3 limits completed.
- Mid-June - Public relations and community outreach begins (site visits while seeps/leaks are happening for community awareness), assume 2-3 months duration.
- Mid-September - Final design agreed upon.
- Early October – submit environmental permit applications for actual work to be completed. (time for agency review and approval assumed to be 2-3 months).
- January - Construction begins, tree cutting, stump pulling and removal, slope flattening, drainage systems/filter blanket installation continues through the winter months (as weather allows).
- May 6 - All excavation and backfill operations would need to be complete, just prior to "watering up" for the next navigation season.
- May 6 thru June - Topsoil and grass seeding completed while watered up, with full lawn establishment by end of June.

Projects would have to be "sized" appropriately making sure the work could be completed within the timeframe provided. Early closure and/or late opening of canal sections would need to be discussed if needed.

When Community Thresholds Are Exceeded and Embankment Restoration Alternative Is Not Selected

- Early March – Temporary erosion and sediment control measures in place. Wetlands marked/protected in field.
- Late March thru April - Brush removal, trees < 3" DBH, and dead, diseased, and imminently dangerous trees >3" DBH completed.
- Late April/early June - Tree inventory and identification of Zones 2B and 3 limits completed.
- Mid-June - Public relations and community outreach begins (site visits while seeps/leaks are happening for community awareness), assume 2-3 months duration.
- Mid-September - Final design not agreed upon/No resolution obtained.
- Late September thru December - Brush removed again, installation of permanent erosion and sediment control measures. 5-year brush removal/grass cutting maintenance plan initiated in Spring of following year.

7.4 SUMMARY

Embankment maintenance activities are outlined, and the detailed Best Maintenance Practices are provided in Attachment 1. Definitions for compatible and non-compatible vegetation and a description of goals for vegetation management in each of the five embankment zones are provided. The necessity of embankment maintenance, the scheduling of embankment maintenance, and how non-compatible vegetation is to be safely removed are explained.

8 ENVIRONMENTAL CONSIDERATIONS

Potential environmental effects of the routine maintenance activities covered in this *Guide Book* are usually negligible or minor in scale and are temporary in nature. Environmental regulations may apply to some or all maintenance activities in a specific location. Please refer to the most current version of **"Environmental Permits & Compliance Procedure Number: ENV-PRO-002"** for guidance as to when permits may be required. Obtaining permits must be coordinated through the Director of Environmental, Health & Safety. The following describes typical types of best management practices that should be used when performing maintenance activities on embankments.

8.1 EROSION AND SEDIMENT CONTROL

All work that involves earth disturbance should provide best management practices to minimize the potential for erosion and sediment-laden runoff into adjacent waterbodies or onto neighboring properties. Two types of projects are to be considered:

Disturbances < 1.0 acre:

- Project does not require formal permit notice or Stormwater Pollution Prevention Plan (SWPPP) development.
- Workers must provide best management practices (see commonly used practices below) to minimize erosion and potential for sediment laden runoff.
- Workers should minimize excessive compaction of soils and removal of grasses & vegetation outside the necessary work area.

Disturbances ≥ 1.0 acre:

- The maintenance activity requires a formal Notice of Intent for coverage under the NYSDEC State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity, GP—0-20-01 (or current permit number). To obtain coverage under the General Permit, a Notice of Intent (NOI) must be filed with NYSDEC prior to ground disturbance. The NOI preparer must be able to certify that the project is in compliance with all aspects of the General Permit. Preparation of the NOI must be coordinated with the Director of Environmental, Health & Safety.
- The maintenance activity requires the development of a SWPPP prepared by a licensed Professional Engineer, Registered Landscape Architect or other NYSDEC endorsed individual.
- Should the maintenance activity also involve the development of new or redevelopment of existing impervious surfaces, Post-Construction Stormwater Management (PCSM) facilities may be required.

The NYSCC may elect to reduce this threshold to 0.75 acres for the planning and design of projects where the limits of disturbance cannot be precisely defined, due to project constraints.

Best Management Practices for Erosion Control Measures

The following is a list of commonly used best management practices for erosion and sediment control. These practices, or any other used during the course of a maintenance activity, should follow the requirements of the *New York State Standards and Specifications for Erosion and Sediment Control [NYSDEC, 2016]* and any subsequent revisions.

- Silt Fence
- Dust Control
- Rolled Erosion Control Product
- Seeding and Mulching
- Construction Access Entrance / Roads
- Turbidity Curtain
- Cofferdam Structure
- Fiber Rolls
- Compost Filter Sock
- Dewatering Device
- Geotextile Filter Bag

8.2 RARE, THREATENED AND ENDANGERED SPECIES

Some areas of the Canal System are located in areas where State or Federally listed rare, threatened or endangered (RTE) species are known to exist or have potential for sufficient habitat. Prior to the commencement of any maintenance activity, qualified personnel must evaluate the project area for the potential for RTE species and consult with US Fish and Wildlife Service (USFWS) and/or the appropriate NYSDEC Region(s).

A review of the USFWS website, Information for Planning and Conservation (IPaC)[15] may be used to determine if there is a potential to encounter Federally listed species, which may require further consultation with USFWS to be coordinated by the Director of Environmental, Health & Safety.

A review of the NYSDEC's website, The Environmental Resource Mapper (ERM)[16] may be used to determine if there is a potential to encounter State listed species. If a screening for a specific area is more than 12 months old, a new screening review must be conducted to ensure updated information is used. If the ERM indicates that there are no species listed, no further review for State listed species is needed. If the ERM indicates that there are species, contact the Director of Environmental, Health & Safety.

The NYSDEC works with the New York Natural Heritage Program to map verified reports and provide screening tools for both the public and NYSDEC staff to identify areas where listed species are known to

[15] http://ecos.fws.gov/ipac/
[16] http://www.dec.ny.gov/gis/erm/

occur. NYSCC has direct access to this database and trained staff use it in the process of determining if any listed species may be present within the proposed project area.

If the screening indicates the potential for RTE species to be present in the activity area, then the Director of Environmental, Health & Safety will contact the applicable NYSDEC Regional Division Environmental Permits for consultation. The consultation may include the appropriate habitat survey(s) that may be conducted including the appropriate protocols. The NYSDEC may also advise as to any licenses required to do the survey(s).

Table 8-1 and 8-2 summarize the types of federally and state listed species that may be encountered.

Table 8-1: Federally Listed Species Potentially Present in EEIP Project Area (as of December 2020)

Common Name	Scientific Name
Indiana Bat	*Myotis sodalis*
Northern Long-eared Bat	*Myotis septentrionalis*
Eastern Massasauga Rattlesnake	*Sistrurus catenatus*
Chittenango Ovate Amber Snail	*Succinea chittenangoensis*
Karner Blue Butterfly	*Lycaeides melissa samuelis*
American Hart's-tongue Fern	*Asplenium scolopendrium var. americanum*

Table 8-2: State Listed Species Potentially Present in EEIP Project Area (as of February 2021)

Common Name	Scientific Name
Birds	
Short-eared Owl	*Asio flammeus*
Black Tern	*Chlidonias niger*
Northern Harrier	*Circus hudsonius*
Sedge Wren	*Cistothorus platensis*
Peregrine Falcon	*Falco peregrinus*
Trumpeter Swan	*Cygnus buccinator*
Bald Eagle	*Haliaeetus leucocephalus*
Least Bittern	*Lxobrychus exilis*
Pied-billed Grebe	*Pied-billed Grebe*
Dragonflies and Damselflies	
Midland Clubtail	*Gomphurus fraternus*
Cobra Clubtail	*Gomphurus vastus*
Umber Shadowdragon	*Neurocordulia obsoleta*
Russet-tipped Clubtail	*Stylurus plagiatus*
Fish	
Lake Sturgeon	*Acipenser fulvescens*
Eastern Sand Darter	*Ammocrypta pellucida*

Common Name	Scientific Name
Northern Sunfish	*Lepomis peltastes*
Black Redhorse	*Moxostoma duquesnei*
Freshwater Mussels	
Threeridge	*Amblema plicata*
Wabash Pigtoe	*Fusconaia flava*
Fragile Papershell	*Leptodea fragilis*
Eastern Pondmussel	*Ligumia nasuta*
Pink Heelsplitter	*Potamilus alatus*
Lilliput	*Toxolasma parvum*
Deertoe	*Truncilla truncata*
Paper Pondshell	*Utterbackia imbecillis*
Rainbow	*Villosa iris*
Mammals	
Northern Long-eared Bat	*Myotis septentrionali*
Indiana Bat	*Myotis sodalis*
Mosses	
Rolled-leaf wet ground moss	*Hyophila involuta*
Reptiles	
Spiny Softshell	*Apalone spinifera*
Timber Rattlesnake	*Crotalus horridus*
Vascular Plants	
Side Oats Grama	*Bouteloua curtipendula var. curtipendula*
Davis' Sedge	*Carex davisii*
False Hop Sedge	*Carex lupuliformis*
Schweinitz's Sedge	*Carex schweinitzii*
Big Shellbark Hickory	*Carya laciniosa*
Salt-meadow Grass	*Diplachne fusca ssp. fascicularis*
Wright's Spike Rush	*Eleocharis diandra*
Rough Pennyroyal	*Hedeoma hispida*
Olive Green Water Nymph	*Najas olivacea*
Straight-leaved Pondweed	*Potamogeton strictifolius*
Culver's Root	*Veronicastrum virginicum*
Northern Bog Violet	*Viola nephrophylla*

Best Management Practices for Threatened and Endangered Species

Management practices vary depending on the species in question. Through the consultation process, specific protection measures may be requested by USFWS or NYSDEC depending on the maintenance location, habitat conditions, proximity of the maintenance activities to the potential habitat, and time of year. Table 8-3 provides some generic types of management actions required by USFWS and/or NYSDEC to avoid and minimize impacts to frequently encountered species. Where such conditions cannot be adhered to, Federal and/or State permits may be required and should be coordinated through the Director of Environmental, Health & Safety.

Table 8-3: Avoidance and Minimization Measures

Species	Avoidance and Minimization Measures
Indiana Bat (*Myotis sodalis*)	• Restrict tree removal (≥ 4" diameter at breast height (dbh)) to between October 31 and March 31 • Use bright flagging/marking to identify trees for removal
Northern Long-eared Bat (*Myotis septentrionalis*)	• Restrict tree removal (≥3" dbh) to between November 1 and March 31 • Use bright flagging/marking to identify trees for removal
Bald Eagle (*Haliaeetus leucocephalus*)	Restrict activities within 660 feet of a Bald Eagle nest during nesting season (January 15 to August 15).
RTE Plant Species considered as compatible vegetation	• Avoid and mark (if in Zones 2B or 3 and not a tree) or relocate. • Restrict use of pesticides. Consult with other agencies.
Timber Rattlesnake (*Crotalus horridus*)	Provide exclusion fencing to minimize possible construction interactions with snakes

Direct impacts on plants and animals have the potential to occur as a result of vegetation altering activities contemplated under the EEIP. Direct impacts to RTE species are organized into two distinct classes: those that require an incidental take permit and those that do not.

When a specific project cannot fully avoid adverse impacts to listed animal species, the regulations regarding issuing a permit under 6 NYCRR Part 182 come into play. The NYSDEC refers to "listed species" as threatened or endangered animal species.[17] The regulations require an incidental take permit for any "taking" of threatened or endangered animal species. "*Take* or *taking* means the pursuing, shooting, hunting, killing, capturing, trapping, snaring and netting of any species listed as endangered or threatened in this Part, and all lesser acts such as disturbing, harrying or worrying."[18] It should be noted that listed plants are not subject to these regulations.

The NYSDEC's authority to regulate activities involving the taking of threatened or endangered animal species is based upon appellate court decisions that have ruled that the term "take," as used in the State's Endangered Species Act, includes adverse modification of the occupied habitat of protected species. The term "occupied habitat" is defined as "a geographic area in New York within which a species listed as endangered or threatened is in this Part has been determined by the department to exhibit one or more essential behaviors."[19]

[17] All federally listed species are also state listed species.
[18] 6 NYCRR 182.2(x)
[19] 6 NYCRR 182.2(o)

Examples of essential behaviors include:

- breeding
- hibernation
- reproduction
- feeding
- sheltering
- migration
- movement
- overwintering

Once habitat is verified to be occupied by a protected species, the location will be assumed to remain occupied unless the habitat is no longer suitable and there have been recent surveys confirming that the species is no longer present. No incidental take permit would be required if appropriate surveys confirm that the species is no longer present in the habitat.

- The criteria applied by NYSDEC in determining whether or not to issue an incidental take permit are set forth in NYCRR Part 182.12. Generally, in order to obtain an incidental take permit, an applicant must provide the NYSDEC with a mitigation plan that commits the applicant to perform measures that will result in a *net conservation benefit* to the protected species impacted by the proposed activity. Examples of mitigation plans approved by the NYSDEC include: purchase and protection by conservation easement of existing occupied habitat;
- permanent protection of migration corridors;
- creation of new suitable breeding habitat; and
- other land management activities designed to enhance survival and recovery of the protected species.

State and Federally listed plants are not afforded the same level of protection as listed animals. In accordance with ECL Article 9 Title 15 and 6 NYCRR Part 193, protected plants may be destroyed with permission of the landowner, thus agency coordination is not necessary. Regardless, when protected plants are identified during screening, a concerted effort should be made to avoid and minimize impacts to them to the maximum extent practicable.

8.3 SURFACE WATERS AND WETLANDS

8.3.1 SURFACE WATERS

Article 15 of the Environmental Conservation Law regulate the protection of waterbodies. The NYSCC is not required to obtain permits from NYSDEC but it must comply with the substantive requirements in Article 15 and regulation 6 NYCRR Part 608. As such, all work within waterbodies of the Canal System itself (e.g., canal, or feeder) or work within the NYSCC owned lands or where the NYSCC has easements that abut other waterbodies, has the potential to require a permit. Any maintenance activities that require work within a waterbody, or on the banks of a waterbody, should be referred to the Director of Environmental, Health & Safety who will see that the proposed work is reviewed by qualified environmental personnel, and, in

conjunction with the appropriate NYSDEC region(s), determine the need for a permit, and any additional protection measures, work conditions, appropriate safety measures and best management practices (e.g., closure periods, maintenance of flow). Waterbodies in New York State are classified by NYSDEC according to their best usage. Their classification aids in identifying the level of protection NYSDEC will require when working in the vicinity of these waterbodies. The NYSDEC ERM can be used to determine the classification of any State waterbody. Table 8-4 Freshwater Classifications below summarizes the classifications applied to freshwaters.

Table 8-4 Freshwater Classifications

Freshwater Classification	Usage
N	Enjoyment of water in its natural condition and where compatible, as a source of water for drinking or culinary purposes, bathing, fishing, fish propagation, and recreation. Waters suitable for fish, shellfish and wildlife propagation and survival.
AA-Special (AA-S)	Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. Waters suitable for fish, shellfish and wildlife propagation and survival.
A-Special (A-S)	Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. Waters suitable for fish, shellfish and wildlife propagation and survival.
AA	Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish, shellfish and wildlife propagation and survival.
A	Source of water supply for drinking, culinary or food processing purposes; primary and secondary contact recreation; and fishing. The waters shall be suitable for fish, shellfish and wildlife propagation and survival.
B	Primary and secondary contact recreation and fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival.
C	Fishing. These waters shall be suitable for fish, shellfish and wildlife propagation and survival. The water quality shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes.
D	Fishing.
Symbols may also be applied to a classification, elevating the protection to that classification.	
Symbol (T)	Trout waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout or trout waters applies.
Symbol (TS)	Trout spawning waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout, trout spawning, trout waters, or trout spawning waters applies.

Ref: https://www.dec.ny.gov/chemical/23853.html

Best Management Practices for Surface Waters

All work in, or adjacent to perennial, intermittent or ephemeral streams may require Federal and/or State permits. The process of investigating avoidance, minimization and mitigation of impacts to surface waters will be completed as a part of the design process for each individual embankment project. All work near or

adjacent to a waterbody must provide protection from pollutants entering the waterbody. Pollutants can include, but are not limited to, sediment laden runoff, concrete mix or leachate, oils or gasoline, pesticides and chemicals, trash, weeds and debris, or other materials that may impact the water quality or cause potential problems downstream. Care shall be taken when working in the proximity of a waterbody. Protection measures, such as those described in Section 8.1 should be used to avoid and minimize any impacts to the adjacent waterbody. In addition, where permits are required to perform the maintenance activities, the conditions of the permit must be followed in the performance of the work.

8.3.2 WETLANDS

Wetland features are commonly found adjacent to the embankment sections of the Canal. All disturbance or work within, or sometimes near, a federal or state jurisdictional wetland requires one or more permits. All project areas should be reviewed, and wetlands should be delineated by qualified personnel to determine the need for a permit, any additional protection measures, any mitigation requirements, or restoration activities.

Certain wetlands may fall under federal jurisdiction. To aid in the study of wetlands, the USFWS developed an inventory of potential wetland locations across the country. This National Wetland Inventory (NWI) can be viewed at https://fwsprimary.wim.usgs.gov/wetlands/apps/wetlands-mapper/. For jurisdictional purposes, the NWI mapping is for reference only and can only provide an indication of the wetlands at any particular location. It cannot be used to determine the presence or absence of jurisdictional wetlands within an area. The determination of wetland areas may only be made by qualified wetlands specialists. All work within a federal wetland will require a permit from the US Army Corps of Engineers (USACE). Coordinate with the Director of Environmental, Health & Safety to obtain any permits that may be required.

Some wetlands may also be under the jurisdiction of New York State. The NYSDEC has jurisdiction over wetlands that are generally greater than 12.4 acres in size, as well as a 100-ft adjacent area (buffer zone) surrounding these wetlands. Most activities within these areas or within 100 feet of these areas requires an Article 24 Freshwater Wetlands permit from NYSDEC.[20] The approximate location of the State Wetlands can be found on NSYDEC's ERM website (http://www.dec.ny.gov/gis/erm/). Unlike the NWI maps, the NYSDEC Freshwater Wetlands mapping has regulatory authority; however, the precise extents of the wetlands shown on the mapping are subject to change and must be verified by the NYSDEC and/or by qualified personnel. Furthermore, unlike federally regulated wetlands, the NYSDEC has jurisdiction of a 100-foot adjacent area to the NYSDEC Freshwater Wetland. The NYSDEC suggests consultation with that agency prior to any activity within a 500-foot buffer zone of a mapped NYSDEC freshwater wetland. Any such consultation with the NYSDEC should be done in coordination with the Director of Environmental, Health & Safety.

Best Management Practices for Surface Waters and Wetlands

All work in, or adjacent to Federal or State wetlands will require Federal and/or State permits. The process of investigating avoidance, minimization and mitigation of impacts to wetlands will be completed as a part of the design process for each individual embankment project. All work near or adjacent to a Federal or

[20] This includes the application of pesticides.

State wetland must provide protection from pollutants entering the wetland. Pollutants can include, but are not limited to, sediment laden runoff, concrete mix or leachate, oils or gasoline, pesticides and chemicals, trash, weeds and debris, or other materials that may impact the water quality or cause potential problems downstream. Care shall be taken when working in the proximity of a wetland. Protection measures, such as those described in Section 8.1 should be used to avoid and minimize any impacts to the adjacent wetland.

Additional protection / protection measures include:

- Prior to commencing any physical work on the site, adjacent wetlands must be fenced off to prevent accidental access over wetland areas by construction equipment.
- Investigate the use of timber matting or some other protection from construction vehicular access over wetland areas.
- Temporary impacts to wetlands should be restored with vegetation / seed mixes similar to the existing vegetation.
- All measures should be in conformance with the permit requirements.

8.4 CULTURAL RESOURCES

Federal permits require that the permitted activities do not have the potential to cause effects to properties listed, or eligible for listing, in the National Registers of Historic Places. State permits have similar requirements. Section 106 of the National Historic Preservation Act requires consultation with the State Historic Preservation Office (SHPO), which is part of the NYS Office of Parks, Recreation and Historic Preservation. The "New York State Barge Canal" was recently listed as a National Historic Landmark (NHL). The listed New York State Barge Canal is a twentieth-century network of canals, canalized rivers, and lakes that allows commercial and pleasure vessels to pass from the Atlantic Ocean to the Great Lakes. It is composed of four branches: the **Erie Canal**, 340 miles from the tidal Hudson River near Waterford to the Niagara River at Tonawanda; the **Champlain Canal**, 60 miles from the Hudson River at Waterford to Whitehall on Lake Champlain; the **Oswego Canal**, 24 miles connecting the Erie Canal to Lake Ontario at Oswego; and the **Cayuga & Seneca Canal,** 17 miles connecting the Erie Canal to Cayuga and Seneca Lakes. Constructed between 1905 and 1918, these waterways are direct successors to the canals that New York State first built during the 1820s. The 543-page nomination form notes earlier structures that may be listed separately on the National Register or have been determined to be eligible but are not included in this historic district. The nomination states that "19th century water supply features that continue to feed the Barge Canal include Feeder Dam, Glens Falls Feeder Canal, and a portion of the old Champlain Canal that supplies the summit level of the Champlain Canal above Fort Edward; Erie Canal feeders include Lake Moraine, Eaton Brook Reservoir, and Lebanon Reservoir, and portions of the disused Chenango Canal; Jamesville Reservoir, DeRuyter Reservoir, Reservoir, Cazenovia Lake, Tuscarora Reservoir, portions of the old Erie Canal in Madison and Oneida counties and Forestport Reservoir, Forestport Feeder, and portions of the former Black River Canal in Herkimer and Oneida Counties."

Besides the canal, there are other historic properties located adjacent to some of the areas where embankment maintenance is to be done. The Cultural Resource Inventory System (CRIS) may be checked to get an indication of such resources (See https://cris.parks.ny.gov).

The NYSCC plans to enter into a Programmatic Agreement (PA) with the Advisory Council on Historic Preservation and the New York State SHPO to implement a Historic Properties Management Plan (HPMP) for managing historic resources in the New York State Barge Canal NHL. The HPMP has been designed to address both the federal and state laws and regulations applicable to the NHL as well as ensure the involvement of both federal and state agencies in the implementation of the HPMP. NYSCC will designate an Agency Preservation Officer (APO) who is responsible for overseeing, to professional standards, the implementation of the HPMP. Among their responsibilities, the APO will coordinate the review of potential effects of project operation, maintenance, and construction activities on historic properties and maintenance of records that document review and decision-making. For most maintenance activities, it is anticipated that review by the APO will be sufficient and the proposed work would not need to be reviewed by the SHPO.

Permits that may be needed from the USACE and NYSDEC for a maintenance activity may also require consultation/coordination with the SHPO as one of the conditions of the permit. Should permits issued by the USACE or NYSDEC be required for a maintenance activity, as described in other parts of this section, coordinate with the Director of Environmental, Health & Safety to request a review of the maintenance activity area from the SHPO. In some cases, surveys by a professional archaeologist may be required as well.

Best Management Practices for Cultural Resources

Best management practices will be dictated by the type of work and the requirements of SHPO. The following are some commonly used practices that may be investigated in potentially impacted areas.

- Use timber mats or gravel for access paths and staging areas to minimize the amount of ground disturbance
- Minimize earth disturbance
- Keep all work within the NYSCC right-of-way or within the limits of the Site Access / Vegetative Management Permit.

8.5 CONTROL OF INVASIVE SPECIES

The control of invasive species is regulated by Presidential Executive Order 13112[21] and NYS Environmental Conservation Law Article 9, Title 17. Agencies are required to prevent the introduction and spread of invasive species, as well as provide for their control, where practicable. Management activities should be context appropriate and consistent with landscape-scale and long-term strategic planning efforts. Management activities should follow NYS Invasive Species Council recommendations and include priorities established by approved Partnerships for Regional Invasive Species Management (PRISMs). Table 8-5 is a list of commonly encountered invasive species in New York State. Factors to consider in determining context appropriate management include:

- Whether the species in question is a national, statewide, PRISM priority;
- The character of the infestation:
    - Does the NYSCC control the entire infestation?

[21] Any Federal agency that may issue a permit is subject to a Presidential Executive Order.

- Is the infestation isolated?
- Is this the leading edge of the invasion?
- Is the species located at a critical environmental nexus, e.g. stream crossing, critical habitat, etc.?

NYSCC will train personnel to identify common invasive species to assist in characterizing the invasive species that are present in a particular area.

NYSCC should not attempt to control small portions of larger contiguous infestations. Qualified personnel should be consulted to determine the extent of an infestation and recommend best management practices, if necessary.

Best Management Practices for Invasive Species

Best management practices can be utilized to minimize the spread of invasive species. These practices should be made part of the contract documents where an embankment project is to be bid for construction. The following specifies protocols for the disposal of contaminated material and the cleaning of contaminated equipment; both tasks which are critical to minimizing the spread of invasive species from a project site.

Disposal of Material:

Specifications for typical invasive species removal include the following: Cut plant material shall be placed in (0.1mm minimum thickness) black plastic bags for transportation out of the area. Bags shall be securely tied or sealed. Soil containing seeds, roots and/or rhizomes shall be wrapped in black plastic sheeting (0.1 mm minimum thickness) and transported in a manner which prevents the spread of the contaminated material during transport. Acceptable disposal methods can be one of the following or approved equivalent:

- Bury – Soil containing invasive plant material shall be buried either in an excavated pit or fill section and covered with at least 6 feet of uncontaminated fill material (e.g., embankment material, topsoil, etc.). Soil containing invasive plant material shall not be buried within 100 feet of a water body (including wetlands).
- Approved NYSCC Disposal Facilities – Where available, plant material or spoil containing invasive plant material may be disposed in a pre-approved NYSCC disposal facility.

Invasive species spoil stockpiled on site shall be identified as such so that it will not be inadvertently used in a manner that is not appropriate. Stockpiles shall be stabilized to prevent erosion and transport of invasive material.

Where invasive species need to be removed as part of the work, the Director of Environmental, Health & Safety should be contacted to determine the current specifications for removal and disposal of the involved species.

Equipment Cleaning

Equipment used in areas containing invasive plant species shall be pressure washed (1000 psi minimum) and cleaned with clean water (without using cleaning soaps or chemicals) before leaving the invasive control/removal area to prevent the spread of seeds, roots, or other viable plant parts. Water may be supplied by a municipal water source or may be pumped from an on-site or local surface water source under certain conditions. If water is drawn from a local water source, to protect aquatic life, there shall not be any loss of water elevation at the site of withdrawal or immediately downstream of the site. Withdrawal from surface waters may be subject to USACE, NYSDEC and other regulations.

Loose plant and soil material that has been removed from clothing, boots and equipment, or generated from cleaning operations, shall be disposed of as described above.

A full list of Prohibited and Regulated Invasive Species can be found in NYCRR Part 575 or on NYSDEC's website https://www.dec.ny.gov/animals/99141.html. Table 8-5 lists some of the more commonly encountered species:

Table 8-5: Commonly Encountered Invasive Species in New York State

Plants	
Garlic Mustard (*Alliaria petiolata*)	Mile-a-minute Weed (*Persicaria perfoliate, Polygonum perfoliatum*)
Porcelain Berry (*Ampelopsis brevipedunculata*)	Common Reed Grass (*Phragmites australis*)
Giant Hogweed (*Heracleum mantegazzianum*)	Golden Bamboo (*Phyllostachys aurea)*
Japanese Hops (*Humulus japonicus*)	Japanese Knotweed (*Reynoutria japonica, Fallopia sachalinensis, Polygonum sachalinensis*)
Hydrilla (*Hydrilla verticillata*)	Common Buckthorn (*Rhamnus cathartica*)
Japanese Honeysuckle (*Lonicera japonica*)	Mulitflora Rose (*Rosa multiflora*)
Tartarian Honeysuckle (*Lonicera tatarica*)	Water Chestnut (*Trapa natans*)
Purple Loosestrife (*Lythrum salicaria*)	Norway Maple (*Acer platanoides*)
Broadleaf Water-milfoil (*Myriophyllum heterophyllum*)	Burning Bush (*Euonymus alatus*)
Broadleaf Water-milfoil Hybrid (*Myriophyllum heterophyllum x M. laxum*)	Black Locust (*Robinia pseudoacacia*)
Eurasian Water-milfoil (*Myriophyllum spicatum*)	Tree of Heaven (*Ailanthus altissima*)
Aquatic Invertebrates	
Zebra Mussel (*Dreissena polymorpha*)	
Terrestrial Invertebrates	
Hemlock Wooly Adelgid (*Adelges tsugae*)	Asian Longhorn Beetle (*Anoplophora glabripennis*)

8.6 HAZARDOUS WASTES / CONTAMINATED MATERIALS

Management of hazardous and contaminated materials in accordance with local, state and federal laws and regulations is needed to minimize the risks of employee and contractor exposure, to protect the public, to prevent further environmental degradation due to the contaminants, and to the extent possible, reduce NYSCC liability for contamination. It is possible that such materials may be located within or below earthen embankments, as embankments were generally constructed with compactable fill materials. It is more likely to find such materials in canal prisms or on adjacent properties with existing environmental impacts.

Materials from adjacent properties could migrate to NYSCC properties or could have been mistakenly left or placed within NYSCC property. Therefore, screening, for hazardous and contaminated materials should be done prior to performing work on an embankment segment if any portion of a reach includes excavation either on NYSCC lands or adjacent lands beyond the NYSCC right-of-way where a Site Access/Vegetation Management Permit has been obtained.

Screening

Where work on embankment segments include the conditions discussed above, screening is to be conducted following the NYSDOT's "The Environmental Manual," Section 4.4.20 Contaminated Materials and Hazardous Substances. The screening is a modified form of standard practice for Phase I Environmental Site Assessments (ESAs), which generally fits the needs of the NYSDOT and the NYSCC. The Director of Environmental, Health & Safety should be consulted with in regard to the specific information needed for the screening. The screening will provide site-specific information for the embankment segment, and include three components that are typically advanced concurrently:

- a review of public and reasonably ascertainable records within standard search radii;
- a site reconnaissance or visit to the project corridor; and
- interviews with current and former owners, employees and occupants of the property, and local government officials such as firefighters, building codes enforcement officers, and local health department staff.

The screening should include conclusions that summarize the findings of the assessment and recommendations for handling each finding that represents an environmental concern. After reviewing the screening report and observing the project location or corridor, the Director of Environmental, Health & Safety may determine that additional information is needed to adequately evaluate the segment, determine the contaminant levels at an area of concern (AOC), or fill in information gaps about possible or suspected contamination. A Phase II Environmental Site Assessment (ESA) can confirm the presence of hazardous substances or petroleum byproducts, help determine the type(s), extent, and magnitude of contamination and allow for an accurate estimate of costs that will be associated with the required remediation. A Phase II ESA includes a surface and subsurface evaluation to identify and delineate impacts. Media samples, such as surface and subsurface soil, groundwater, soil vapor, and/or surface water are frequently obtained for laboratory analysis during Phase II ESA in order to confirm and evaluate potential contamination. Contaminants selected for laboratory analysis may include, but not be limited to Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), metals, pesticides, and Polychlorinated Biphenyls (PCBs).

If contamination is confirmed in Phase II ESA findings, NYSCC would implement preventive or corrective/remedial measures prior to the start of work as well as involvement of appropriate environmental professionals and regulatory authorities, if applicable. Such measures may include preparation of an Environmental Management Plan (EMP) and/or Soil Management Plan (SMP) for identification, testing, and disposition of impacted soils/solid waste prior to or during EEIP activities. The EMP/SMP would be intended to provide guidance to minimize EEIP activity delays as a result of addressing environmental conditions within the activity area.

8.7 LIGHT POLLUTION

Permanent effects on lighting may result from the removal of vegetation which, especially during the growing season, may serve to obscure or block artificial lighting along either side of the Canal or beyond the project area. The extent of the effects may in some cases be noticeable to affected facilities, particularly residential neighborhoods.

The NYSCC will, on a project-by-project basis perform a trespass light pollution evaluation at locations where, as a result of removing tall, dense vegetation, existing artificial light sources could significantly affect locations occupied by humans during nighttime hours.

~~A~~ This evaluation will consist of two steps and be completed during the development of conceptual designs to evaluate the potential effects that the removal of vegetation from the embankments of the canal and outside the toe of embankments would have on trespass light pollution to humans.

The first step will be to visit the site before sunset to evaluate the artificial light sources around the project areas. Existing luminaire types will be determined or estimated based on the site visit and available information. Part of this trip will continue in the evening to measure with an illuminance meter the amount of light measured in foot-candles that currently exists at residents' property line.

The second step will be to produce a photometric model of the area using a lighting software program (ex. Lighting Analyst AGi32). Lighting software programs will be used to model the calculation points at different elevations to track natural topography and make a more accurate lighting model. Before models, with vegetation, and after models, with the vegetation removed, will be prepared to understand the adverse effects of particular existing vegetation removals. Recommendations may be made to replace or adjust luminaires if that would reduce or eliminate the trespass light pollution to humans who are determined to be adversely affected.

As part of this effort, outside entities owning the light sources will be contacted by the NYSCC prior to entering those properties to assess luminaires and lighting. The NYSCC will also develop a strategy for working with outside entities to replace or adjust luminaires <u>as practicable</u>.

8.8 SCENIC MANAGEMENT GUIDELINES

To minimize impacts to aesthetic resources for embankment projects where community thresholds are exceeded, the procedures described in Section 8.15, and Section 10 would be followed. The guidelines provided below are sensible design practices that can apply to all embankment projects, whether or not community thresholds are exceeded.

The Scenic Management Guidelines include:

1. Where stone lining occurs within the viewshed of the trail or waterway a blend of standard dolomite stone meeting NYSDOT material and size specifications, and Medina stone or some other suitable stone would be installed above the normal waterline to minimize the visual impact. This would match treatment in other historic sections of the canal. High priority areas for this treatment would

be similar to those recommended for selective vegetation management – popular sections of the trail and urbanized population centers that have a community, civic, and development pattern focus on the canal.

2. Where seepage controls are required (typically located in Zones 4 and 5) in locations visible to residents and to people in public spaces, NYSCC will make all possible efforts to provide granular filters that are seepage controls that are buried and covered with turf.

8.9 NOISE

Noise is defined as unwanted sound that may interfere with communication, or that may disturb the community. Three characteristics of noise have been identified as being important to analyzing subjective community response to noise: intensity, frequency and the time-varying characteristics of the noise. Numerous environmental factors determine the level or perceptibility of noise at a given point of reception. These factors include distance from the noise source to receptor; the surrounding terrain; ambient sound level; time of day; season of the year (for indoor activities); wind direction; temperature gradient; and relative humidity. Certain adjacent land uses are more sensitive to noise than others. Noise is likely to be a matter of concern to adjacent residential land uses. During the development of conceptual designs for embankment projects, consideration should be given to both indirect permanent impacts resulting from removal of existing tall, dense vegetation and temporary direct noise impacts associated with construction noise.

Best Management Practices for Indirect Permanent Noise Level Increases

Table B of Assessing and Mitigating Noise Impacts (NYSDEC, 2001) classifies noise level increases of less than or equal to 5 dBA as "unnoticed" to "tolerable." It has been demonstrated in previous National Cooperative Highway Research Program (NCHRP) research that 5 dBA of noise attenuation can be provided by tall, dense vegetation that exceeds 200 feet depth. The Federal Highway Administration has adopted that research as guidance for Federal-aid highway projects. The guidance on tree zones is summarized in National Cooperative Highway Research Program Report 25-34, *Supplemental Guidance on the Application of FHWA's Traffic Noise Model*, Appendix I – Tree Zones (NCHRP 2014). There may be unique situations, however, where the line of sight between loud noise sources and noise sensitive receivers passes through tall, dense vegetation, planned for removal, that exceeds the threshold depth of 200 feet.

During the development of conceptual designs, the NYSCC will conduct a screening of individual embankment projects to identify lines of sight where more than 200 feet of tall, dense vegetation between sensitive adjacent noise sensitive receivers and loud noise sources is planned for removal, to identify any situations that exceed that threshold. For those loud noise source and noise sensitive receiver situations where a line of sight through more than 200 feet of tall, dense vegetation is planned for removal, a noise analysis including calculations and noise measurements, as appropriate, will be performed and impacts, if any, will be documented. The screening will consist of the following steps:

1. A desktop evaluation, using recent aerial imagery, land use maps and other web-based resources, to identify potentially loud noise sources (major, high speed and high-volume roadways; warehouses; industrial complexes; mining operations, etc.); noise sensitive receivers (residences, public parks and other land uses where outdoor active use is evident; and stands of tall, dense vegetation. The combinations of loud noise sources and noise sensitive receivers potentially of concern may include:
    a. Noise receivers on the side of the embankment adjacent to where removal of tall, dense tree vegetation could increase noise levels from existing noise sources on the other side of the canal;
    b. Noise receivers on the other side of the canal from where removal of tall, dense tree vegetation could increase noise levels from existing noise sources adjacent to where embankment vegetation removal is being performed; and
    c. Situations where sources and receptors are adjacent to an embankment on the same side of the canal along a curve where a direct line is opened from the vegetation removal.

2. A field visit during the growing season that includes:
    a. Confirmation of noise sensitive receivers, loud noise sources and the density and depth of tall, dense vegetation that exceeds 200 feet depth, and intersects the line of sight between loud noise sources and sensitive noise receivers. The line-of-sight break provided by the earthen embankment will also be determined.
    b. Noise measurements using a Type I integrating sound level meter:
        i. For noise sensitive receivers, to obtain a background (or baseline) noise level; and
        ii. For loud noise sources, to obtain a direct noise measurement at a measured distance from the point, area or line source.

3. Acoustics calculations to determine the before and after growing season noise levels at the sensitive receivers due to removal of tall, dense vegetation.

4. Communication, through NYSCC Public Engagement, of that information to the impacted sensitive receivers and discussion of limited measures that could be provided in Zones 2B and 3 of the embankments where the work is being conducted as an amenity. The options available to the impacted sensitive receivers that could be incorporated into embankment Zones 2B and 3 include providing supplemental plantings; and providing pollinator plantings.

Information and methods for conducting the noise analysis include:

1. *Assessing and Mitigating Noise Impacts* (NYSDEC, 2001);
2. NYSDOT Noise Analysis Policy and Procedures, TEM 4.4.18;
3. FHWA Roadway Construction Noise Model (RCNM), Version 2.0; and
4. FHWA Highway Noise Model, Version 2.5

Best Management Practices for Temporary Construction Noise Impacts

There are three major categories of noise sources for any construction operation: (1) fixed equipment or process operations; (2) mobile equipment or process operations; and (3) transport movements of products, raw materials or waste.

It is anticipated that none of the maintenance activities would cause a permanent change in operational noise levels. Some maintenance activities may cause changes in noise levels during construction. Projects that involve excessive construction noise, nighttime work, and work involving a significant degree of material transport on local roads and along the canal embankments may require a noise analysis.

The following provides a series of noise abatement techniques, modified from the NYSDEC noise guidelines *[NYSDEC, 2001]*, that are available for reducing frequency of sound, duration of sound or sound pressure levels at noise sensitive receptor locations. The mitigation techniques given below are listed according to what sound characteristic they mitigate. The practices should be employed to the maximum extent practicable to lessen the potential temporary noise impact to nearby noise sensitive receptors.

- Reduce noise frequency and impulse noise at the source of generation by:
    - Replacing back-up beepers on machinery with strobe lights (subject to other requirements, e.g., OSHA and MINE Safety and Health Administration, as applicable). This eliminates the most annoying impulse beeping;
    - Use appropriate mufflers to reduce the frequency of sound on machinery that pulses, such as diesel engines and compressed air machinery;
    - Changing equipment: using electric motors instead of compressed air driven machinery; using low speed fans in place of high-speed fans;
    - Modifying machinery to reduce noise by using plastic liners, flexible noise control covers, and dampening plates and pads on large sheet metal surfaces; and
- Reduce noise duration by:
    - Limiting the number of days of operation, only working during business days and non-holidays, and restricting the hours of operations between 7 a.m. and 7 p.m.
- Reduce noise sound pressure levels by:
    - Increasing setback distances;
    - Moving equipment during operation further from noise sensitive receptors;
    - Substituting quieter equipment;
    - Using mufflers selected to match the type of equipment and air or gas flow on mechanical equipment;
    - Ensuring that equipment is regularly maintained;
    - Erecting temporary sound barriers or screens around a portion of the noise generating equipment or near the point of reception. The angle of deflection also increases as the height of a screen or barrier increases. Screens or barriers should be located as close to the noise source or the receptor as possible. The closer the barrier is located to the source or the receptor, the greater the angle of deflection of the sound waves will be creating a larger

"sound shadow" on the side opposite the barrier. Stockpiles of raw material or finished product can be an effective sound barrier if strategically placed.
    - Phasing operations to preserve natural barriers as long as possible;
- Where local noise ordinances have been enacted, the NYSCC will make all reasonable attempts to comply with substantive requirements of local noise ordinances.
- Public notification of upcoming loud events should also be considered as a form of mitigation, although it does not physically reduce the noise or perception of the noise.

8.10 DUST CONTROL

NYSCC maintenance personnel and/or contracted personnel shall schedule and conduct activities to minimize impacts to air quality and to prevent hazardous or objectionable air quality conditions within the project area or surrounding areas.

Best Management Practices for Dust

The following best management practices shall be used when controlling dust:

- Buffer areas of vegetation should be left in place, where practical.
- For areas not subject to traffic, the following materials may be applied to minimize dust:
    - Vegetative cover – provides the most practical method of dust control
    - Mulch (including rolled erosion control products)
    - Spray adhesives – generally composed of polymers in a liquid or solid form mixed with water to form an emulsion that is sprayed on the soil surface. The mixing ratios and application rates shall be in accordance with the manufacturer's recommendations for the specific soils on the site. Adhesives shall not be applied to wet soils or if there is a probability of precipitation within 48 hours.
- For areas subject to traffic, (e.g., access roads, haul roads), the following materials may be applied to minimize dust:
    - Water sprinkling – the site, especially haul roads and gravel access routes, may be sprayed with water until the surface is wet.
    - Polymer additives – polymers mixed with water may be applied to driving surface using mixing ratios and application rates in accordance with the manufacturer's recommendations. Polymers shall not be applied if there is a probability of precipitation within 48 hours of its proposed use. Polymers must be used in accordance with the NYSDEC issued conditions for use and application instructions.
    - Barriers – woven geotextiles or stone may be placed on the driving surface to effectively reduce dust throw and particle migration of haul roads.
    - Windbreak – a silt fence or similar barrier may be installed to control air currents at horizontal intervals equal to ten times the barrier height. Existing vegetation that acts as a wind barrier should be preserved as much as practical.
    - Wheel washing – on-road construction vehicle tires may be cleaned by mechanical or manual wet method prior to leaving the site.

- Tarps – haul trucks carrying fine materials should be covered with tarps, securely fastened, when transporting materials off of the project site.
- Covering stockpiles – stockpiles of may be covered with a plastic barrier to prevent wind-blown transport from the piles.

8.11 FLOODPLAINS

For maintenance activities, where any part of the work is known to be located within a FEMA floodplain, and where construction (i.e., excavation, fill, grading, paving) within the floodplain is planned, further screening of the project site is needed to assure compliance with applicable State and Federal regulations. Although the NYSCC is not required to obtain a local community Floodplain Development Permit, it is required to comply with the provisions of 6 NYCRR 502 - Flood Plain Management for State Projects, and with EO 11988 where federal permits are involved.

The screening, performed during conceptual design of embankment projects, begins with a site-specific review of the effective FEMA Flood Insurance Rate Map (FIRM). The most recent FIRMs (as well as preliminary FIRMs can be obtained online from the FEMA Map Services Center (https://msc.fema.gov/portal/home). From this review, the extents of the floodplain and floodway (if one exists), relative to the work limits should be determined. Previous hydrologic and hydraulic studies that have been conducted for the NYSCC for hydraulic planning and designs for canal facility improvements should also be reviewed.

For a few recommended actions, hydrologic and hydraulic analysis including HEC-RAS modeling may be used to evaluate impacts on the 100-year water surface elevation resulting from a proposed EEIP activity. The primary location where a HEC-RAS model may be used is where an embankment outboard slope is to be flattened or an abutting stream is to be relocated to provide stability or to control seepage, and the repair area is located within the 100-year floodplain of a waterway that crosses the Canal or runs parallel and immediately adjacent to it.

If analysis determines that placing fill for embankment repair would increase the water surface elevation for the 100-year flood in the mapped floodplain adjacent to the Canal, alternatives would be investigated to eliminate the rise in water surface elevation. Once floodplain effects, if any, have been determined, NYSCC should document the following actions and statements concerning each of the relevant regulations.

6 NYSCRR Part 502

The maintenance activity is within the Special Flood Hazard Area (SFHA) of the [**waterbody**], as indicated by FEMA on [**map reference number**].

To the extent that the following apply, plan and conduct the maintenance activities so that they are:

- designed and adequately anchored to prevent flotation, collapse or lateral movement;
- constructed with materials and utility equipment resistant to flood damage; and
- constructed by methods and practices that minimize flood damage.

The maintenance activities must be conducted so that:

- the flood carrying capacities within any altered or relocated watercourses are maintained;
- they are consistent with the need to minimize flood damage within the special flood hazard area;

- any relocated public utilities and facilities, such as sewer, gas, electric and water systems, are located and constructed to minimize or eliminate flood damage; and
- adequate drainage is provided to reduce exposure to flood hazards.

The NYSCC needs to document the following:

> *In accordance with the provisions of 6 NYCRR 502 - Flood Plain Management for State Projects, this action has considered and evaluated the practicality of alternatives to any floodplain encroachments. As a result of this evaluation, it is concluded that: (1) a significant encroachment does not exist; (2) there is no significant potential for interruption or termination of a transportation facility which is needed for emergency vehicles; and (3) there are no significant impacts on natural beneficial floodplain values.*

Executive Order 11988

In the event that the proposed maintenance activity requires the use of a floodplain, and approval of a Federal agency, the activity must also comply with Executive Order 11988.

The regulations and procedures vary depending on the federal agency granting approval of the activity, however, the NYSCC should consider alternatives to avoid adverse effects and incompatible development in the floodplains. If the only practicable alternative consistent with the law and with the policy of the federal approval agency requires siting in a floodplain, the NYSCC should design or modify its maintenance activity in order to minimize potential harm to or within the floodplain, consistent with the guiding federal regulations. The approving federal agency will prepare and circulate a notice containing an explanation of why the action is proposed to be located in the floodplain.

8.12 RECREATIONAL TRAFFIC

Recreational traffic must be notified during embankment maintenance. Depending on the level of maintenance and the time of year for that maintenance, boat or other waterborne traffic within the affected area of the Canal System and/or foot/bike traffic on the towpaths and embankment crests may need to be diverted or prohibited. Signs shall be placed at either end of the work limits notifying users of the on-going maintenance. Notifications may also be posted by the NYSCC Public-Engagement at www.canals.ny.gov as well as messaging through the Notice to Mariners (NTM) system,

Boat/Waterborne Traffic: In the event of significant in-Canal System work during the navigation season, locks and guard gates should be used to prevent boat and waterborne traffic from entering the work area, unless expressly permitted and accompanied by NYSCC staff. Where temporary closure of the Canal is not required, warning signage and buoys may be provided for boaters.

Pedestrian/Bike Traffic: If possible, detour routes should be established allowing users alternate routes safely around the construction area without impeding travel. Where temporary trail closures are required, work zone traffic control would be provided in accordance with NYSDOT Standard Sheet 619.0.

8.13 ACCESS, EASEMENTS AND TEMPORARY WORKSPACE

All work must be conducted on NYSCC property or on lands where NYSCC has easement rights unless access to adjacent lands beyond the NYSCC right-of-way is obtained through a Site Access/Vegetation Management Permit. If the property owner is agreeable to work that Canals desires to do, then a permit can be used. These permits should be placed on the shared drive Design/DESIGN/Agreements for future reference. Permits though State Agencies and Corporations can be used to obtain permission to do work on an owner's property. Site Access/Vegetation Management Permits and Permits though State Agencies and Corporations cannot confer title to the property. Any proposed work that requires a permanent easement or acquisition of areas not on NYSCC property will require NYPA Real Property involvement and additional environmental review as a separate SEQR action.

8.14 PERMITTING REQUIREMENTS

The following section describes several of the permitting thresholds that may be met during maintenance activities, thus requiring authorization from a federal and/or state agency. All maintenance activities should be reviewed by qualified personnel prior to commencement to ensure all environmental permitting requirements and regulations are met.

Table 8-6: Permits, Thresholds and Requirements

Permit	Threshold	Requirements
USACE		
Section 404 – Nationwide Permit	• Fill in waterbody (i.e., non-navigable canal, feeder, stream, wetland) below the ordinary high water (OHW). • Exceeding the NWP limit of 0.5 acres of permanent wetlands impacts will require an individual permit. • The threshold for the need for compensatory mitigation from wetland losses is 0.1 acres.	• Depending on amount of fill and type of activity, may need Pre-Construction Notification and permit authorization from USACE • May require mitigation • Will require to avoid, minimize and/or mitigate fill in waterbodies • Require Section 401 Water Quality Certification from NYSDEC (see below)
Section 10 – Navigable Waters Permit	Construction of any structure in or over a navigable water, including dredging, excavation, filling or any other modification of a navigable water.	• Requires authorization from USACE. • Same requirements as above. • Will require continued access for navigable vehicles

Permit	Threshold	Requirements
USFWS		
Consultation required for USACE permits Coordination required for any activity that affects a listed species.	Work within areas that may impact federally listed threatened or endangered species (TES)	• Minimize disturbance to TES habitat. • May require species surveys to identify presence or absence of species. • Take permit may be required if work is deemed significant to TES and/or habitat
NYSDEC		
Section 401 Water Quality Certification	Accompanies Section 404 and 10 permits from the USACE	• Will require erosion and sediment control measures to protect water quality. • May result in in-stream work restriction dates
Article 15 – Protection of Waters[22]	Disturbance of the bed or banks of a stream. NOT required for streams classified as C or D.	• Will require E/S measures to protect water quality. • May result in in-stream work restriction dates
Article 24 – Freshwater Wetlands	Activities within a State Wetland and most activities within its 100-foot buffer zone	• Will require permit authorization from NYSDEC. • Will require E/S measures to protect water quality. • Will require to avoid, minimize and/or mitigate fill in waterbodies
SPDES GP 0-20-001	Earth disturbance of 1 acre or more	• Requires E/S measures and plan • Requires development of SWPPP • Requires NOI to be submitted to NYSDEC • May require post-construction stormwater management measures (only if impervious area involved)
Endangered/Threatened Species (Incidental Take) Permit[23]	Where the "take" of listed species cannot be avoided	• Specific Net Conservation Benefits will be required, as negotiated with NYSDEC

[22] Note that the NYSCC is not subject to Article 15 procedural requirements but must substantively comply with the requirements.

[23] The need for this is determined as described in Section 8.2

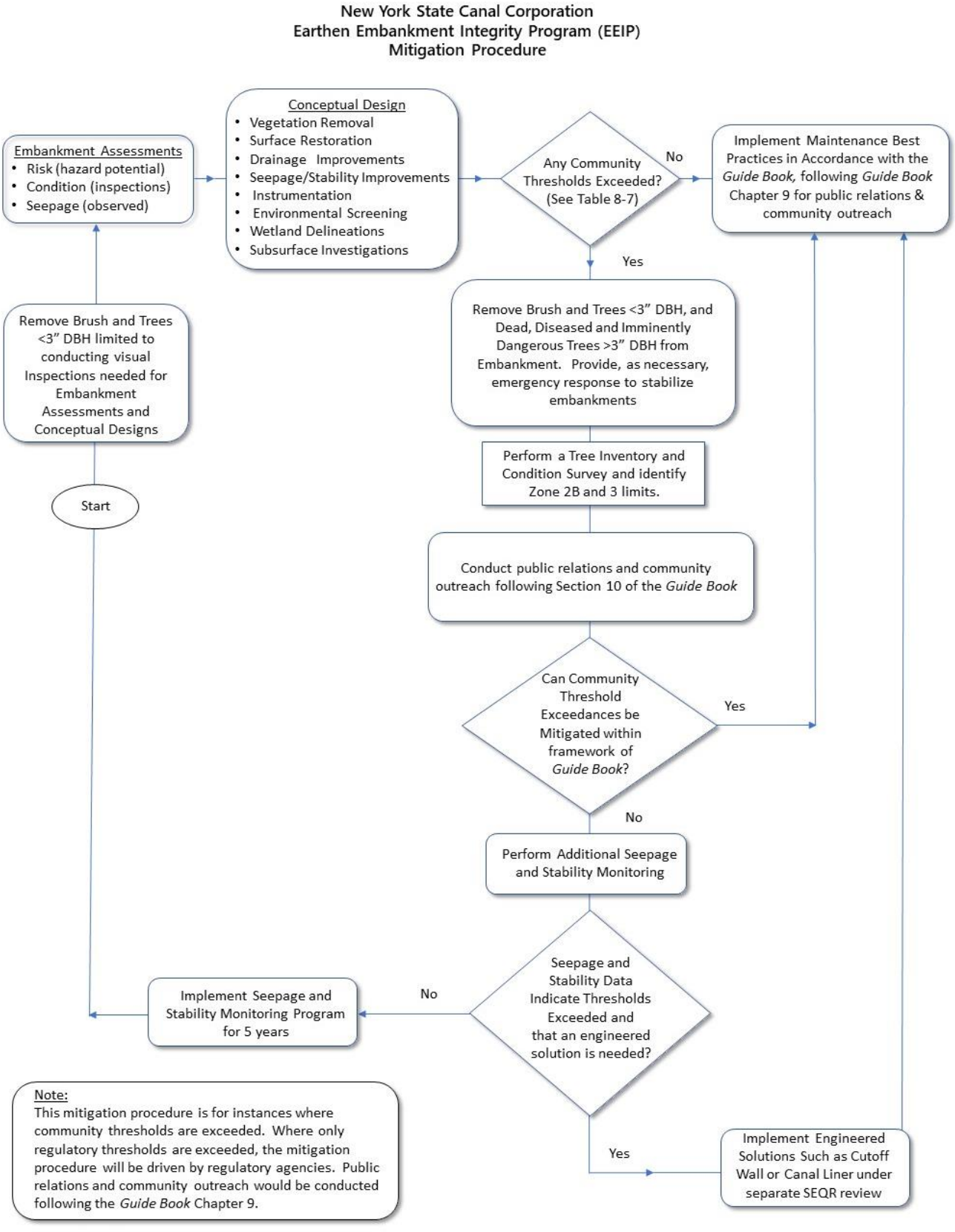
Permit	Threshold	Requirements
NYSDOS		
Coastal Consistency – Required for any State or Federal permits	Any work in areas within Coastal Zones (i.e., Erie Canal between Niagara River and 900 feet upstream of SR 62, and Oswego Canal between Lake Ontario and 150 feet upstream of Varick Dam[24]) and within municipalities that have Local Waterfront Revitalization Programs approved by the NYSDOS	• Requires review by NYSDOS for consistency with State Coastal Policies and/or Local Waterfront Revitalization Program (LWRP) Policies
SHPO		
Consultation	Submit project information to SHPO via CRIS if the work will require a State or Federal Permit or if it will require additional SEQR review. All submittal to SHPO must be coordinated through the NYSCC Cultural Resources Coordinator	• Will require review by SHPO • May require studies by historic preservation professionals • May require additional protection/avoidance measures • May require special documentation or construction practices
NYSCC		
State Environmental Quality Review	Any work not consistent with that described in this *Guide Book* or beyond the scope or parameters of the SEQR GEIS.	• Will require additional environmental review by qualified personnel

8.15 SEQR THRESHOLDS AND MITIGATION PROCEDURE

Figure 8-1 illustrates the process NYSCC will follow in implementing the EEIP. The process includes projects where either consultation with regulatory agencies, or community outreach following Section 10 of the *Guide Book* is needed to determine if threshold exceedances can be mitigated within the framework of the *Guide Book*. Where community threshold exceedances cannot be mitigated within the framework of the *Guide Book*, additional seepage and stability monitoring is implemented and if the monitoring shows an engineering solution is required, then that action would be implemented under a separate SEQR review.

[24] Varick Dam which Canals refers to as Curved Dam, creates the headwater pond of Lock O7

Figure 8-1 Mitigation Procedure



There are site-specific situations where the proposed maintenance activities would result in exceedances of regulatory or community thresholds as identified in Table 8-7.

Table 8-7: Regulatory and Community Thresholds

Regulatory: Federal or State rare, threatened, or endangered plant species are located on NYSCC property or on adjacent lands that would experience an incidental take as defined in 6 NYCRR Part 182 as a result of being disturbed by EEIP activities.
Regulatory: EEIP activities would significantly reduce or degrade occupied habitat (as defined in 6 NYSCRR Part 182) used by any rare, threatened or endangered species.
Regulatory: EIPP activities would significantly reduce the quantity or quality of the resource or characteristic which was the basis for its designation as Critical Environmental Area.
Regulatory: EEIP activities that would cause the loss of any wetlands in the Montezuma Marshes National Natural Landmark as identified in Section 3.2 of the Generic EIS.
Community: NYSCC property where EEIP activities are contemplated involves or is adjacent to a public park, and those activities would significantly impair the park's aesthetic, historic or recreational function.
Regulatory: Where historic resources listed or eligible for inclusion in the State or National Registers of historic places, are located on or in close proximity to NYSCC property where EEIP activities are contemplated, and the EEIP activities would result in a determination of an adverse effect on the historic resource by the Agency Preservation Officer or the SHPO.
Community: Where an aesthetic resource of local importance has previously been officially designated as an aesthetic resource in an adopted comprehensive plan or zoning and is located on or immediately adjacent to lands where EEIP activities are contemplated and where those activities would significantly damage the aesthetic character of the resource. See note (1) below for NYSDEC reference document.
Community: Where EEIP activities are inconsistent with an approved Local Waterfront Revitalization Program (LWRP) in accordance with the New York State Waterfront Revitalization of Coastal Areas and Inland Waterways Act (NYS Executive Law, Article 42).

Note:

(1) NYSDEC Program Policy DEP-00-2 "Assessing and Mitigating Visual and Aesthetic Impacts," http://www.dec.ny.gov/docs/permits_ej_operations_pdf/visualpolicydep002.pdf

Where exceedances of regulatory community thresholds are identified, the following steps would be taken:

1. Remove trees and brush smaller than 3 inches in diameter at breast height (DBH) that impede inspections and trees larger than or equal to 3 inches DBH that are dead, diseased, and imminently dangerous to property and people. Provide, as necessary, emergency response to stabilize embankments.

2. Perform an embankment condition survey and a tree inventory with an arborist, landscape architect, and engineer to assess the potential of preserving any trees. The arborist would determine the tree's health and viability; the landscape architect would determine the aesthetic suitability of the preserved tree within the context of the overall project limits; and the engineer would determine the feasibility of its retention with respect to its effect on embankment integrity and trail user safety. Develop a minimum of two viable alternatives, such as: 1) a baseline conceptual design retaining healthy, non-invasive trees in Zones 2B and 3; 2) a conceptual design with limited tree removal to facilitate necessary corrective actions to address identified seeps (healthy trees equal to 3" DBH and greater remain outside

Zone 2B and 3); or 3) confirm compatibility of performing enhanced inspections and engineering evaluations over a 5 year period in lieu of executing the conceptual designs.

3. Engage with community task force based on specific thresholds identified. Community task force members will review and discuss the conceptual designs provided by the NYSCC that mitigate aesthetic effects and indicate which of the NYSCC conceptual designs is preferred considering the overall project schedule. All final conceptual designs must consider the results of the embankment condition survey and be approved by the Engineer of Record.

4. If, a different conceptual design can be agreed upon and approved by the Engineer of Record, these measures would be implemented and the EEIP activities would continue as prescribed in Figure 8-1. If none of the community task force proposed conceptual designs involving additional tree removal are determined to be appropriate by the Engineer of Record, continue with Action Item 5 below. No additional tree removal beyond that described in Action Item 1 above occurs in any zones, however, NYSCC will stabilize and establish appropriate ground cover.

5. Perform more detailed inspections, including detection of embankment seepage and embankment stability monitoring. The prescribed content and frequency of inspections is provided in the *Guide Book*. These include bi-weekly to monthly Bank Walk Inspections and quarterly Enhanced Embankment Monitoring for a more detailed investigation.

6. If the results of the detection and monitoring of embankment seepage and embankment stability suggest that the embankment is stable, a seepage and monitoring program would be developed and implemented. Perform additional surface stabilization as needed to prevent surface erosion. Monitoring may include: piezometers, slope indicators, observation wells and seepage weir boxes. Seepage and stability monitoring would continue for an additional 5 years if the gathered information suggests that the embankment is stable. At the conclusion of the 5-year period, the earthen embankment would be reassessed and the *Guide Book* procedure would commence again as shown on Figure 8-1. During the 5-year monitoring period dead and dying trees would be removed.

7. If the results of the seepage and stability monitoring indicate instability or that safe conditions are deteriorating, corrective, large scale engineering solutions possibly extending over entire embankment segments could be implemented (e.g., sheet piling, clay cutoff walls, lining the canal, etc. as noted in Figure 8-1). Such solutions are not addressed in the *Guide Book*. Implementation of corrective engineering solutions would be considered a separate site-specific action under SEQR and would be reviewed accordingly.

The mitigation procedure is shown in Figure 8-1, illustrating the evaluation and corrective action process for Canal embankments, where regulatory or community thresholds, shown in Table 8-7, are exceeded. If at any time, safety and conditions elevate to an emergency condition, such conditions shall be remediated pursuant to NYSCC emergency response procedures.

Scenic Management Guidelines for Projects Where Community Thresholds are Exceeded

The following scenic management guidelines should be considered as part of developing conceptual designs for embankment segments where community thresholds are exceeded.

1. No trees located within Zone 1 will be allowed to remain because of the need to maintain navigation safety.
2. Where a recreational trail is present, no tree in Zone 2A and 2B should be allowed to remain within the allowable clear zone distance specified outside the edge of travel way in accordance with AASHTOs Guide for the Development of Bicycle Facilities (AASHTO, 2012).
3. In areas where there is a very wide Zone 2B relative to embankment height, tree vegetation (equal to or > 3" DBH) and that is not an invasive species, is healthy, is not a danger tree, and is outside the allowable AASHTO clear zone should be preserved to the greatest extent possible.
4. Pollinators and Vegetative Screening Plantings found in Attachment 1, are optional features that may be added to the development of conceptual designs within Zones 2B and 3 when requested by the Community Task Force (see Section 10).
5. In locations where seepage controls are required by the Engineer of Record, NYSCC will make all possible efforts to provide seepage controls (typically located in Zones 4 and 5) that do not include exposed gravel surfaces but buried gravel covered with new turf, however, where exposed stone linings are required for toe drains and filter blankets, within the viewshed of the trail or waterway a blend of standard dolomite stone meeting NYSDOT material and size specifications, and Medina stone or some other suitable stone would be installed to minimize the visual impact. This would match treatment in other historic sections of the canal.

8.16 SUMMARY

This section provides guidance for conforming to the environmental requirements for specific embankment projects including: erosion and soil control; rare, threatened and endangered species; surface waters and wetlands; cultural resources; control of invasive species; hazardous wastes/contaminated materials; light pollution; scenic management guidelines; noise; dust; floodplains; recreational traffic; access, easements and temporary workspace; permitting requirements; and the SEQR thresholds and mitigation procedure. The SEQR thresholds and mitigation procedures sub-section provides the table of regulatory and community thresholds and the mitigation procedure (a flow chart) that guides the development of specific embankment segment projects.

9 PUBLIC RELATIONS & COMMUNITY OUTREACH – COMMUNITY THRESHOLDS ARE NOT EXCEEDED

When planned activities on a project-by-project basis do not exceed community threshold(s) as set forth in Table 8-7 "Regulatory and Community Thresholds" of this *Guide Book*, the NYSCC will inform affected municipalities, residents, property owners, businesses and non-governmental organizations (collectively, "affected stakeholders") of planned work.

9.1 COMMUNICATIONS & NOTIFICATIONS

Other than routine maintenance activities of existing landscape (e.g., mowing and clearing debris), all embankment maintenance activities, planned in accordance with this *Guide Book*, are communicated to the Public Engagement office for determination of need for public communications and notifications, which may include:

- Notification to adjacent property owners, businesses, residents or Canal System users who may be impacted by the planned activity or activities,
- Notification to the local municipalities
- Trail closure signs and detour routes as applicable for the work to be performed

Projects that include work in the water or dewatering and closure of canal sections must also include legal, regulatory and NYSCC procedural requirements for such activities, including:

- Advanced notification of closure, if feasible,
- Boater and waterborne traffic warning signs and closure signs,
- Notifications to regulatory agencies in accordance with Section 8 of this *Guide Book*, and
- Notice to Mariners.

The following notification formats will be used as determined by NYSCC Public Engagement:

- Signage or public postings (virtual or physical), such as physical signs posted at the project site and upstream and downstream control structures,
- Door hangers,
- Postings at www.canals.ny.gov and social media accounts,
- Press release, and
- Long-term closures (>5 days) of the canal waterway or recreational resources may also be referred to local newspaper, television and radio stations.

The notifications may include the following information:

- Estimated time of completion or closure period,
- Brief description of the type of work to be performed,
- Alternate routes or access points if a closure is required, and
- Point of contact for questions.

9.2 PUBLIC MEETINGS

NYSCC may schedule public meetings or information sessions at its discretion for planned activities conducted pursuant to this *Guide Book*. NYSCC Operations Staff will coordinate with the Public Engagement Office to develop and implement public meetings with cooperation of internal subject matter experts as needed.

9.3 FAQ SHEETS

The Public Engagement Office will maintain FAQ sheets for public distribution or posting to the NYSCC's website regarding projects and activities under this *Guide Book*, such as vegetation management~~,~~ and other maintenance activities and for capital improvement projects. As the embankment management program progresses, FAQ sheets may be amended or created and posted at www.canals.ny.gov.

9.4 SUMMARY

This section provides guidance on public relations and community outreach, including communications and notifications, public meetings and FAQ sheets for embankment maintenance projects where community thresholds defined in Table 8-7 are not exceeded.

10 PUBLIC RELATIONS & COMMUNITY OUTREACH – COMMUNITY THRESHOLDS ARE EXCEEDED

When planned activities on a project-by-project basis exceed community threshold(s) as set forth in Table 8-7 "Regulatory and Community Thresholds" of this *Guide Book*, the NYSCC will conduct public relations and community outreach for those activities with affected municipalities, residents, property owners, businesses and non-governmental organizations (collectively, "affected stakeholders"). Where the project limits extend through more than one municipal boundary, all affected municipalities will be contacted by NYSCC. Public engagement will be conducted through a community task force comprised of affected stakeholders.

10.1 COMMUNITY TASK FORCE

A community task force will be convened for projects identified that exceed community threshold(s) as set forth on in Table 8-7 "Regulatory and Community Thresholds" of this *Guide Book*. The community task force will be briefed by NYSCC on their conceptual designs. Additional briefings or site visits will be provided to the community task force as determined by NYSCC and consistent with Figure 8-1 and the *Scenic Management Guidelines for Projects Where Community Thresholds are Exceeded*, on a schedule or at key points in the development of final plans. This involvement will include:

- Community task force kickoff meeting, facilitated by the affected municipality, with NYSCC representatives (such as NYPA/NYSCC staff and consultants).
- Site visit(s) with NYSCC representatives who may discuss mitigation approaches within the framework of the *Guide Book*, and receive information from the community task force for consideration in finalizing conceptual designs.
- Project boundary details, the results of the tree survey and locations of embankment zones specific to the project.
- Additional information required to make an informed decision may include, but will not be limited to, the following: renderings illustrating a range of future conditions; information on seeps or animal burrows; and information about prior mitigation efforts within the project boundaries. The community task force will also be informed of any instrumentation measures that must be installed to monitor embankment conditions where applicable.
- Being advised of construction milestones, waterway or trail closures or detours, and related notices.

While the community task force will not participate in the professional engineering design, which must be signed by the Engineer of Record, they will have the opportunity to observe the design process, consistent with Section 8.15 and provide input to the selection and placement of embankment restoration plantings, landscaping, and inclusion of ancillary betterments that are consistent with the *Guide Book*.

A supplemental procedural document will be developed by NYSCC that provides more details on the community task force, including but not limited to:

- Description of a community task force,
- Key objective of a community task force,

- Establishment of a community task force,
- Materials and logistics,
- Goals,
- Participatory governing rules,
- Guidance and reference documents, and
- Definitions.

10.2 COMMUNICATIONS & NOTIFICATIONS

Other than routine maintenance of existing landscape (e.g., mowing and clearing debris), all embankment maintenance activities, planned in accordance with this *Guide Book*, are communicated to the Public Engagement office for determination of need for public communications and notifications, which may include:

- Notification to adjacent property owners, businesses, residents or Canal System users who may be impacted by the planned activity or activities,
- Notification to the local municipalities
- Trail closure signs and detour routes as applicable for the work to be performed, and

Projects that include work in the water or dewatering and closure of canal sections must also include legal, regulatory and NYSCC procedural requirements for such activities, including:

- Advanced notification of closure, if feasible,
- Boater and waterborne traffic warning signs and closure signs,
- Notifications to regulatory agencies in accordance with Section 8 of this *Guide Book*, and
- Notice to Mariners.

The following notification formats will be used as determined by NYSCC Public Engagement:

- Signage or public postings (virtual or physical), such as physical signs posted at the project site and upstream and downstream control structures,
- Door hangers,
- postings at www.canals.ny.gov and social media accounts,
- Press release, and
- Long-term closures (>5 days) of the canal waterway or recreational resources may also be referred to local newspaper, television and radio stations.

The notifications may include the following information:

- Estimated time of completion or closure period,
- Brief description of the type of work to be performed.,
- Alternate routes or access points if a closure is required, and
- Point of contact for questions.

10.3 PUBLIC MEETINGS

NYSCC and the community task force, collaborating together, may schedule public meetings or information sessions at their discretion for planned activities conducted pursuant to this *Guide Book*. NYSCC Operations Staff will coordinate with the Public Engagement office and community task force to develop and implement public meetings with cooperation of internal subject matter experts as needed.

10.4 FAQ SHEETS

The Public Engagement office will develop and will maintain FAQ sheets for public distribution or posting to NYSCC's website regarding projects and activities under this *Guide Book*, such as vegetation management and other maintenance activities, and for capital improvement projects. As the embankment management program progresses, FAQ sheets will be amended or created, and posted at www.canals.ny.gov.

10.5 SUMMARY

This section provides guidance on public relations and community outreach, including the creation of a community task force, communications and notifications, public meetings and FAQ sheets for embankment maintenance projects where community thresholds defined in Table 8-7 are exceeded.

11 CONCLUSIONS

The NYSCC Embankment Inspection & Maintenance *Guide Book* establishes the methods and processes necessary for reducing the risk of failure of its 130 miles of water impounding earthen embankments, while supporting asset preservation, environmental protection and existing community character.

Development of the *Guide Book* has been informed by the recommended practices of public agencies that that also have a responsibility of maintaining water impounding earthen embankments and reducing the risk of failures that could result in life loss, injury, damage to infrastructure, economic losses, and environmental damage.

Development of this *Guide Book* followed New York's SEQRA regulations (6 NYCRR Part 617 and 21 NYCRR Part 461), was determined to be a Type I project, and a Generic Environmental Impact Statement (GEIS) was prepared. The GEIS documents and other information are available at Earthen Embankment Integrity Program | Preserving NY's Canals (nyscanalintegrity.org). Input from the public and government officials, received during the public comment period, was used to clarify the *Guide Book* and to inform the approaches and methods for essential and effective public relations and community outreach contained in this *Guide Book*.

This *Guide Book* is required to be updated, at a minimum, every 2 years, or as necessary to ensure accurate mapping, inspection and prioritization procedures, best maintenance practices, improved approaches and methods for public relations and community outreach, and changes to environmental regulations.

12 REFERENCES

1. ASCE, 2010. American Society of Civil Engineers, *So, You Live Behind a Levee! What you should know to protect your home and loved ones from floods*.

2. AASHTO 2012. AASHTO Task Force on Geometric Design. *AASHTO Guide for the Development of Bicycle Facilities*. Fourth Edition. Washington, DC: American Association of State Highway and Transportation Officials, 2012.

3. FEMA, 2004. Federal Emergency Management Agency, *Federal Guidelines for Dam Safety – Hazard Potential Classification System for Dams*

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5. FEMA, 2015. Federal Emergency Management Agency, FEMA P-1025, *Federal Guidelines for Dam Safety Risk Management*

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7. NYSDEC, Undated. New York State Department of Environmental Conservation, DOW TOGS 3.1.5, *Guidance for Dam Hazard Classification*, DRAFT.

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9. NYSDEC, 1989. New York State Department of Environmental Conservation, *Guidelines for Design of Dams*.

10. NYSDEC, 2001. New York State Department of Environmental Conservation, *Assessing and Mitigating Noise Impacts* (DEC Program Policy).

11. NYSDEC, 2016. New York State Department of Environmental Conservation, *New York State Standards and Specifications for Erosion and Sediment Control*

12. USACE, 2019. US Army Corps of Engineers EP 1110-2-18, 2019. *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*

13. USACE, 2010. US Army Corps of Engineers, Engineer Research and Development Center ERDC SR-10-2. *Literature Review – Vegetation on Levees,* December 2010.

BERGMANN
ARCHITECTS ENGINEERS PLANNERS

NEW YORK STATE OF OPPORTUNITY. Canal Corporation

NEW YORK STATE CANAL CORPORATION

Earthen Embankment Integrity Program

SEQR Draft Generic Environmental Impact Statement

APPENDIX A
EMBANKMENT MAINTENANCE GUIDEBOOK

ATTACHMENT 1
NYSCC EMBANKMENT MAINTENANCE BEST MANAGEMENT PRACTICES (BMPs)

November 2022

Contents

1 GENERAL

INTRODUCTION

GENERAL NOTES:

- These Best Management Practices are not an all-encompassing guide. Prior to starting a task, if the procedure is unclear, review the recommended documents associated with the task at hand. Contract maintenance and capital improvement projects will in many cases require development of specifications and drawings specific to the work being done, and involvement by the **Regional Canal Engineer** or **Dam Safety Engineer** may be necessary to assess the situation and define the work.

- For cases where significant new or changed seepage is noted or where there is turbid flow emanating from an embankment, notify the **Dam Safety Engineer** immediately. If the **Dam Safety Engineer** is not available, notify the Thruway Statewide Operations Center (**TSOC**) immediately at **1-866-691-8282** and inform them of a potential dam safety emergency situation at the site and request that they notify the **Canal Duty Officer**.

- The canal is a legacy system that has been built and maintained through a century where the dam safety knowledge base has greatly expanded. Because of this, the conditions of the canal do not always conform to dam safety best practices in many instances. In some cases, implementing those best practices may be difficult or impossible due to factors outside of the control of the NYSCC. Compromises must be made in the implementation of the Guide Book and the various BMPs, but those compromises will be made to prioritize public safety and reduce the inherent risk of the embankments.

- These Best Management Practices do not address health and safety aspects for Canal System embankment maintenance activities. Follow appropriate standards for applicable precautions and personal protective equipment.

- NYSCC Environmental Health and Safety will review each embankment segment prior to the start of maintenance activities, and determine the environmental requirements and permits needed to perform the work.
- Where best practices dictates that the work on property not currently owned by the NYSCC is recommended (vegetation clearing, filter and toe drainage installation, etc.), The NYSCC will endeavor to work with those landowners to accomplish the dam safety best practices to the greatest degree practical.

CAUTIONS AND LIMITATIONS:

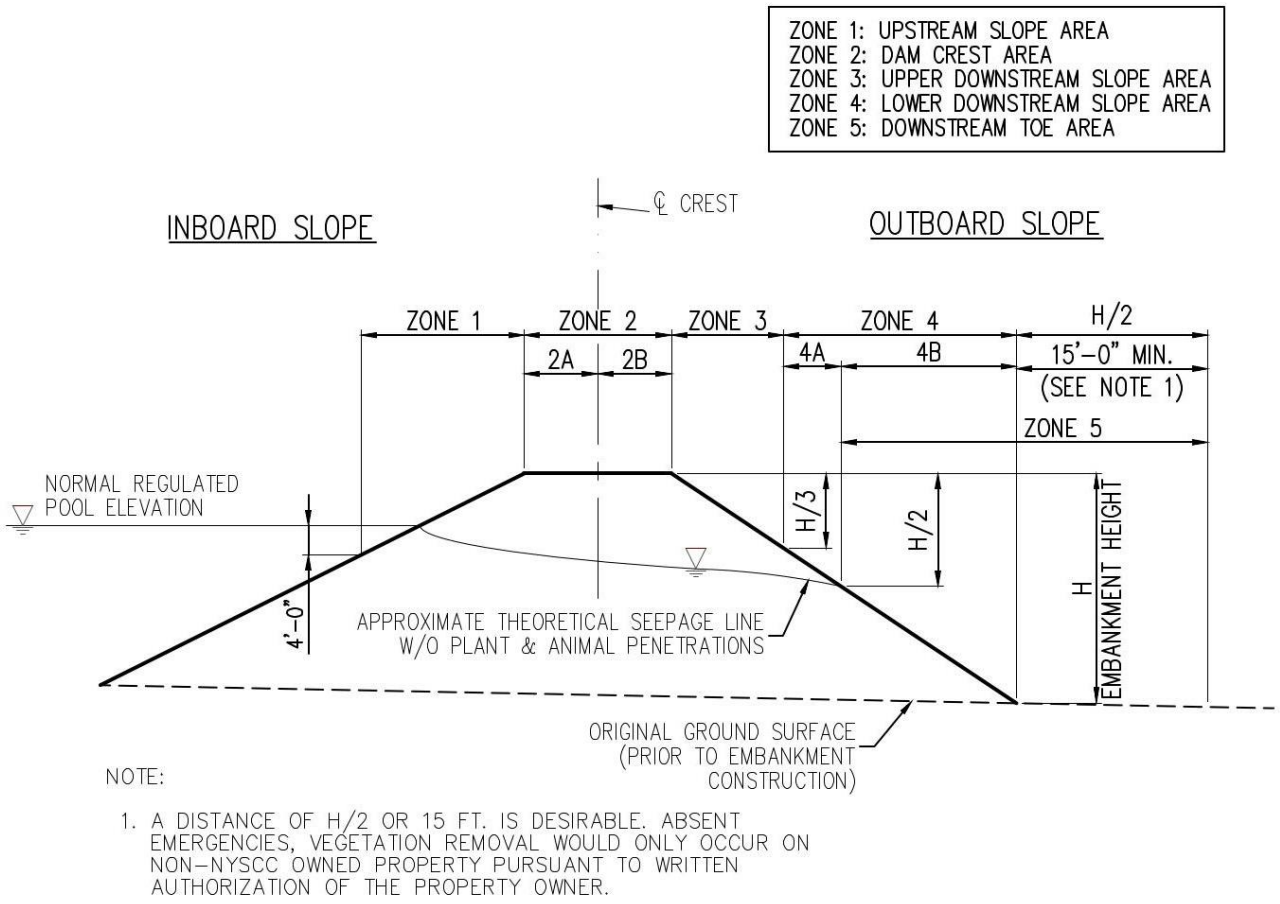
- **The best practices and suggested details contained in this manual are general and may require modification based on specific site conditions.** As such, some of the recommendations, procedures and details must be reviewed by a licensed professional prior to implementation. **Specific BMPs that require review by licensed engineers prior to implementation are noted with "PE Review Req'd" in the heading.** The use of these BMPs must be reviewed by a competent licensed professional prior to implementation. Furthermore, the licensed professional reviewing the BMP for use in the project will serve as the designer of record for the specific implementation of the detail/procedure in that case.

- BMPs not marked as "PE Review Req'd" are less critical in terms of potential consequence from an engineering perspective, though there are inherent risks involved in all work items contained herein. In addition, there are other important factors such as environmental, health, safety, historic preservation, etc. that must be considered. **Impacts of these BMPs must be considered by the individual(s) performing the work as not all situations can be addressed explicitly.**

- **All BMPs herein must be considered as general guidance that may require adjustment depending on actual site conditions.**

EMBANKMENT ZONES

EMBANKMENT ZONES:



Five dam safety inspection and evaluation zones have been identified within the geometric configuration of a typical earthen embankment. The delineated zones, illustrated in the figure below, have been numbered from upstream (inboard side) to downstream (outboard side). These zones have been delineated based on typical seepage characteristics. Descriptions of the zones, as adapted from and outlined in *FEMA 534 Technical Manual for Dam Owners – Impacts of Plants on Earthen Dams* and *FEMA 473 Impacts of Animals on Earthen Dams* are listed below (zone designations have been modified slightly from the FEMA references to simplify and reduce overlap of some zones).

EMBANKMENT ZONE DESCRIPTIONS:

Zone 1: Zone 1 begins on the upstream slope (inboard slope) of the earthen embankment at about four feet below normal pool elevation and extends to the shoulder break of the embankment crest.

Zone 2: Zone 2 includes the entire width of the crest of the embankment. Zone 2 extends across the entire top of embankment from shoulder break to shoulder break and is further subdivided into equal length zones - Zone 2A is inboard of the crest centerline and Zone 2B is outboard of the centerline.

Zone 3: Zone 3 extends from the shoulder break of the embankment crest to a point on the downstream (outboard) embankment slope that is about one-third of the structural height below the crest of the embankment.

Zone 4: Zone 4 extends from a point on the downstream (outboard) embankment slope that is about one third the structural height of the embankment to the toe of the downstream embankment slope.

Zone 5: Zone 5 extends from the mid-height of the downstream (outboard) embankment slope to a distance of one-half the structural height or a minimum of 15 feet beyond the toe of the downstream embankment slope, but work shall not occur beyond the NYSCC property limit without an easement or access agreement. Zone 5 overlaps Zone 4 for the distance of Zone 4B.

- For land not currently owned by NYSCC but where best practices dictate that the work on the property is recommended (vegetation clearing, filter and toe drainage installation, etc.), NYSCC will endeavor to work with those landowners to implement BMPs to the greatest degree practicable. This may include obtaining temporary easements and/or grading releases.

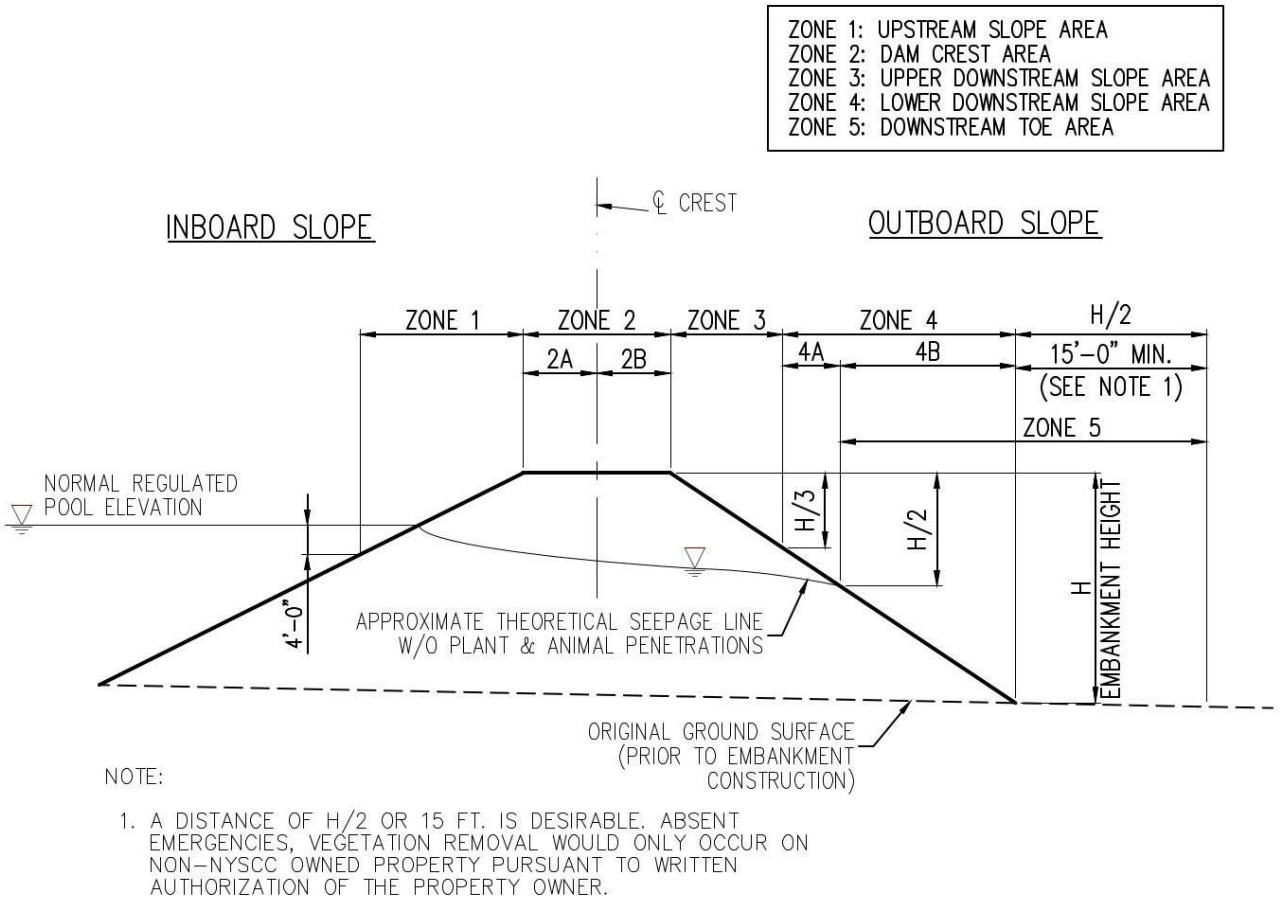
EXCAVATION (PE Review Req'd)

General

Excavating in and around water retaining embankments must be performed with care and understanding of Excavations in an embankment, when necessary, shall be governed by and performed under the following conditions and guidance.

Precautions

- Performing any excavation in or near an embankment retaining water should never be undertaken without explicit approval of a competent licensed professional engineer and the **Dam Safety Engineer**. **Do not proceed with any excavation under such circumstances without direct supervision of a licensed professional engineer.**
- Excavations within Zone 5 are not allowed without the direction of a competent licensed professional engineer. Notify the **Regional Canal Engineer** and **Dam Safety Engineer** prior to performing any such excavation.
- Excavations within Zones 1, 2, 3, & 4A may be performed if the canal is dewatered with approval from the **Regional Canal Engineer**.



Construction

- Prior to performing any installation, contact Dig Safely New York by calling 811 or visiting their website (www.digsafelynewyork.com) for utility mark out. Also contact NYSCC Section Office to review site for NYSCC-owned utilities. Use had excavation or other appropriate means to locate utilities identified before performing work.
- No excavation performed within the embankment should not advance below the water table.

- Follow OSHA and other appropriate health and safety standards for excavation including proper excavation support and/or layback.

- Fill shall be tested for compatibility with the remaining embankment material and for appropriate use in a water retaining embankment. Consult a competent licensed professional engineer for guidance.

- Fill should be compacted to 95% maximum dry density as based on the standard Proctor test unless project specific guidance is provided by the Engineer of Record. Placement and is dependent on the compaction method used.

- The following basic fill lift thickness guidance shall be utilized in the absence of project specific recommendations by the Engineer of Record:
  - When using a full size 10-ton roller, the backfill should be placed and compacted in 8-inch loose lifts.
  - When using smaller walk behind rollers, the backfill should be placed and compacted in 4-inch loose lifts.
  - When using small hand-held tampers, the backfill should be placed and compacted in 2-inch loose lifts.

2 VEGETATION

ESTABLISHING TURF GRASS

Establishing proper vegetation is an important aspect to embankment maintenance. Properly maintained vegetation can help reduce erosion of embankment slopes, stabilize ditches and help to reduce the influx of invasive species and unwanted vegetation. In areas where construction, overuse, or normal wear and tear has caused the normal ground cover to be disturbed, turf seeding should be conducted to promote regrowth.

See additional guidance in *New York State Standards and Specifications for Erosion and Sediment Control*, November 2016; and NYSDOT Standard Specifications Section 610 - *Ground Vegetation - Preparation, Establishment and Management.*

ESTABLISHING TURF GRASS:

1. Time of Planting:

   Fall planting is preferred. Seed after August 15. In the spring, plant until June 15.

   If seeding is done between May 15 and August 15, irrigation may be necessary.
2. Prepare site by loosening soil to a depth of 4-6 inches and applying a minimum 4 inches of topsoil.
3. Lime soil to a pH of 6.5.
4. Fertilize soil as per soil test. If cannot be completed, lime with commercial fertilizer at 850 lbs. of 5-5-10 or equivalent per acre (20lbs/1,000sf).
5. Prepare seed bed, smooth and grade area, remove unwanted debris.
6. Plant using a cultipacker type seeder if possible. Seed to a depth of 1/8 to 1/4 inch. If seed is to be broadcast, cultipack or roll after seeding.
7. All seeding should be mulched until turf cover is established. Mulch should be straw (cereal grain) mulch applied at 2 tons/acre (90 lbs./10000 sq. ft.) and anchored with wood fiber mulch (hydromulch) at 500—750 lbs./acre (11-17 lbs./1000 sq.ft.). The wood fiber mulch must be applied through a hydroseeder immediately after mulching. See the *New York State Standards and Specifications for Erosion and Sediment Control* for alternate methods of mulching.

TURF GRASS SEED MIXTURE:

For general use as a turf grass seed use:

65% Fine Fescue at 2.6-3.3 lbs (PLS) / 1,000sf or 114-143 lbs (PLS) / acre
15% Perennial Ryegrass at 0.6-0.7 lbs (PLS) / 1,000 sf or 26-33 lbs (PLS) / acre
20% Creeping Red Fescue at 0.8-1.0 lbs (PLS) / 1,000 sf or 35-44 lbs (PLS) / acre

Alternate seed mixes for a variety of site conditions can be found in the *New York State Standards and Specifications for Erosion and Sediment Control.*

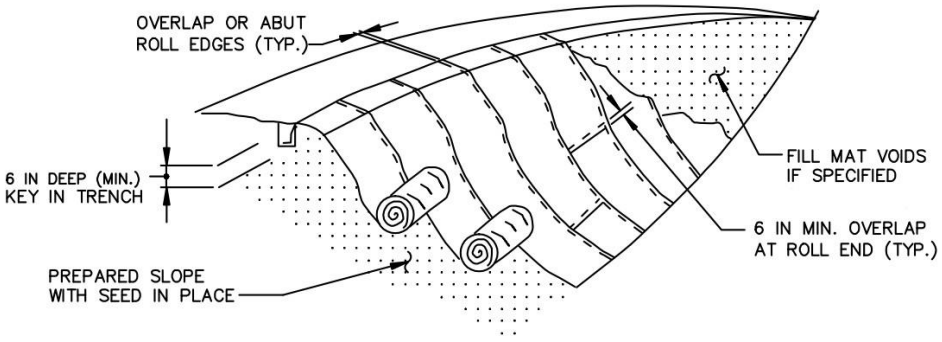
PURE LIVE SEED (PLS):

Pure Live Seed (PLS) refers to the amount of live seed in a lot of bulk seed. Check the information on the seed bag label.

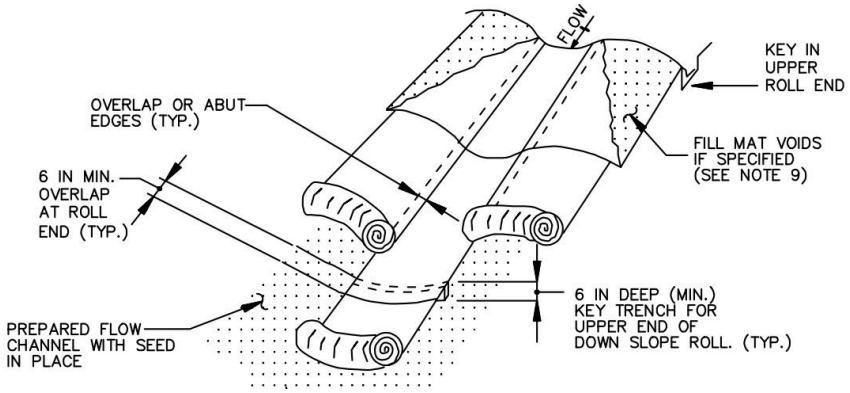
$$\text{Pure Live Seed (PLS)} = \frac{\%\ \text{Germination} \times \%\ \text{Purity}}{100}$$

STABILIZATION MATTING:

1. All slopes 3h:1v or steeper, vegetated channels, streambanks, shorelines and areas where wind prevents standard mulch application shall be further stabilized with stabilization matting. Matting is not required for areas stabilized with sod, rock riprap or other hard material. Matting is not suitable protection for prevention of slope failure or areas with significant anticipated erosion (i.e., embankment slope areas subject to wave actions or eroding channel banks).
2. Stabilization Matting for embankment slopes shall be semi-permanent products made entirely of organic materials. Products shall meet NYSDOT Standard Specification Class II Type C (have the ability to protect soil from hydraulically induced shear stresses under bench scale conditions for at least 1 psf at ½-inch soil loss).
3. Turf Reinforcement Matting for grassed waterways such as ditches where velocities are anticipated to exceed 5 ft/sec shall be lined with permanent, non-degradable synthetic fibers, fillings or nettings which may be supplemented with degradable natural fiber components. Turf reinforcement matting products shall meet NYSDOT Standard Specification Class III Type B (have the ability to protect soil from hydraulically-induced bench scale conditions for at least 3 psf at 1/2 soil loss). Upper velocity limits vary dependent on product manufacturer, quality of vegetation, type of flow and slope. Applications with anticipated velocities greater than 8-10 ft/sec and all potential applications of Turf Reinforcement Matting should be verified by the **Dam Safety Engineer**.



TYPICAL DETAIL FOR SOIL STABILIZATION MATTING ON SLOPE APPLICATION INSTALLATION



TYPICAL DETAIL FOR TURF REINFORCEMENT MATTING IN A CHANNEL APPLICATION INSTALLATION

VEGETATIVE SCREENING PLANTINGS (PE Review Req'd)

Supplemental plantings consist of small, nonwoody vegetation that may be planted on the canal embankment in addition to normal vegetative turf covering. While there are aesthetic benefits, there are also concerns and considerations with their use on water-impounding embankments.

Frequency: As Needed

NOTES:

- Supplemental plantings should only be installed in areas approved by the **Regional Canal Engineer** or **Dam Safety Engineer.**
- Plantings may only be installed in Zones 2B & 3 of the embankment (upper third of outboard slope). Refer to GENERAL section for description of the various embankment zones.
- Plantings should only be installed in areas that are easily accessible for routine maintenance. Vegetation on embankments reduces the visibility of the embankment surface that may show signs of failure. Additionally, vegetation can attract burrowing animals. As such, areas with supplemental plantings require maintenance on a regular basis to keep the vegetation in check and not allow for excessive growth.
- Plants shall be non-woody, have shallow root systems and a maximum mature height of 12 feet.

MAINTENANCE:

- Areas shall be thoroughly evaluated during inspections to ensure the vegetation is not obscuring potential signs of embankment distress.
- Areas shall be weeded regularly during the growing season to reduce the amount of vegetative growth, expansion of unwanted vegetation and general aesthetic value.
- Dead or diseased plants shall be removed and may be replaced in-kind as required. Any alteration in plant species must be approved by the **Dam Safety Engineer.**

INSTALLATION:

The following plants are permitted as supplemental plantings in Zones 2B & 3.

Butterflyweed *(Asclepias tuberosa)*
Big Blue Stem *(Andropogon gerardi)*
Switch Grass *(Panicum virgatum)*
Tufted Hair Grass *(Deschampsia cespitosa)*
Big Leaf Aster *(Eurybia macrophylla)*
Oxeye Sunflower *(Heliopsis helianthoides)*
Prairie Dropseed *(Sporobolus heterolepis)*
Lady Fern *(Athyrium filix-femina)*
Purple Lovegrass *(Eragrostis spectabilis)*

POLLINATOR PLANTINGS (PE Review Req'd)

Because pollinator plants are non-woody, have shallow root systems and provide resistance to soil erosion, they may be an acceptable substitute for turf grass in certain situations. A drawback to their use is that the visibility through the plantings is diminished over that of normal turf grass. Pollinator plantings provide much needed food and shelter for our native pollinators. Embankment vegetation management practices are friendly to pollinator landscapes.

Recommended Shallow-Rooted Pollinators for Zones 2B & 3:

Alumroot *(Heuchera americana)*
Blazing Star *(Liatris spicata)*
Beebalm *(Monarda didyma)**
Black-eyed Susan *(Rudbeckia hirta)*
Butterflyweed *(Asclepias tuberosa)*
Fireworks Goldenrod *(Solidago rugosa)*
Garden Phlox *(Phlox paniculata)*
Heath Aster *(Sympotrichum ericoides)*
Hyssopleaf Thoroughwort *(Eupatorium hyssopifolium)*
Joe Pye Weed *(Estrochium dubium)**
Labrador Violet *(Viola labradorica)*
New England Aster *(Symphyotrichum novae-angliae)**
New York Aster *(Symphyotrichum novi-belgii)**
Prairie Phlox *(Phlox pilosa)*
Smooth Aster *(Symphyotrichum laeve)*
Swamp Milkweed *(Asclepias incarnata)**
Tall White Beardtongue *(Penstemon digitalis)*
Wild Bergamot *(Monarda fistulosa)*
Wild Columbine *(Aquilegia canadensis)*
Woodland Sunflower *(Helianthus divaricatus)*
Zig Zag Goldenrod *(Solidago flexicaulis)*

** Prefers moist to average garden soil. Does not tolerate dry conditions.*

Notes:

- Pollinator plantings should only be installed in areas approved by the **Regional Canal Engineer** or **Dam Safety Engineer.**
- Pollinator plants should only be installed in Zones 2B & 3 of the embankment (upper third of outboard slope). Refer to GENERAL section for description of the various embankment zones.
- Plan for continuous bloom times throughout the growing season with a variety of flower color to support a variety of pollinator types
- Forbid the use of insecticides/pesticides within the areas (and beyond as practicable)
- Use only native non-woody pollinator plants
- In general, the use of cultivars of native plants (nativars) is not recommended.
- Plant in groups to increase pollinator efficiency

Maintenance:

- Mowing is required at least once per year to prevent the growth of woody vegetation.
- Limit mowing to 1 or 2 times per year, during the dormant period. Mowing should only be performed after the first hard frost in the fall or before plant growth begins in late winter or early spring.
- Provide educational signage and bee boxes to identify pollinator areas and educate the public

Installation:

- See plant list above

MOWING

Excessive vegetation on the embankment can lead to infestation by invasive species and other non-desirable growth (e.g., brush, trees and other woody vegetation), attract rodents and burrowing animals, and make inspections along the embankment more difficult.

Frequency: Twice per year, minimum or as required to maintain a desire maximum 12 in. height.

MOWING OPERATIONS:

1. Mowing off no more than 1/3 of the leaf blade is standard for good turf management. Prior to reaching the desired allowable maximum height, grasses should be mowed to between 2-4 in. height.
2. Ideally, NYSCC personnel should monitor site conditions and program mowing to occur when grass reaches 6" height.
3. All embankment slopes should be mowed at least twice per year.
4. Mowing just after seed has formed but before maturity will slow the growth of the turf for the rest of the summer. This allows for good inspection and not cause as frequent a mowing interval.
5. All appropriate safety apparel shall be worn as required by **Canal Corporation Safety Rules, CCHQ-1000.04R1; July 31, 2017 (or most current version).**
6. NYSCC personnel should determine the safe and appropriate equipment for mowing based on the site location. Manufacturer's recommendations should be followed to ensure proper use and maintenance of equipment.
7. Mowing should not be conducted when vegetation is wet.
8. Employees are responsible for selecting the right equipment for the mowing conditions. Refer to the operator's manual for maximum slope allowed for your equipment. Refer to the as-built plans for reference to embankment slopes.

CONTROL, REMOVAL & DISPOSAL OF JAPANESE KNOTWEED

Japanese knotweed can grow from 3 to 15 feet tall, has bamboo-like stems and is sometimes called Japanese bamboo. Japanese knotweed is considered an invasive species in New York and thrives in disturbed areas and once established can spread rapidly, creating monoculture stands that threaten native plant communities. It is commonly found along streams and rivers, in lowling areas, disturbed areas such as rights of way, and around old home and farmsteads. In New York State, NYSDEC refers to pesticides and herbicides collectively as pesticides and their application is regulated.

The information for this best practice has been taken from *New York Invasive Species Information*, www.nyis.info. And Homeowners guide to Japanese knotweed control: https://dnr.wi.gov/topic/invasives/documents/japanese_knotweed_control.pdf

PREVENTION

One of the best ways to prevent the colonization of Japanese knotweed is to ensure that disturbed habitats are rehabilitated with native vegetation before knotweed can invade.

MECHANICAL CONTROL

Single young plants can be pulled by hand depending on soil conditions. If all of the root system isn't removed, resprouting can occur. For small initial populations beyond single plants, grubbing with a pulaski or similar tool to remove all of the roots after cutting back the standing vegetation can be an effective control measure.

Cutting the knotweed only without root removal stimulates the below-ground rhizome to produce more growth. Furthermore, mowing or cutting with weed trimmers can move pieces of the plant to re-sprout, spreading, rather than controlling the plant.

CHEMICAL CONTROL

The use of pesticides for vegetation removal must be reviewed and approved by the **Director of Environmental Health & Safety**.

All pesticides must be applied by a licensed certified applicator.

All pesticides must be applied in accordance with manufacturer's written instructions.

DISPOSAL

If mechanical control is employed, all parts of the removed plants should be bagged and disposed of in a secure location.

BEST PRACTICE

The best approach to control is through a combination of cutting and pesticide application. A late spring/early summer treatment followed by an early fall re-treatment is needed. Several years of treatment may be needed for well-established populations. The plant will not resprout from the cut cane but removing them may aid in finding and treating resprouts in an infested patch. The area will also be more conducive to revegetation if the cut canes are removed.

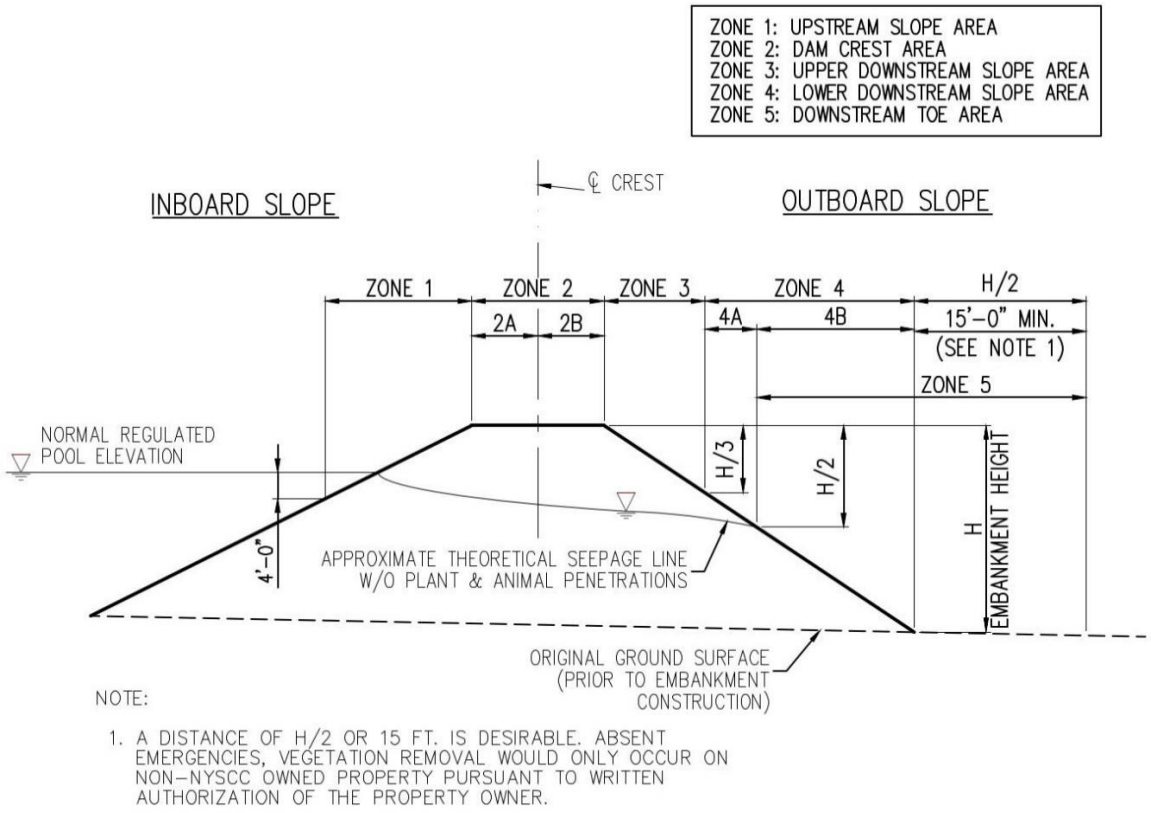
RECOMMENDED PROCEDURE

1. Coordinate with pesticide applicator to work concurrently as effective treatment requires treatment with pesticide immediately after cutting.
2. On a day where it will be free of rain for at least 1 hour after treatment, cut the stem of the plant 2-3 inches above the soil.
3. Wearing rubber gloves, spray immediately with pesticide mixture. You will only need to spray the cut rim of the plant stem. The plant will want to seal itself up soon after injury, so there is a window of just a few minutes where the pesticide can be taken up. Overspray will harm surrounding vegetation.
4. You must wait at least 7 days before re-cutting, mowing or disturbing treated stems. The pesticide needs time to move into the belowground structures for an effective kill.
5. After the plant has regrown (early fall), you may use the cut and treat method again. Treatment of the leaves with pesticide after regrowth may also be effective.

TREE AND BRUSH REMOVAL (PE Review Req'd)

Growth of woody vegetation on embankments can lead to serious problems and prevent visibility and access for inspections and routine or emergency maintenance. Sudden uprooting can enable embankment sloughing. Root systems of dead trees can allow for possible increases seepage and potential piping. Falling trees can damage parts of the embankment. These are just a few of the possible problems woody vegetation can cause. Control and removal of woody vegetation should be done routinely as part of the embankment maintenance program.

Frequency: As Needed



Embankment Zones for Vegetation Management

TREES AND BRUSH WITH TRUNK DIAMETER AT BREAST HEIGHT (DBH) GREATER THAN 3"

Trees and brush with DBH greater than 3" can pose a significant threat to an embankment and need to be treated with care. There are a number of considerations to take into account when dealing with removal. All plans for tree and brush removal of this type must be reviewed and approved by the **Dam Safety Engineer** prior to completion. Some special considerations that must be taken into account when developing a removal plan include:

- Permits or restrictive clearing dates for bats such as the Northern long-eared bat (NLEB) and Indiana Bat

- Diameter of tree—indicator of root size, depth. Larger trees may have larger root systems that may go further into the embankment
- Location of tree — damage from trees and good tree removal and repair techniques are most critical near the toe of the embankment in Zones 4 & 5 [lower 2/3 of embankment outboard side] and on the inboard side of the embankment in Zone 1 (zones shown in figure on previous page).
- Proximity to additional trees— roots from multiple trees may have formed together into a larger root ball
- Number of other trees to be removed—the quantity of holes being dug and repaired in the dam embankment is of concern. A large number of holes or a cluster of repaired holes could lead to instability of the embankment.
- Water levels in the canal— to minimize risk while repairing holes in the embankment water levels should be at their lowest. If possible, work should be completed when the embankment is not retaining water such as during the non-navigation season. Water level draw down may be necessary.

REMOVAL PLANS:

Removal plans should, at a minimum, include:

- A sketch or plan indicating the location of the tree(s) to be removed. The sketch should be kept on file with the embankment inspections and be used for future monitoring.
- A determination of what stumps (if any) can remain. Consult with **Dam Safety Engineer** for this determination as it will vary by location. Generally, all stumps greater than 4" diameter must be pulled in all zones and stumps smaller than 4" diameter may require removal in Zones 1 & 5. High hazard embankments or embankments with seepage or other noted issues may require more extensive stump removals.
- Coordination with Environmental Health & Safety (EH&S) for removal restrictions including, but not limited to:
    - Documentation of compliance with Endangered Species Act. Northern Long-eared Bat and Indiana Bat are known to exist in some locations of New York State. If tree clearing within one of these areas, coordination with NYSDEC and USFWS may be required. Tree removal within 0.25 mi of known bat hibernacula or 150 ft of known roost trees as determined by Environmental Affairs is not permissible. Clearing must only be conducted between November 1st and March 31st.
    - For work sites within the NYSDEC designated Emerald Ash Borer (EAB) Restricted Zone, the contractor shall certify compliance with the NYSDEC regulations regarding EAB.
    - Community outreach (See Chapter 9 of Guide Book).
- Excavation which allows for removal of all roots greater than 1" in diameter.
- Backfill the hole with suitable approved embankment material to 95% compaction per ASTM D-698 (standard proctor).
- Coordinate with NYPA EH&S for removal restrictions
- Coordinate any excavation of the dam embankment with **Dam Safety Engineer** prior to start. See additional guidance in FEMA 534 "Technical Manual for Dam Owners—Impacts of Plants on Earthen Dams," September 2005 for additional detailed provisions for tree and brush removal.

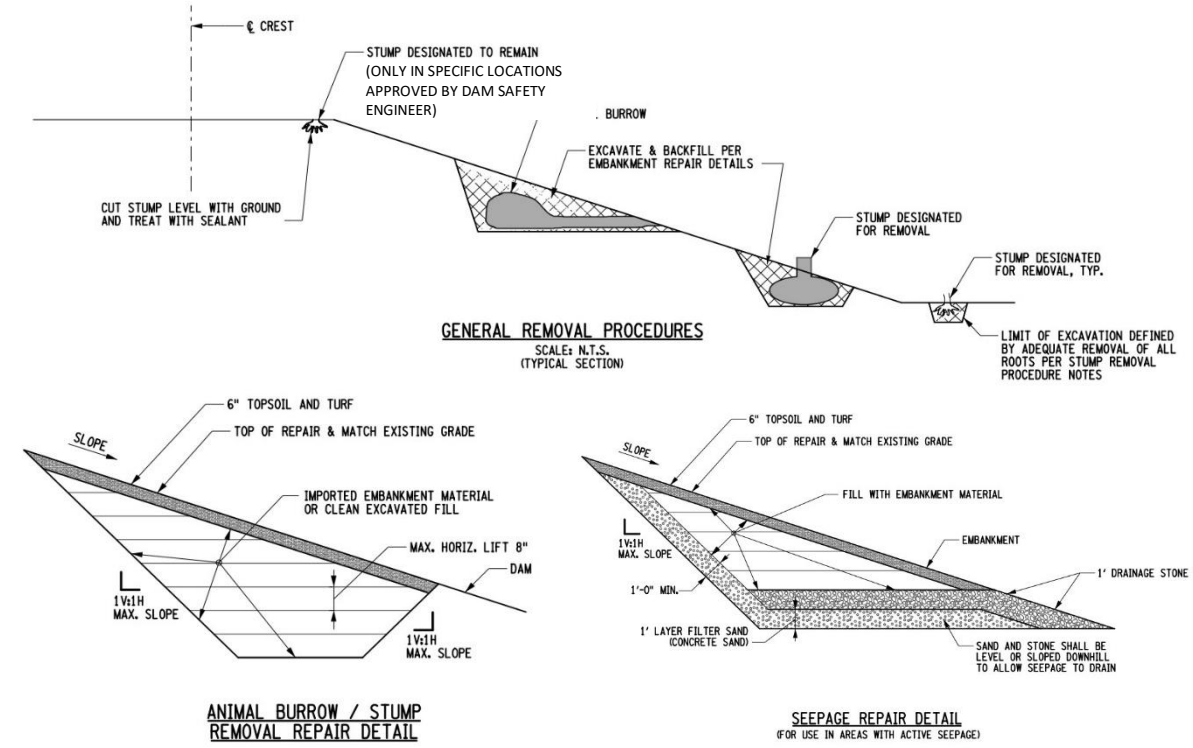
TREE REMOVAL PROCEDURES:

- For trees where the stump is to be removed, cut the tree approximately 2' above ground leaving a well-defined stump that can be used in the root ball removal process.
- For trees where the stump may remain, cut flush with the ground and treat with a waterproof sealant (polyurethane or equivalent) to prolong stump and root ball decay.

STUMP AND ROOTBALL REMOVAL PROCEDURES (P.E. SUPERVISION REQUIRED):

- Consult with **Regional Canal Engineer**.

- Professional Engineer (P.E.) must be present during removal.
- Remove the stump and root ball by pulling the stump or extracting with a track-mounted backhoe after loosening the root ball by pulling on the stump from different directions.
- Remove the remaining root system down to 1/2" diameter roots for Zone 1 and 1" diameter roots for Zones 2-5.
- Remove loose soil from the root ball cavity by excavating the sides of the cavity no steeper than 1H:1V and the bottom of the cavity approximately horizontal.
- Backfill the excavation with well-compacted soil placed in maximum loose lifts of 8".
- Sand and stone filter material selection (for seepage areas) should be performed by a P.E. to satisfy filter criteria



DISPOSAL:

All wood and brush shall be disposed of and removed from NYSCC property. **No burning is permitted on NYSCC property**. The following methods are generally approved for disposal. All methods shall be authorized by the **Regional Canal Engineer**.

- Salvage marketable timber provided the amount of timber is great enough to make the hauling practical. Costs for removal should be factored into potential salvage value and extraction plans. Chips are easier to haul on the site than whole logs. Typically, marketable timber includes logs 8 –16 feet in length, plus appropriate trimming allowance, having a diameter inside the bark, at the small end, of approximately 10 inches.
- Any wood that is cut up in firewood lengths or other marketable lengths may be neatly piled on site in an approved area until transport arrangements can be made.
- **No burial of wood is permitted on NYSCC property.**

Wood may be chipped. Chips shall be less than 1/2" thick and no greater than 4" in any dimension. Chips may be mulched on site, disposed of off-site or stored at location approved by **Regional Canal Engineer** and **Director of Environmental Health & Safety**.

AQUATIC VEGETATION REMOVAL

Aquatic vegetation is typically not wanted within the Canal System as it can impede boat traffic and clog operational structures. In New York State, NYSDEC refers to pesticides and herbicides collectively as pesticides and their application is regulated. Removal of Aquatic Vegetation may be undertaken by Canals only when approved by **Director of Environmental Health & Safety** and **Regional Canal Engineer** and shall be executed only when a permit is in place and aquatic weed growth is impacting Canal hydraulic control structures (spillways, weirs, gates, etc.) or navigation traffic (in the navigation channel as an obstruction or in the lock/lock approach).

AQUATIC VEGETATION REMOVAL:

- Aquatic vegetation removal and control is primarily accomplished by the application of aquatic pesticides.
- In NYS, the application of aquatic pesticides is regulated by NYSDEC through pesticide registration, pesticide applicator certification, pesticide business registration and two types of aquatic pesticide permits.
- Aquatic vegetation removal should only be conducted when a permit is in place.
- The use of pesticides for vegetation removal must be reviewed and approved by the **Director of Environmental Health & Safety**.
- All pesticides must be applied by a licensed certified applicator.
- All pesticides must be applied in accordance with manufacturer's written instructions.

DEBRIS COLLECTION & REMOVAL

Debris accumulation is often a problem within the Canal System, particularly following large storm events. Debris can include trees, grasses, garbage, fences, etc. The debris can cause irregular flow patterns that cause increased loads on the embankments. It can also become a hindrance for boat traffic.

Debris accumulation can also be the result of beaver activity.

Frequency: As Needed

MONITOR:

- A visual check for debris along the Canal System embankments should be conducted at each visit. Any significant debris should be reported to the **Regional Canal Engineer** and be scheduled for removal.
- It is especially important to check for debris at culvert entrances in the vicinity of the canal embankments. A partially blocked entrance tends to trap more and more debris progressively until there is essentially no flow. If this occurs at a dive culvert within an embankment or at a culvert in close proximity to an embankment, the flow can eventually back up enough to flood adjacent areas and if left unchecked can get high enough to flow over the canal bank into the canal. The flow into the canal can cause erosion which if significant enough could lead to failure of the embankment.
- Another area of floating debris accumulation is at waste weirs and spillways. It is important that excessive debris buildup be prevented so as not to diminish the conveyance capacity of the spillways or weirs.
- Woody debris may be able to be chipped and used elsewhere within the Canal System. See *Tree and Brush Removal* for disposal options. Garbage and other debris should be disposed of appropriately. Material should not be deposited back into the Canal System, wetlands or adjacent waterways.
- When large debris is encountered, the embankment should be checked for signs of damage or scour from the debris and repaired as necessary.
- Confirm access with respect to wetlands, private property, etc. prior to selecting and mobilizing equipment.
- Check gate areas and probe for debris prior to operating gates/valves.
- Monitor buoy lines for debris collection.
- Culverts with inlet protection (grates) must be monitored and debris cleared and disposed of regularly.
- If inlet protection (grating, bars or similar) is added, the monitoring and clearing of debris should be added to the maintenance schedule.
- Monitoring and clearing of culvert inlets prior to and during flood events are recommended to help prevent blockages.

3 EROSION, SETTLEMENT, & EFFECTS OF ANIMALS

GULLEYS / RILLING

Erosion is one of the most common maintenance problems on earthen embankments. Periodic and timely maintenance can help keep this problem in check. Establishing turf grass, providing drainage blankets, installing toe drains or installing inboard or outboard slope protection, as specified by the **Dam Safety Engineer** are the appropriate practices to apply.

Frequency: As Needed

EMBANKMENT REPAIRS:

- Rills and gullies should be:
    - Examined by a **Dam Safety Engineer** to identify whether large or deep features constitute an emergency condition or an on-going problem.
    - Scraped or excavated to remove unsuitable surface materials, such as organics, segregated aggregates (fines washed out), surface irregularities that will impede compaction of subsequent fill, vegetation, debris, etc.
    - Shaped as necessary to ensure suitable compaction of subsequent fill. This is typically 1V:2H or flatter.
    - Filled with suitable embankment material and compacted. If possible, the top 6" should be soil that will support grass growth if *Establishing Turf Grass* is to be implemented.
    - Reseeded and stabilized with appropriate vegetation if *Establishing Turf Grass* is implemented.
    - *Toe Drains, Drainage Blankets or Slope Protection* are specified by the **Dam Safety Engineer** follow the appropriate Maintenance Best Practice.
- To minimize recurrence, the source of the erosion problem should be investigated by the **Dam Safety Engineer**. Erosion and sediment control measures such as rolled erosion control product, straw bales or others may be used to prevent erosion from occurring during the vegetation establishment.
- If the erosion is from a more chronic issue, such as a low point in the crest or concentrated runoff from upstream sources, other forms of repairs may be necessary in addition to stabilization of the rill. Large gulleys may require more involved repairs. Rock check dams can be placed to slow runoff and reduce erosion until more substantive repairs can be made. If the problem persists, contact the **Dam Safety Engineer** for guidance.

SLOUGHS / SLIDING

Embankment slides and sloughing of banks can be a sign of a much more serious problem. Signs of potential sliding or sloughing include, but are not limted to, bulging soil, tilted trees or posts, deformed fencing, cracked paving, formation of a scarp, development of cracks in an arcuate (curved or bowlike) shape, and settlement at the crest.

Frequency: As Needed

EMBANKMENT EVALUATION & REPAIRS:

- Depending on size and location, this situation is a potential embankment safety emergency. The **Dam Safety Engineer** should be notified immediately to assess the situation and determine if emergency notifications should be enacted.
- On the canal embankments, slides and sloughs on the inboard slope often occur due to wake or wave erosion at the waterline. Proper shoreline protection is usually sufficient to prevent to formation of sloughs.
- Repairs for large sloughs or slides on an embankment should not be addressed in-house.

TEMPORARY STABILIZATION (or as directed by **Dam Safety Engineer**):

- In the event of a slide, all effort should be made to divert any runoff or anticipated drainage from reaching the affected area. Straw bales, waterway diversions and other erosion and sediment control measures should be employed.
- The area should be covered to prevent further exposure to rain and wind. Erosion control matting, tarps, and other forms of temporary covering—depending on the size of the slough, may be appropriate. Care should be taken when working near the slide. Earth slides can be unstable and subject to further shifting. Heavy equipment should not be driven on or near the slide until approved by the **Dam Safety Engineer**.
- Geotextiles shall not be used for long-term repairs. Geotextiles are typically not used in dam/water retaining embankments because they can degrade over time and because they can clog or become fouled with organic material potentially creating a situation where the geotextile “blows out” due to hydrostatic pressure.

SETTLEMENT VOIDS / SINKHOLES / SUBSIDENCE (PE Review Req'd)

Settlement voids and sinkholes are caused by material being lost from below the surface and may be an indication of piping occurring.

Frequency: As Needed

INVESTIGATION:

- Settlement voids and sinkholes may be indicative of a severe problem. The **Regional Canal Engineer** should be contacted immediately.
- Search the area on the outboard side of the embankment to look for signs of seepage flow and sediment transport. Look for where the lost material from within the embankment may be going.
- If sinkholes align with a culvert or other feature within the embankment, note that. Such locations may be locations where embankment material can be lost and washed away without any obvious trace.
- Monitor sinkhole exit for signs of turbid water, which will indicate if active erosion of earthen material from the dam embankment is occurring. Contact **Dam Safety Engineer** immediately in situations where turbid water is seen. If the **Dam Safety Engineer** is not available, notify the Thruway Statewide Operations Center (**TSOC**) immediately at **1-866-691-8282** and inform them of a potential dam safety emergency situation at the site and request them to notify the **Canal Duty Officer**.
- Thoroughly inspect other areas of the embankment for other signs of failure.
- Subsidence is the general term for ground movement. Settlement voids are typically smaller and more stable than sinkholes, which are typically considered larger and less controlled.

REPAIRS:

Any repairs should be performed under the supervision of a licensed professional engineer. In general, repair of settlement voids, sinkholes, or subsidence consists of:

- **Slow excavation** to 1) expose the extent of the underlying void (normally a larger void exists beneath the surface depression or hole), and 2) determine the underlying cause (e.g., seepage carrying away fines causing piping, loss of fine material into coarser base fill material such as rock fill, etc.).
- **Stabilization** of the area to prevent enlargement of the depression or sink hole expressed at the surface.
- **Prevent the underlying loss of material**. Unless the underlying root cause is identified and addressed, any repairs will be temporary.
- **Filling** the sinkhole/ depression is the last step after the root cause has been addressed. Fill material must be compatible with the surrounding soils (particle size/filter criteria to prevent migration of fines). Soil materials

(granular fill, or excavated native material), grout, concrete or flowable fill may also be appropriate fill depending on the specific situation.

- **Safety.** Provide a safety barrier around the area as needed.

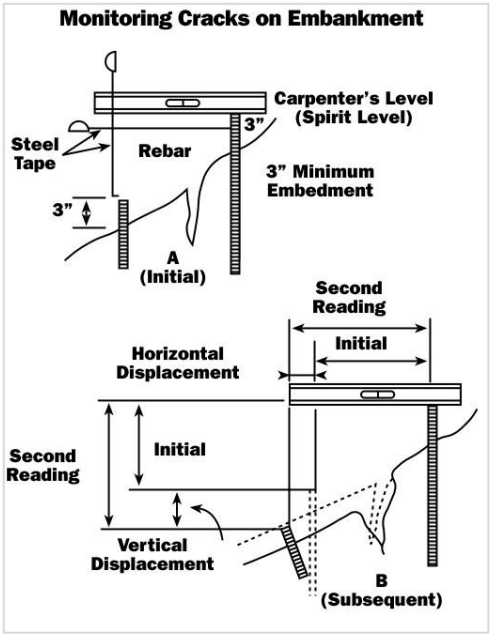
EMBANKMENT CRACKS

The entire embankment should be inspected for cracks. Short, isolated cracks are not usually significant, but larger (wider than 1/4 inch) well-defined cracks can indicate a serious problem.

Frequency: As Needed

MONITORING CRACKS:

- Cracks can be either drying cracks, due to the lack of moisture and surface drying which are not usually of significant danger to the embankment, or structural cracks which may be a sign of a more serious problem and could lead to sloughing or localized failure. All cracks should be reported to the **Regional Canal Engineer** for further evaluation.
- Cracks should be monitored routinely for evidence of further crack development or growth. Stakes and monitoring pins can be used to mark the longitudinal limits and width of the crack, record measurements and take photos of the cracking including width, depth, alignment and other pertinent features of the crack. Cracks with edges that are vertically offset are typically structural in nature.
- Formation of cracks in an arc could be indicative of instability. See Sloughs / Sliding.
- Recurring cracks or cracks which appear seasonally or routinely may indicate a problem. Report such situations to the **Dam Safety Engineer** for further evaluation.
- Erosion and sediment control measures such as straw bales may be used to minimize the amount of runoff or other drainage from entering the crack and causing further damage.



REPAIR OF MINOR CRACKS:

- Once approved by the **Dam Safety Engineer**, minor cracks may be filled and repaired. Cracks may be backfilled with bentonite-sand mixture with the top 6" being soil that can support vegetation and vegetation should be established. Alternatively, cracks that have been stable over time may be over excavated and filled with material similar to the existing embankment fill. This should be thoroughly compacted with a hard tamper and vegetation established.
- Following repair, the location of the crack should continue to be monitored for signs of further movement.

RODENT BURROWS (PE Review Req'd)

Rodents, such as woodchucks (groundhogs) and muskrats often occupy areas alongside the Canal System, earthen embankments, trestles, and culverts. Their burrowing activities can cause serious damage to the Canal System. Burrowing activities in earthen embankments can lead to structural damage, incidents and costly repairs. These types of damages are widespread throughout the NYSCC portfolio and so maintenance and prevention is of utmost importance.

Frequency: As Needed

See additional guidance, *FEMA 473 "Technical Manual for Dam Owners, Impacts of Animals on Earthen Dams"* September 2005—Section 5.0.

IDENTIFICATION

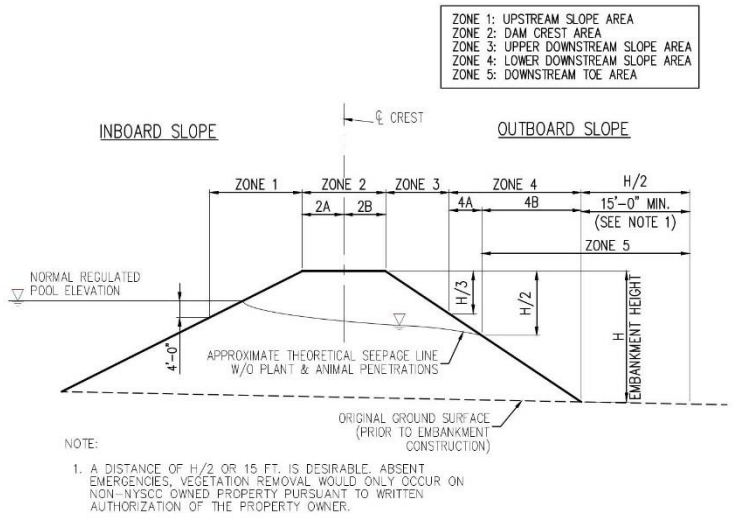
- Animal burrow entrances, mounds of excavated soil, debris, cracks, depressions, erosion, sinkholes, paths and ruts, sloughs, slides, and scarps near the inboard shoreline and crest.
- Concentrated seeps, wet/spongy areas, cracks, depressions, erosions, sinkholes, paths and ruts, sloughs, slides, and scarps associated with animal burrows in Zones 1, 4 and 5 (inner slope and lower two thirds of outboard slope, refer to next page for zone identification) should receive immediate attention and notification of the **Regional Canal Engineer.**
- All rodent burrow repairs should be noted on the inspection form and marked for follow up inspections. Repairs should be monitored for rodent activity, slumping, seepage and erosion.

ANIMAL CONTROL:

- NYSCC has entered an agreement with USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services (WS) for assistance with control of the rodent population at its canal embankments. All trapping, relocating and population control measures shall be undertaken by APHIS, not by NYSCC directly.
- Any specific needs for animal control should be addressed to the Director of Environmental Health & Safety using Environmental Permit SOP Obtaining, Renewing or Modifying Environmental Permits CCHQ-2010.09 R00.

REPAIRING RODENT BURROWS:

- Identification of, and controls on rodent activity should be implemented during early spring when active burrows are easy to find, the young rodents have not scattered, and there is less likelihood of damage to other wildlife or damage to other wildlife.
- Have animals removed before attempting burrow repairs.
- Burrows in Zones 1-3 without accompanying signs of embankment distress can be filled with bentonite chips or flakes or cementitious slurry (mud-packing).
- Signs of embankment stress surrounding a burrow may indicate massive soil movement. In this case, complete removal of the burrow is preferred (excavation).
- Excavation: Refer to the Excavation BMP for further information. The **Regional Canal Engineer** should be consulted prior to any excavation activities.



ZONE REMEDIATION

- Zone 1: Critical due to proximity to phreatic surface. Potential issues: Muskrat burrowing and wave erosion. Treatment measures: Lower water level, excavate and backfill under the direction of the **Dam Safety Engineer,** slope hardening (along entire inboard slope, not just at burrow location).
- Zones 2 and 3: Not as critical, but important. Burrows can be extensive, must identify culprit; refer to FEMA 473. If burrow is discrete or limited in size and extends down from entrance, not up slope, fill with earth or standpipe system. Extensive burrows that won't easily be completely filled should be excavated and repaired under the direction of the **Dam Safety Engineer.**
- Zones 4 and 5: Phreatic surface effects very possible. Remediate burrows under the direction of the **Dam Safety Engineer** and involve installation of drainage blanket, or toe drains as appropriate. Carefully select backfill (silty sand predominantly acceptable), compatible with existing embankment material.

SMALL BURROWS (<6" diameter):

- Small, shallow holes may be repaired by filling the hole with earthen material or bentonite chips or flakes.
- Place earthen material as deep as possible into hole, place in lifts, tamping and compacting continuously.
- Fill the last 6" with soil that will support grass growth, or with gravel or other suitable material to match existing embankment.
- Establish turf grass.

LARGE BURROWS (>6" diameter):

- Large burrow holes should be filled with a mud-pack mixture: 90% earthen material, 10% cement, adding water until a slurry of thin cement is obtained.
- Fit a vertical vent pipe or other suitable material into the burrow hole, creating a tight seal. Pour mud-pack mixture into vent pipe allowing the mixture to fill as much of the burrow as possible, to within 6" of the surface.
- Fill the last 6" with soil that will support grass growth, or with gravel or other suitable material to match existing embankment.

EXTENSIVE DAMAGE:

- Widespread, extensive rodent tunneling is a very significant problem requiring evaluation by the **Dam Safety Engineer**. Problem should be immediately brought to **Regional Canal Engineer's** attention for contract repairs. Refer to details on the Tree and Brush Removal Best Management Practice sheet for details to excavate and backfill large animal burrows.

PREVENTATIVE MEASURES

- Use proper and frequent mowing to discourage burrowing and limit vegetation for food supply, protective cover and shelter, including aquatic vegetation along shore.
- Maintain Upstream Slope Protection (inboard side).
- Relatively flat slopes (less than 1V:3H) deter burrowing of aquatic rodents.
- Proper soil compaction to discourage burrowing.

BEAVER DAMS

Beavers often occupy areas alongside the Canal System, earthen embankments, trestles, and culverts. Their damming and impounding of water can cause serious damage to the Canal System. These damages are widespread throughout the NYSCC portfolio and so maintenance and prevention is of utmost importance.

Frequency: As Needed
Removal permits are easier to obtain if the beaver den is < 2 years old. Prompt attention is recommended.
See additional guidance, *FEMA 473 "Technical Manual for Dam Owners, Impacts of Animals on Earthen Dams"* September 2005—Section 5.0.

IDENTIFICATION

- Gnaw marks in a circular pattern on tree trunks, and beaver dams.

ANIMAL CONTROL:

- NYSCC has entered an agreement with USDA Animal and Plant Health Inspection Service (APHIS) Wildlife Services (WS) for assistance with control of the rodent population at its canal embankments. All trapping, relocating and population control measures shall be undertaken by APHIS, not by NYSCC directly.
- Any specific needs for animal control should be addressed to the **Director of Environmental Health & Safety** using Environmental Permit SOP Obtaining, Renewing or Modifying Environmental Permits CCHQ-2010.09 R00.

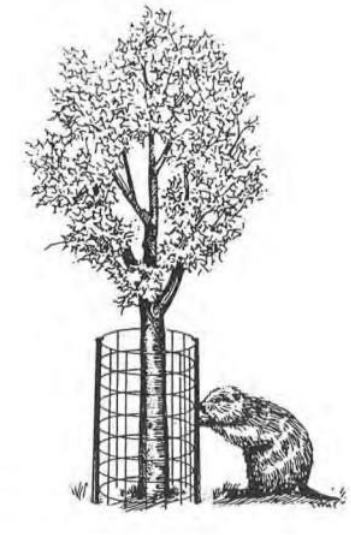
PERMITTING:

A permit is required prior to removing or disturbing a beaver dam.

New York Environmental Conservation Law Article 11 Section 11-0505 states that no person is allowed at any time to disturb a beaver's dam, house, or den without written permission from DEC. If needed, permission to go on lands that the NYSCC does not own or legally control must be obtained prior to performing the work.

The *Beaver Damage Control Techniques Manual* (NYSDEC, 1996) was developed to provide information on the most effective techniques available for resolving beaver/human conflicts. A summary of standard procedures for handling beaver nuisance complaints are as follows:

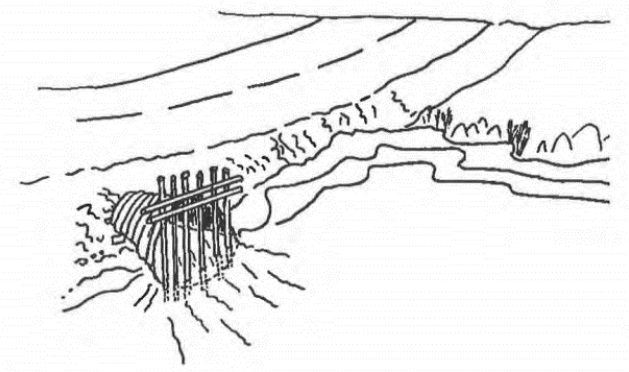
- A "Nuisance Beaver Permit" needs to be acquired from the NYSDEC to permit to kill or harass destructive wildlife pursuant to Environmental Conservation Law 11-0521. The permit may authorize agents certified by NYSDEC for lethal removal (via firearm or trapping), disturbance or removal of any beaver dams, and to set traps within 15 feet of the beaver dam and the beaver lodge.
- The Nuisance Beaver Permit may be issued along with a General Permit for Breaching/ Removal of Beaver Dams no more than 2 years old. The General Permit is only valid when issued concurrently with a Nuisance Beaver Permit. This permit is applicable to regulated freshwater wetlands, including the wetland adjacent area, and to protected and navigable waterways throughout New York State, excluding New York City, and Long Island. The permits expire concurrently.
- Both permits consist of a set of Conditions and Notification of other Permittee Obligations. This includes the requirement to lower water levels within the beaver impoundment with slow and partial breaching. This slow breaching reduces downstream impact from the water release, helps minimize sediment disturbance and can help with trapping the beavers since they are attracted to the flow.

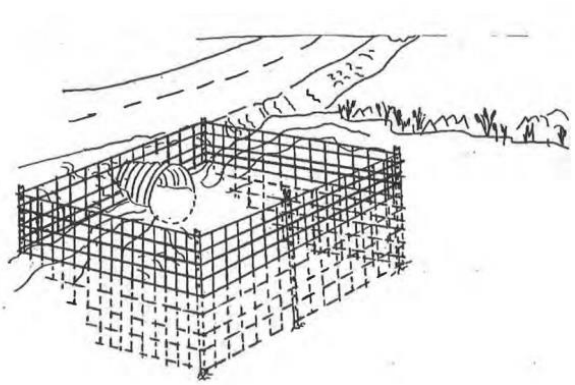


PREVENTATIVE MEASURES

The *Beaver Damage Control Techniques Manual* (NYSDEC, 1996) was developed to provide information on the most effective techniques available for resolving beaver/ human conflicts. A summary of standard procedures for handling beaver nuisance complaints are as follows:

- Protect Trees and Shrubs: Individual Shrubs and Trees can be protected by loosely wrapping welded wire fencing, zinc or plastic coated, or roofing felt held in place with string or wire, to a minimum height of 36 inches. Groups of shrubs or trees can be protected with 36-inch-high fences made of welded wire, woven wire or 12-inch-high tensile electrified wire with a minimum of 3 strands of wire spaced at 4-inch intervals.
- Pitchfork-shaped guard: This is made of heavy steel rods welded 6" apart to 2 horizontal braces or a piece of 3- to 4-inch channel iron. This device is pushed into the bottom to hold it in place in front of the culvert. It is a preventative measure to keep wandering beaver from getting inside a culvert and plugging it.
- Deep Water Fence: These D-shaped or square fences, 10 to 20 feet on each side, made of 6-inch by 6-inch reinforcing steel mesh held by 6' steel fence posts. These are placed above intakes to prevent flood-water debris or beaver from blocking a culvert. If beaver place material against the fence, the resulting dam becomes a temporary emergency spillway which must be removed or modified.
- Refer to **Debris Collection & Removal** BMP for information regarding monitoring and debris removal that will be required when adding grating or fencing around culverts.





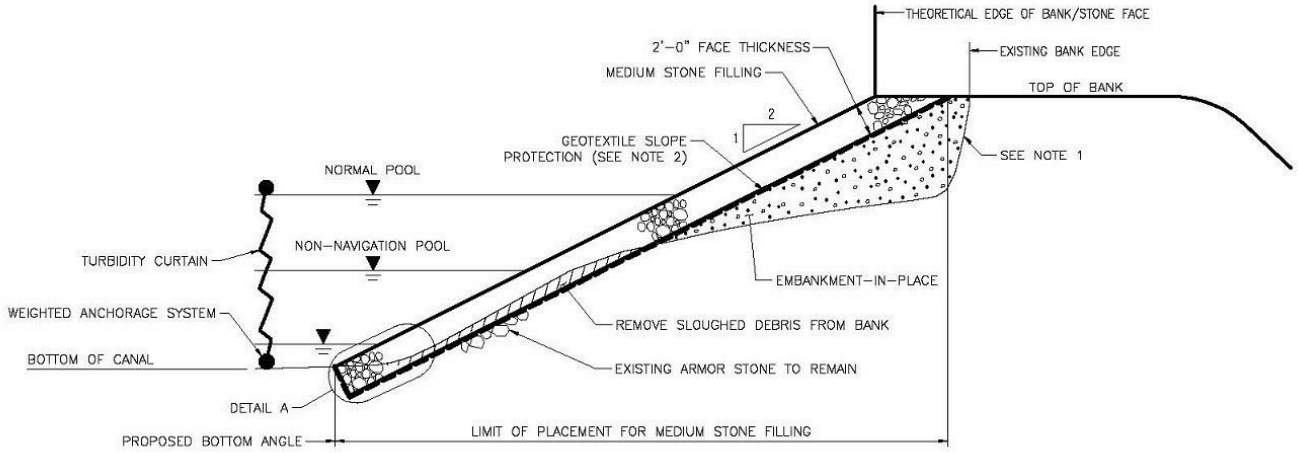
UPSTREAM SLOPE PROTECTION (INBOARD SIDE) (PE Review Req'd)

Some locations of the Canal System are protected on the inboard side of the embankment from erosion caused by wave action from wind or boating activities.

Frequency: As Needed

REPAIRS:

- Where riprap is already in place and general shifting over time has occurred, reestablish grade line with material meeting the specifications of NYSDOT Medium Stone Fill and thickness of 2 feet. Place slope protection material along extents of as-built slope protection as shown on record plans which may extend from above maximum navigation pool along inboard slope to the bottom of the Canal Prism OR a minimum of 3.5 feet above the maximum navigation pool level and 5 feet below the minimum navigation pool level. Installation during non-navigation season or lowering the water level of the canal may be necessary for installation.
- Riprap will erode and shift naturally, however, the need for repeated maintenance and repair is an indication of inappropriately sized or placed material or improper bedding material. Contact the **Regional Canal Engineer** for further analysis and recommendations.
- For embankments adjacent to open expanses of water (e.g., lakes and reservoirs), slope protection sizing, and toe key detail shall be reviewed and confirmed by a licensed engineer prior to placement. For areas along the typical canal channel, medium stone fill is acceptable to use for slope protection.
- Work and placement of fill below the Mean High Water Mark may require permitting. Contact the **Director of Environmental Health & Safety** for guidance on permit requirements.
- For stone protection in riverine conditions, the stone should be sized by a professional engineer for stability in flowing water conditions.
- Do not use geotextiles in these installations.
- See Chapter 8 of Guide Book for permitting, surface waters and floodplains involvement.

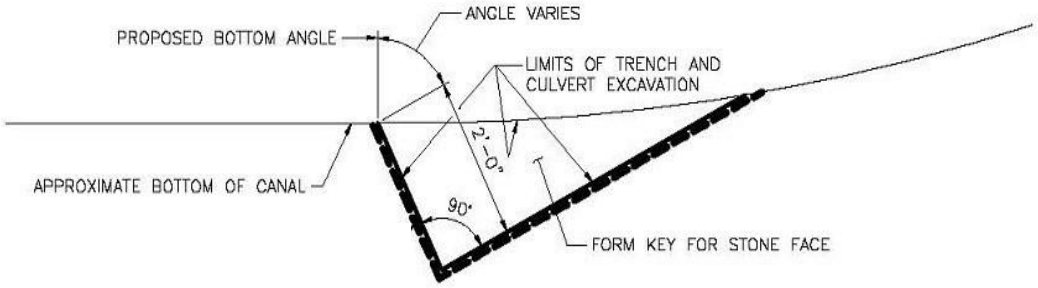


TYPICAL SECTION

NOT TO SCALE

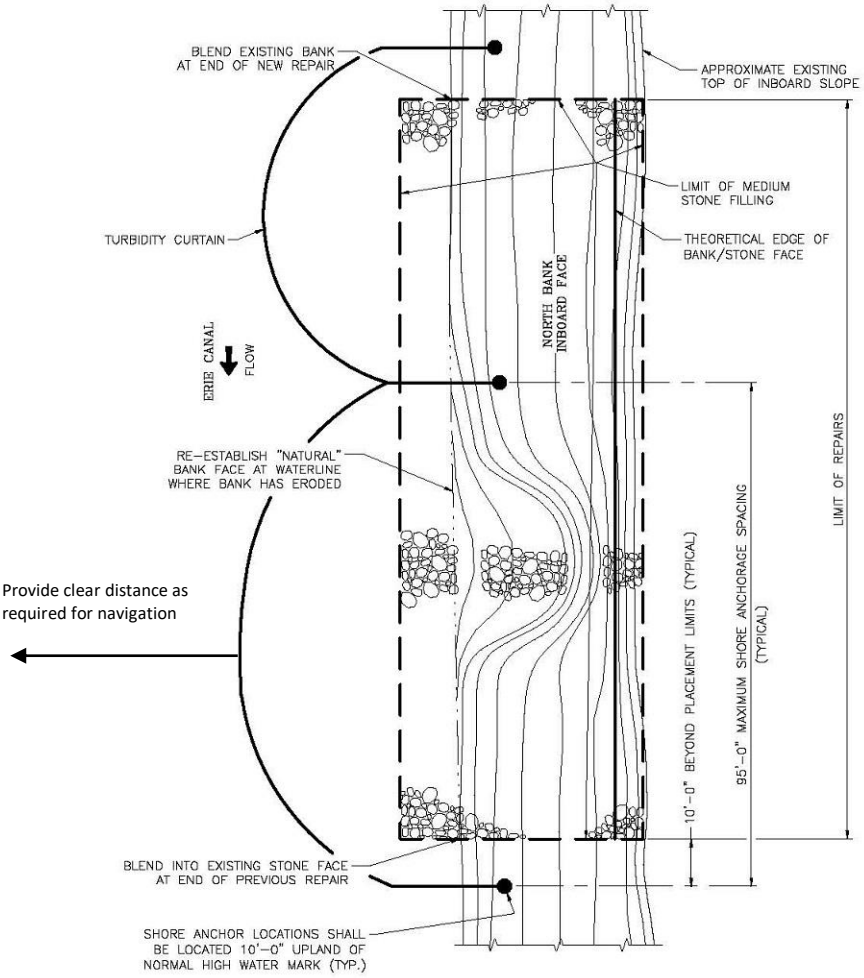
NOTES:

1. FOR EXISTING SLOPES GREATER THAN 1 ON 3, BENCHING IS REQUIRED.
2. GEOTEXTILE SLOPE PROTECTION, SHALL COMPLY WITH THE FOLLOWING: GEOTEXTILE BEDDING (CLASS 1/COMBINATION MONOFILAMENT/FIBRILLATED WOVEN, BD CLASS B).



DETAIL A

NOT TO SCALE



TYPICAL REPAIR PLAN

NOT TO SCALE

RUTTING ALONG CREST

Access roads along embankments are common; however, if the surface is not constructed with the proper subbase, base and wearing surface for driving, ruts can form from traffic during wet conditions. Low spots may lessen water storage capacity and create areas for concentrated overflow.

Frequency: As Needed

NOTES:

- Timely repair of ruts and vegetation loss can save considerable effort and expense later.
- Driving on unprotected embankments in wet conditions should be avoided.
- Ruts, near surface deformation, and loss of vegetation can be the result of frequent vehicle and animal crossings.
- If embankment is to be used as a frequent driving surface and a durable surface does not already exist, **Regional Canal Engineer** should be consulted to provide suitable wearing surface, line, grade, and cross slope.
- If the embankment is rutting, but rutting is not from driving, or animal crossings, or is a frequent maintenance issue, this could be a sign of a settlement issue or an impending slide. Contact the **Dam Safety Engineer** for further evaluation.

REPAIRING RUTS AND NEAR SURFACE DEFORMATION:

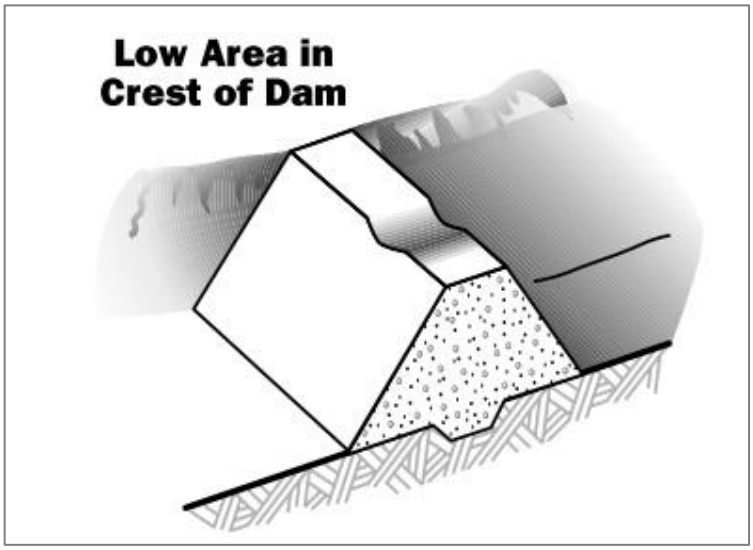
The repair methodology for ruts, surface deformation, and vegetation loss includes the following steps:

1. Clear the area of deleterious material such as organics, debris, and wet/saturated soils. If excavation of the area becomes necessary, contact the **Dam Safety Engineer** for further instruction. Fill the rut with soil of a similar type to that of the embankment. Where ruts are within a prepared driving surface, fill with suitable granular material. Overfill the rut slightly to account for compaction of the fill material.

2. Compact the soil using hand-held or walk behind equipment. In order to achieve reasonable compaction, the fill material should not contain particle sizes greater than 1 inch in diameter. For larger ruts, and ruts created by vehicles, larger diameter material may be acceptable. The compacted surface should be smooth and level with the surrounding ground and sloped to drain into the canal.

3. Stabilize areas to be vegetated with turf grass. See *Establishing Turf Grass* BMP.

ISOLATED SETTLEMENT



Settlement is to be expected along the embankment crest due to further compaction; however, excessive settlement or isolated areas of settlement can be signs of a more serious problem. Settlement in the crest can also reduce the Canal Segment's storage volume and potentially create locations for concentrated embankment overtopping in a flood even.

Frequency: As Needed

MONITOR:

- Establish survey monuments along the crest of the embankment to determine the exact amount, location and extent of the settlement along the crest.
- Report the issue to the **Regional Canal Engineer** for further evaluation.

REPAIRS:

- Backfill of the settled area with suitable embankment material approved by the **Regional Canal Engineer** to 95% compaction per ASTM D-698 (standard proctor).
- Area should be compacted and graded to allow runoff to drain into the canal.
- Where practicable, the top 6" should be soil that will support grass growth. Stabilize the crest with appropriate vegetation. See Establishing Turf Grass.
- Reestablish survey monuments for continued monitoring of crest elevation.

PAVED PATH / ROADWAY ALONG CREST

Paved and unpaved paths / roadways are a common feature at the crest the canal embankment. If designed properly, they should have little effect on the condition of the embankment or operation of the canal.

They are important features that provide access for maintenance and operation**.**

MONITOR:

- The path / roadways should be monitored for signs of cracking indicative of isolated settlement along the embankment crest and uplift from tree roots.
- Depending on site-specific conditions, guide rails, handrails and other safety features may be required. All such features should be inspected to ensure the safety of those using the paths / roads. Reference AASHTO "Guide for the Development of Bicycle Facilities" and other industry guidelines.
- Areas adjacent to the pavement should be inspected for signs of rutting, damage from car tires leaving the pavement or localized drainage issues.
- Any signs of significant change in the path / roadway elevation should be reported to the **Regional Canal Engineer** for further evaluation. Coordination with the local Department of Transportation or Public Works may also be necessary for routine road maintenance issues.
- Look for signs of lateral or vertical movement, which may be signs of instability.

REPAIRS:

- Rutting or gulley formation adjacent to the path / roadway should be repaired by reestablishing the slope with suitable compacted fill compatible with existing embankment material.
- Where practicable, the top 6" should be soil that will support grass growth. Stabilize the crest with appropriate vegetation. See Establishing Turf Grass.
- Survey monuments may be considered and established as necessary for continued monitoring of crest elevation and alignment in critical locations.
- Coordinate with the responsible roadway agency (e.g., Town, County, State) for roadway repairs.

4 SEEPAGE

BOILS IN THE FOUNDATION (PE Review Req'd)

Some seepage through the embankment foundation is common. However, sometimes the pressure is large enough to begin erosion of embankment materials which will be deposited in a circular shape around the outlet, referred to as "boils". This could be indicative of a serious, immediate problem and must be brought to the attention of the **Dam Safety Engineer** immediately. If the **Dam Safety Engineer** is not available, notify the Thruway Statewide Operations Center (**TSOC**) immediately at **1-866-691-8282** and inform them of a potential dam safety emergency situation at the site and request them to notify the **Canal Duty Officer**.

Frequency: As Needed

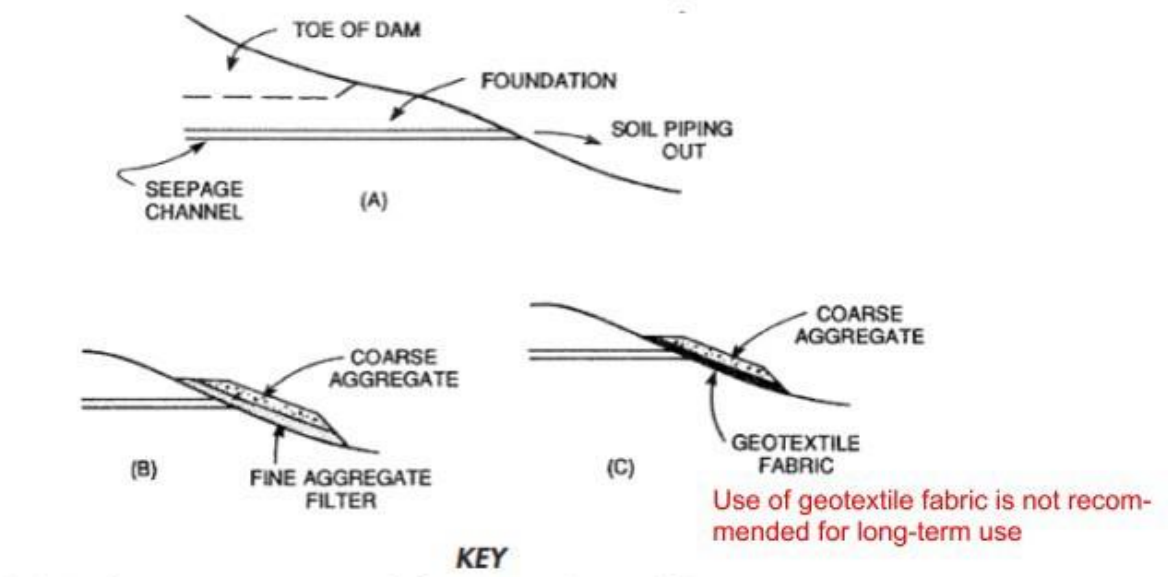
TEMPORARY REPAIRS:

- Boils should be reported to the **Dam Safety Engineer** immediately for further evaluation, as this condition could warrant activation of emergency notifications.
- To temporarily stabilize the boil, a ring of sandbags can be placed to create a dike around the boil which will allow the water level to rise high enough to limit further erosion. The pressure created by the water level within the dike may be enough to control flow velocities and temporarily prevent further erosion. If erosion increases, the canal level should be lowered until permanent repairs can be made.
- The dikes should be maintained until permanent repairs are completed. Permanent repairs will be determined by the **Dam Safety Engineer.**

Photo Credit: USDA Forest Service, Pocket Safety Guide for Dams

TEMPORARY REPAIRS (cont.):

- If the material transport for the boils is not able to be controlled with the use of the sandbag ring, a *filter* can be created within the sandbag ring to further limit the material transport and bring the issue under control. A filter is constructed by placing fine aggregate (concrete sand, NYSDOT Item 605.1101) and then covering the fine aggregate with a layer of coarse aggregate (Underdrain Filter, Type 2, NYSDOT Item 605.1001) in the bottom of the ring to arrest the transport of soil particles. The filter allows the water to flow but reduces the transport of the embankment material.
    - Note that Underdrain Filter, Type 1, NYSDOT Item 605.0901 is a coarser material that may allow for better drainage but still meet filter criteria with the sand material depending on specific gradation. Underdrain Filter, Type 2 will always meet filter criteria with the sand material. If the coarser Type 1 material is desired, contact the **Regional Canal Engineer** or **Dam Safety Engineer** with the material gradations to have them check filter compatibility.
- If the flow rate is too high for the sand to stay in place, an *inverted filter* may be necessary. To construct an inverted filter, coarse drainage material is placed within the sandbag ring to slow both the exit gradient and velocity (water flow rate) before adding the layer sand and stone.
- Geotextile fabric may be used in place of the sand for temporary emergency use, but geotextile fabrics can clog over time and are not recommended for long-term use.



Conventional Filter—Can be constructed within sandbag ring

SEEPAGE FROM EMBANKMENT CONTACTS

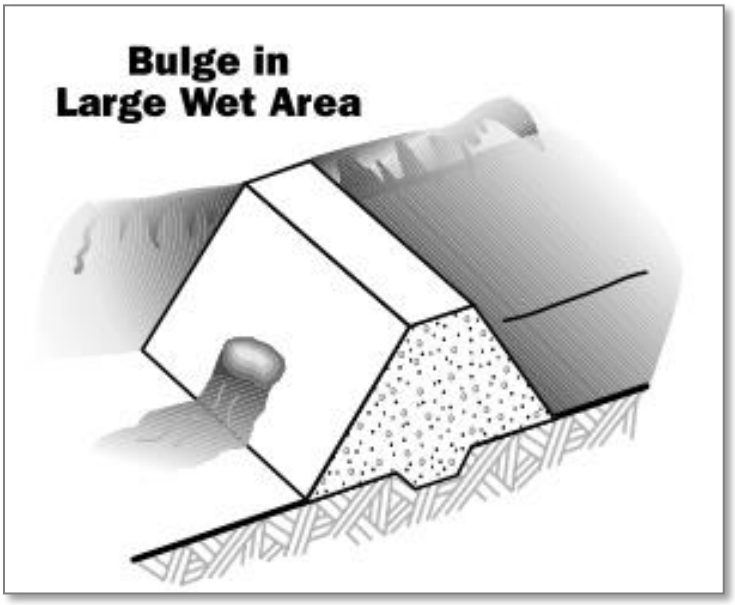
Some seepage is likely to be observed along embankment contact areas such as contacts between cut and fill sections of the embankment, and in areas where the earthen embankment meets structures such as lock walls, waste weirs, spillways, etc. Evidence of seepage may vary from soft, wet areas to a flowing spring and may appear initially only as an area where vegetation is lush and dark green in color.

Frequency: As Needed

REPAIRS:

- New locations of seepage, changes in seepage quantity or seepage that appears to be transporting sediment should be reported to the **Regional Canal Engineer** and **Dam Safety Engineer** immediately for further evaluation.
- Locations of all noted seepage should be tracked by the Sections and reported to the **Dam Safety Engineer** on a master tracking sheet and/or GPS tagged file.
- Seepage must be controlled in both velocity and quantity. Seepage areas should be monitored to determine the quantity of flow through the embankment. Weirs, such as those described in the *Monitoring Devices* section may be used. Changes in flow rate can be indicative of a developing problem and should be investigated further.
- Monitor flow for signs of increasing turbidity (i.e., muddy water) at the source, indicating that active erosion is occurring through the embankment. This is a sign of a serious issue and may require activation of the emergency notifications**.** Consult immediately with the **Dam Safety Engineer.** If the **Dam Safety Engineer** is not available, notify the Thruway Statewide Operations Center (**TSOC**) immediately at **1-866-691-8282** and inform them of a potential dam safety emergency situation at the site and request them to notify the **Canal Duty Officer**.
- If concentrated seepage flow is causing further erosion down slope of the seepage, erosion control measures such as stone check dams, straw bales, erosion control matting or others may be used to temporarily reduce the erosion down slope.
- Permanent control devices such as filter blankets and/or toe drains may be installed if the problem persists. These devices should only be installed at the direction of the **Dam Safety Engineer**.

WET BULGING ON EMBANKMENT



Seepage through the embankment foundation is common. Seepage on the downstream (outboard) face above the toe of the embankment is particularly dangerous. Evidence of seepage may vary from a soft, wet area to a flowing spring and may appear initially only as an area where vegetation is lush and dark green in color. A bulge in a wet area on the embankment is indicative of a potential for massive sliding or sloughing of the embankment.

Frequency: As Needed

REPAIRS:

- Flowing seepage may be indicative of a potentially urgent condition and should be reported to the **Regional Canal Engineer** immediately for further evaluation. Identify source area in length, width, and any other pertinent items such as flow rate, turbidity, condition of vegetation, etc. Any such groundwater breakout locations should also be staked for further monitoring.
- Evidence of seepage (damp areas, softness, lush vegetation) should be noted and monitored, though the urgency is less than where flowing water is observed. Mark the location and notify **Dam Safety Engineer** for further evaluation.
- Seepage must be controlled in both velocity and quantity. Seepage areas should be monitored to determine the quantity of flow through the embankment. Weirs, such as those described in *Monitoring Devices* may be used. Changes in flow rates could be indicative of a developing problem and should be investigated further. The **Dam Safety Engineer** will make recommendations regarding installation of such devices.
- Monitor flow for signs of increasing turbidity (i.e., muddy water) at the source, indicating that active erosion is occurring through the embankment. This is a sign of a serious issue and may require activation of the emergency notifications. Consult immediately with the **Dam Safety Engineer.** If the **Dam Safety Engineer** is not available, notify the Thruway Statewide Operations Center (**TSOC**) immediately at **1-866-691-8282** and inform them of a potential dam safety emergency situation at the site and request them to notify the **Canal Duty Officer**.
- If concentrated seepage flow is causing further erosion down slope of the seepage, erosion control measures such as stone check dams, straw bales, erosion control matting or others may be used to temporarily reduce the erosion down slope.
- Permanent control devices such as filter blankets and/or toe drains may be installed if the problem persists. These devises should only be installed at the direction of the **Dam Safety Engineer**.

WHIRLPOOLS

Whirlpools, as shown at left, (that are unrelated to any known water intakes) are a sign of advanced piping and are an emergency condition. Failure of the embankment could be imminent.

Frequency: Emergency condition

REPAIRS:

- **This situation is a potential embankment safety emergency. Emergency notifications should be enacted, and emergency procedures enacted (Closing guard gates, mobilizing equipment, and delivery of stone and backfill material).**
- Whirlpools are indicative of a severe problem. The **Dam Safety Engineer** should be contacted immediately. Evacuation of properties in the vicinity may be required. If the **Dam Safety Engineer** is not available, notify the Thruway Statewide Operations Center (**TSOC**) immediately at **1-866-691-8282** and inform them of a potential dam safety emergency situation at the site and request them to notify the **Canal Duty Officer**.

DRAINAGE BLANKET/FILTER (PE Review Req'd)

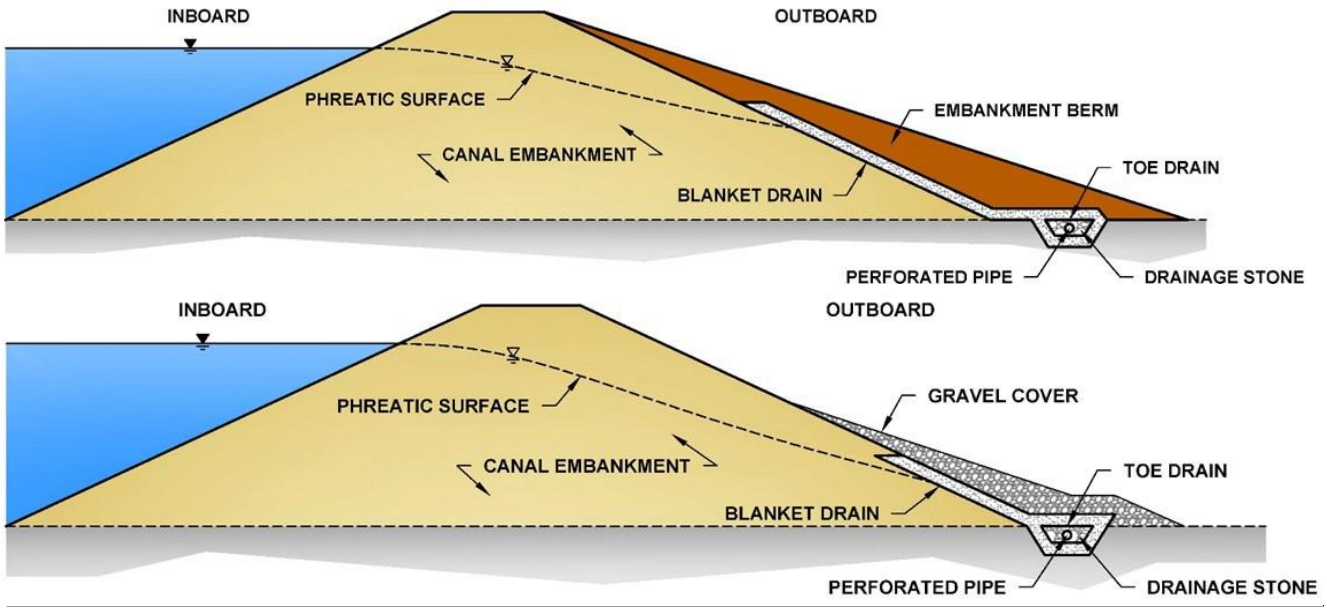
Drainage blankets are a common method for control of seepage through an embankment by collecting seepage in a granular filter from the outboard slope and conveying it downslope to a toe drain. Blanket drains are typically constructed with a sand layer adjacent to the embankment to serve as a filter to retain soil particles. The use of geotextile fabrics within water retaining embankments is generally not acceptable since the fabrics may clog over time and/or create a preferential plane for a slope failure.

Seepage from the drainage blanket can be collected in a stabilized area and directed to an outlet away from the embankment. The blanket and toe drain can be covered with a soil berm or gravel within the Canal ROW. Creating blanket and toe drains can help keep seepage away from the downstream (outboard) face of the embankment. Adding a berm will enhance the embankment stability.

REPAIRS:

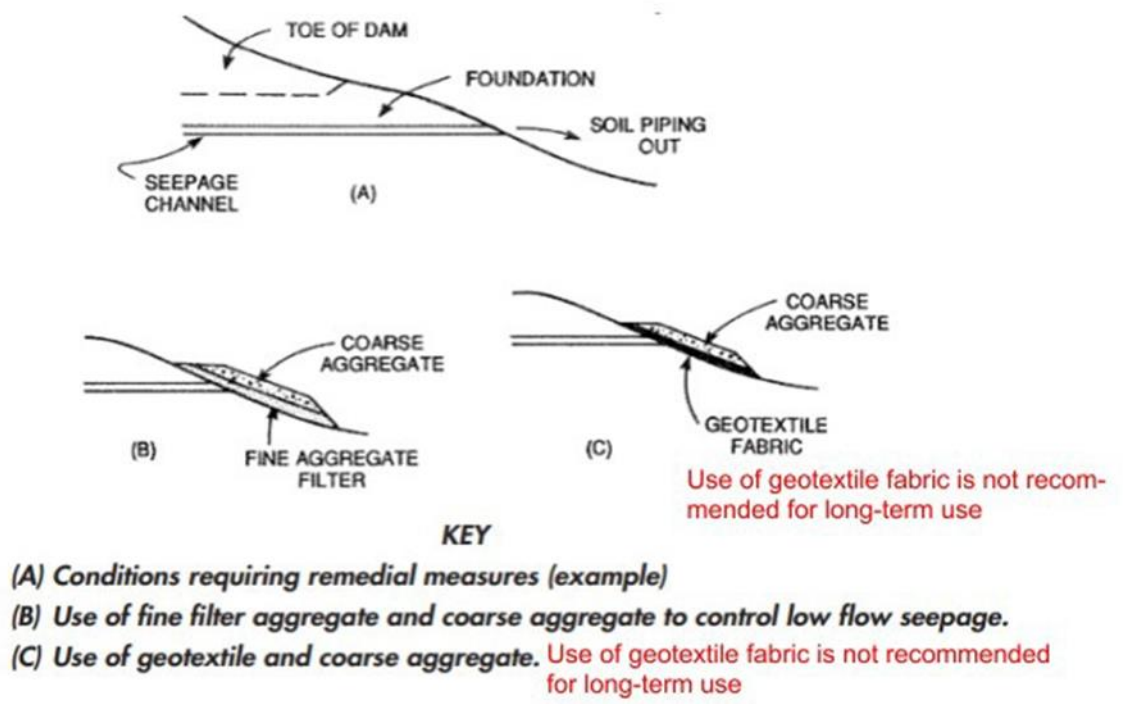
Blanket and toe drains should only be designed, installed or modified under the direction of a competent Professional Engineer (P.E.) and in consultation with the **Dam Safety Engineer**. If seepage is a maintenance issue at the embankment, contact the **Regional Canal Engineer** to request further evaluation. In general, design considerations should include:

- Blanket drains usually, work in conjunction with toe drains as monitoring devices. See *Toe Drains* for additional information and monitoring requirements. Note that the perforated pipe shown is not required in all instances. Design should account for and accommodate (drain to somewhere) the seepage flow that emanates from the drain.
- Visually inspect the drainage blanket (if applicable). Some drainage blankets are constructed of sand and may be vegetated over. Others are constructed of gravel and may be visible. Any signs of seepage above the limits of the drainage blanket should be immediately reported to the **Regional Canal Engineer** for further evaluation.



TEMPORARY REPAIRS:

- A filter can be added to the seepage locations to help prevent transport of embankment material (which could ultimately result in a piping failure). A filter is constructed by placing fine aggregate (concrete sand, NYSDOT Item 605.1101) and then covering the fine aggregate with a layer of coarse aggregate (Underdrain Filter, Type 2, NYSDOT Item 605.1001) in the bottom of the ring to arrest the transport of soil particles. The filter allows the water to flow but reduces the transport of the embankment material.
    - Note that Underdrain Filter, Type 1, NYSDOT Item 605.0901 is a coarser material that may allow for better drainage but still meet filter criteria with the sand material depending on specific gradation. Underdrain Filter, Type 2 will always meet filter criteria with the sand material. If the coarser Type 1 material is desired, contact the **Regional Canal Engineer** or **Dam Safety Engineer** with the material gradations to have them check filter compatibility.
- The design of the filter is site-specific and tailored to be compatible with the materials in the embankment. For temporary use, concrete sand and drainage stone will suffice in most cases.
- In the absence of site-specific information, provide a 1-foot layer of concrete sand covered with a 2-foot layer of drainage stone (Underdrain Filter, Type 2 - NYSDOT Item 605.1001) for the filter.
- Geotextile fabric may be used in place of the sand for temporary use, but geotextile fabrics can clog over time and/or create a preferential plane for a slope failure and are not recommended for long-term use.



Conventional Filter

ENVIRONMENTAL:

- In locations where aesthetic resources are present (see Chapter 8 of Guide Book), the embankment berm is preferred over the gravel cover repair.

TOE DRAINS (PE Review Req'd)

Toe drains are a common method for control of seepage through an embankment, by creating an avenue for seepage through a perforated pipe system, or a rock filter system, or other form of stable void space at the toe of the embankment. The condition and quantity of the water can be observed for possible embankment issues by used of a V-notch weir or weir box. Creating toe drains can help keep seepage away from the downstream (outboard) face of the embankment.

DESIGN & CONSTRUCTION:

- Toe drains should only be designed and installed under the direction of a Professional Engineer (P.E.) and in consultation with the **Dam Safety Engineer**. If seepage is a maintenance issue at the embankment, contact the **Regional Canal Engineer** to request further evaluation.
- Toe drains should only be installed within a filtered area so as to prevent particle movement and potential embankment piping. Filter design consists of aggregates selected to prevent particle movement. The use of geotextile fabrics within water retaining embankments is generally not acceptable since the fabrics may clog over time and/or create a preferential plane for a slope failure.
- Monitor for changes in turbidity, or amount of sediment in the water. An increase in turbidity could indicate erosion within the embankment. Notify the **Dam Safety Engineer** immediately, it could be an indication of a more serious issue. If the **Dam Safety Engineer** is not available, notify the Thruway Statewide Operations Center (**TSOC**) immediately at **1-866-691-8282** and inform them of a potential dam safety emergency situation at the site and request them to notify the **Canal Duty Officer**.
- Toe drains need to be monitored to ensure proper function. If the toe drain has a collector pipe system that discharges to an outlet:
  - ⇒ Record the flow rate and canal or feeder water level. Use a container of known volume (i.e., 5-gallon bucket) and record the amount of time required to fill the container. *Volume (Gal) / Time (min) = Flow Rate (GPM).* Also see *Flow Measurement* BMP for this and other methods to measure flow.
  - ⇒ Record the canal or feeder water surface elevation. From the canal or feeder staff gauge, record the date and time of the toe drain readings.
  - ⇒ Some toe drain systems may have observation wells or manholes that can be used to identify changes in water level to help identify blockages within the system. Record the water level in each toe drain manhole (if included).
- Monitor for erosion at the outlet of the drain pipe. If the flow is causing erosion at the outlet, stone protection should be placed to stabilize the outlet. If erosion is present where it was not previously, this could be an indicator of increased flow and velocity from the toe drain.
- The height of water in the canal or feeder is important and affects the amount of seepage flow. Seepage flow rates should only be compared for similar canal elevations.

- Significant changes in the flow rate could indicate a problem with the embankment or drain.

  ⇒ *Increase* in flow could mean a change internally at the embankment. Contact the **Regional Canal Engineer**.

  ⇒ *Decrease* in flow could mean the pipe is becoming clogged. The drain pipe should be cleaned. If, after cleaning the flow does not return to a more normal flow, or it could be a more serious indication. Contact the **Regional Canal Engineer**, it could be an indication of a more serious issue.

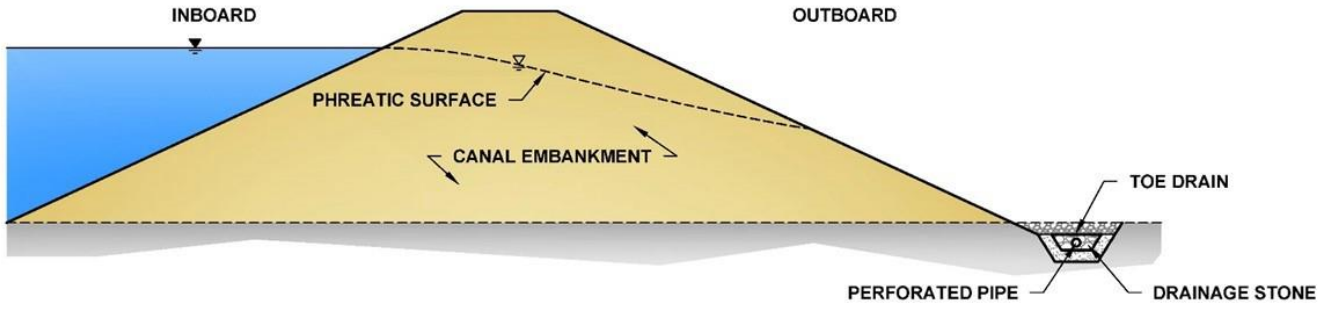
  ⇒ *No Flow* - and has never flowed, could mean the drain was designed or installed incorrectly. Contact the **Regional Canal Engineer.**

  ⇒ *No Flow* - and flowed at one time, could mean the drain is clogged, which could cause seepage to exit in other locations or increase the internal pressure. Drain pipe should be cleaned.

  ⇒ Increase in water level in manholes could mean a blockage has developed downstream of that location.

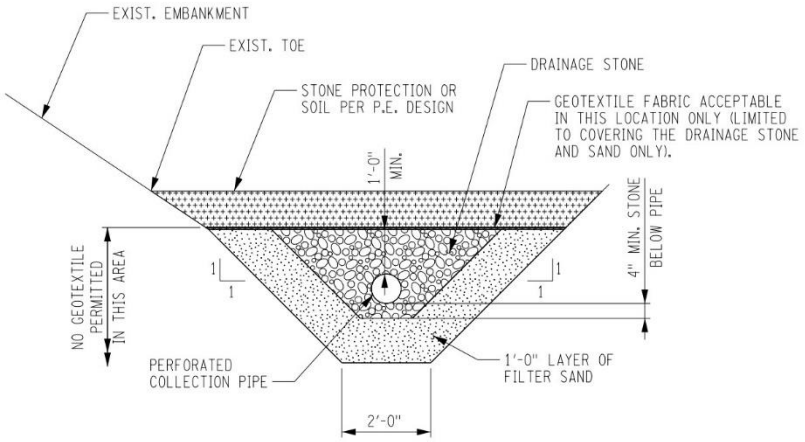
  ⇒ Significant difference in water surface elevation referenced to a datum between adjacent manholes of an underdrain line could indicate a blockage in that section of the system between the manholes.

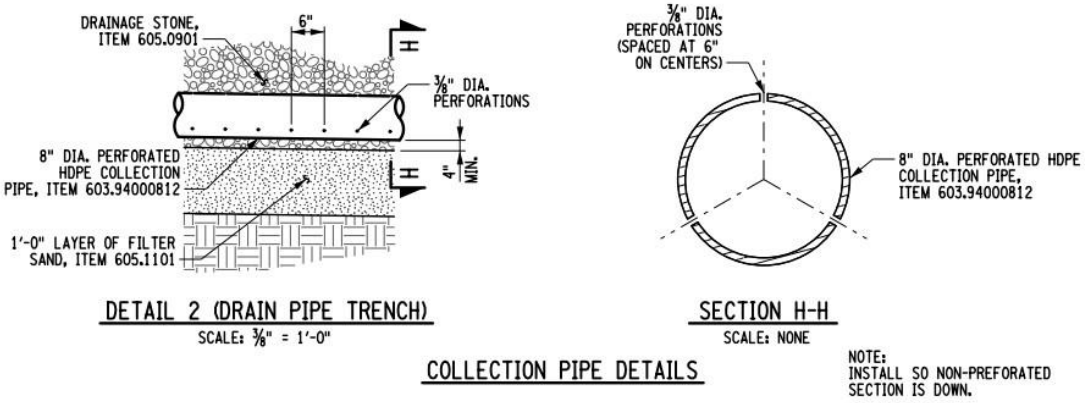
  ⇒ If water surface elevation referenced to a datum, between adjacent manholes of an underdrain line are increased and nearly equal, this indicates there could be a downstream blockage.



DETAILS:

- If available, solid wall HDPE pipe DR 17 or heavier should be used. This pipe requires thermally fused connections, and a specialty contractor is likely required for installation. See details below for perforation size and spacing. Perforation size is dependent on the adjacent drainage material. Contact **Regional Canal Engineer** for information.
- Corrugated HDPE and PVC pipe can be used, but durability will suffer.
- Toe drains should only be installed within a filtered area so as to prevent particle movement and potential embankment piping. Filter design consists of aggregates selected to prevent particle movement. The use of geotextile fabrics within water retaining embankments is generally not acceptable since the fabrics may clog over time and/or create a preferential plane for a slope failure.
- Cleanouts should be provided at terminations, junctions and 300' maximum spacing.



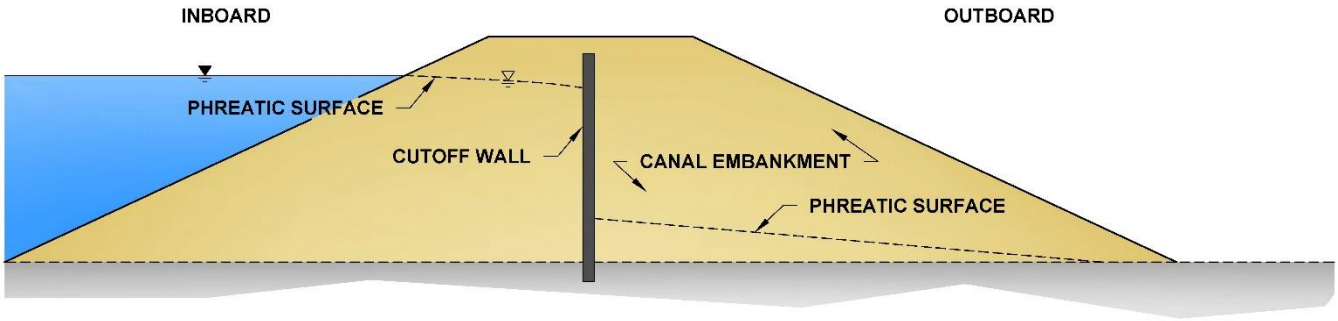


Pipe Diameter may vary depending on length
Perforation diameter should be sized for compatibility with Drainage stone

CUTOFF WALLS (PE Review Req'd)

General

Installing a cutoff wall along the crest of the embankment creates a continuous seepage barrier to lower the phreatic surface within the embankment and reduce or eliminate concerns with seepage and piping failure. Lowering the phreatic surface also improves the stability of the outboard slope thereby reducing the risk of embankment failure. Because of these positive effects on the embankment, some of the trees on the embankment slope may remain although enough vegetation must be removed to allow inspection of the embankment slope and outboard toe area. Piezometers installed on each side of the cutoff wall can provide verification of the reduction in the phreatic surface and the risk of a failure due to seepage. The following schematic shows this alternative:



CUTOFF WALL ALTERNATIVE
SCALE: N.T.S.

The work associated with the cutoff wall alternative generally involves the following:

- Setting up the work zone including equipment and material lay down areas and developing access to the embankment to complete the work.
- Installation of the cutoff wall, including testing and design work, and construction QC and monitoring.
- Restoration of the embankment crest after the wall is installed.

There are several alternatives that can be used to install the cutoff wall including steel sheet piles, cement bentonite and deep soil mixing. Specific site conditions will dictate which is most appropriate. Each of the cutoff wall alternatives has an expected design life of at least 100 years with no maintenance required under normal conditions.


Sheet Piling


Cement Bentonite Wall


Deep Soil Mixing

SHEET PILE WALLS

Sheet piles (also referred to as simply "sheeting") are sometimes used within embankments to control seepage. Sheet piles create a relatively impermeable barrier within the embankment to reduce the seepage through the embankment.

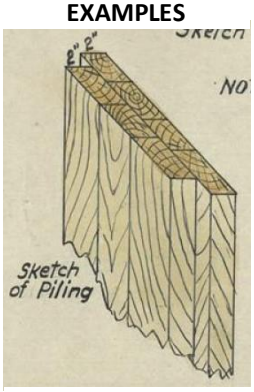
Sheet piles can also be used to as a means of retaining soil (retaining wall). This BMP does not cover the use of sheet piles for soil retention and retaining walls.

GENERAL

Cutoff walls are used to control seepage through the embankment by dissipating and diverting the flow of water. Cutoff walls may also be part of a combined seepage control strategy that includes drainage features. Steel sheet piling applications include, but are not limited to, earth retention for excavation, embankment support and for cutoff purposes. This BMP deals only with cutoff application. The decision to install a steel sheet pile cutoff wall to address seepage is made by the Director of Design, **Regional Canal Engineer**, **Dam Safety Engineer** or authorized representative.

- Sheet piles have been installed in the canal to control seepage both during its original construction and afterwards as maintenance activity.
- Historically both steel and timber sheeting have been installed in canal embankments.
- All new installations shall use hot rolled steel sheet piles.
- There are many manufacturers, styles, shapes and sizes of steel sheet piles.

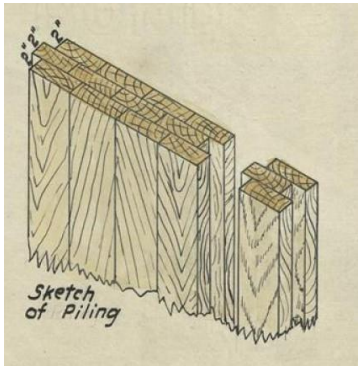
TIMBER SHEETING EXAMPLES



Double Lap-Timber Sheeting

DESIGN AND CONSTRUCTION:

- The piles are to be designed by a competent licensed professional engineer.
- The piles are to be interlocking. Only hot rolled steel sheet piling is allowed, no other type of piling is acceptable for use including cold rolled steel, fiberglass and vinyl.
- In locations with competent rock, the piles should be installed to refusal to form a barrier to seepage under the wall.
- Do not install steel sheet piling in areas where the rock beneath the wall is porous which will allow the seepage to divert under the wall and potentially affect the embankment foundation.
- In areas of undulating bedrock surfaces consider other potential cutoff options. If other options are not practical and steel sheet piling is installed, additional measures may be required to control the seepage beneath the wall. These measures may include grouting of the space between the wall and the undulating rock, or other measures as determined during or after pile installation.
- Consider performing a preconstruction survey to document the condition of nearby structures to avoid damage claims resulting from the construction induced vibrations. Notify nearby properties of the upcoming work.
- There are polymer materials (swell seal) that can be added to the sheet pile interlocks for reduced permeability if the application requires it.



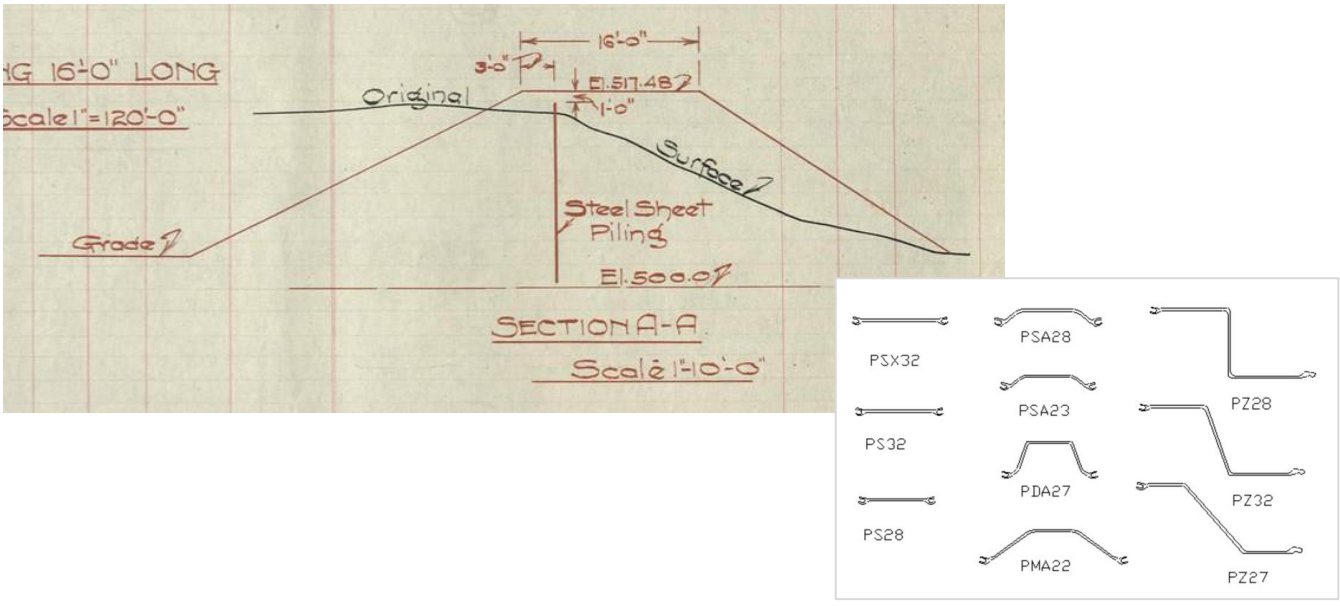
Triple-Lap Timber Sheeting (Wakefield Sheeting

INSTALLATION:

- Prior to performing any installation, contact Dig Safely New York by calling (811) or visiting their website (www.digsafelynewyork.com) for utility mark out. Also contact Canals Section to review site for Canal-owned utilities. Use had excavation or other appropriate means to locate utilities identified before performing work.
- Sheet piles are installed with a vibratory or impact hammer usually from a crane or excavator.
- The piles are to be installed vertically to minimize the potential for gaps between the piles.
- The piles are to be installed through the top of the embankment using appropriate equipment to ensure adequate installation and embedment into competent bedrock while minimizing the amount of damage caused to the embankment.
- Any damage to the embankment is to be corrected immediately after cutoff wall installation is completed.
- Installation of the cutoff wall is to be inspected by a licensed professional engineer or an inspector well versed in sheet piling installation.
- After installation, a record of where and what length of sheeting was installed should be kept and added to the master files.
- Installation has been performed under dewatered and watered up conditions. A licensed professional engineer should provide guidance on whether the canal must be dewatered prior to performing the installation.

LOCATION AND REPAIR:

- Extent of existing sheeting can be determined from final book drawings and past maintenance records.
- Steel sheet piles can be located with a metal detector as they are usually cut off within a foot or so of the ground surface.
- Existing sheeting using past and historical practice may include timber sheeting and steel sheet piles of different structural grades and shapes. Consult with the **Dam Safety Engineer**.



Example of various sheet pile shapes

CEMENT BENTONITE WALL

A cement-bentonite wall involves excavating a trench using an excavator and supporting it using slurry (i.e., a slurry wall). With this method the slurry is a self-hardening mixture of cement, bentonite, and water that replaces the excavation spoil. The slurry typically hardens within a day or so and becomes a low permeability barrier. This seepage control method has not been used along the canal; however, it has been used elsewhere to address the same concerns.

A drawback of this method is that all excavation spoil needs to be disposed of offsite as it is not placed back into the trench. This method also requires more space than installing sheet piles and may not be feasible in areas where the embankment crest is too narrow. In addition, while the cement bentonite wall will reduce the potential for tree roots to penetrate through the embankment, in some rare cases, some tree roots have been found to penetrate similar walls. If trees remain in close proximity to such walls, some increased risk is possible compared with the sheet pile alternative.

THE USE THIS TYPE OF METHOD REQUIRES A SPECIALTY CONTRACTOR EXPERIENCED IN THE APPLICATION OF THIS CONSTRUCTION METHOD.

DEEP SOIL MIXING

This method involves advancing augers into the embankment (2 to 8 feet in diameter) while mixing grout in with the soil to create a barrier wall. With this method the grout mixes with the soil creating a mixture of cement-grout and soil that forms the low permeability barrier.

Some excavation spoil needs to be disposed of (about 30 percent of the excavated volume) but not as much as with cement bentonite wall construction. The photograph to the right shows a deep soil mixed wall being constructed. As shown in the photograph, space is required for the equipment and to contain the mixing operation and spoil. Therefore, it may not be possible to use this technique at sections along the embankment where the crest is too narrow.

Like the cement bentonite wall, this method may be more effective than a sheet pile wall in creating a cutoff in areas of high bedrock elevation where it is necessary to seal the wall to the top of bedrock. This is particularly true if the rock is soft, and the drill can penetrate into it a few feet. Also like the cement bentonite wall, if trees remain in close proximity to such walls, the potential for some increased risk of root penetration is possible compared with the sheet pile alternative.

THE USE THIS TYPE OF METHOD REQUIRES A SPECIALTY CONTRACTOR EXPERIENCED IN THE APPLICATION OF THIS CONSTRUCTION METHOD.

CLAY CUTOFF WALLS

Clay has been used historically as a way to reduce seepage to its low permeability if installed correctly. However, because effectiveness is highly dependent on proper design and installation and because clay itself can erode, its use in modern structures is limited. In older drawings and references, this clay is often called “puddle.”

The decision to install a clay cutoff wall to address seepage must be under guidance of the **Regional Canal Engineer, Dam Safety Engineer** or authorized representative, with approval of the **Dam Safety Engineer**. A clay cutoff wall can decrease the amount of seepage through the embankment but will still allow a limited amount of seepage to occur. While it may be an adequate solution in some situations, it is not as positive a solution as a steel pile cutoff wall.

Clay cut offs are very sensitive to design and construction variation. The use of this means for seepage reduction has fallen out of favor with modern dam safety practice.

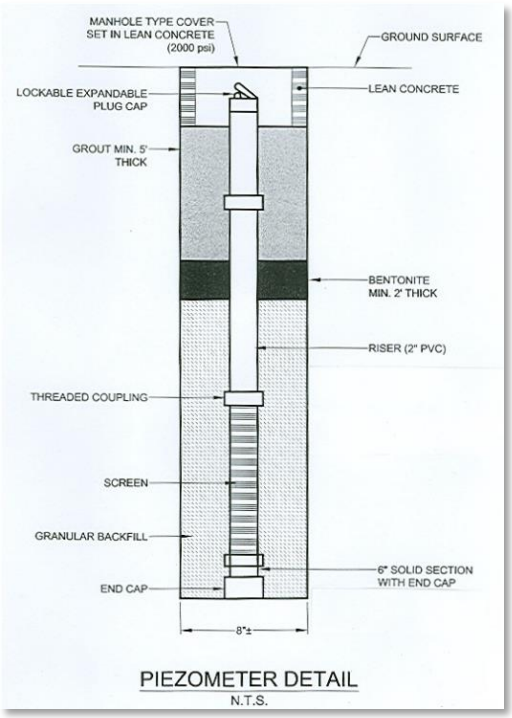
Continued use of this method of addressing seepage is not recommended without careful consideration and if used, it should be performed only under the direct supervision of a licensed professional engineer with extensive experience with geotechnical engineering and dam safety.

5 MONITORING DEVICES

PIEZOMETERS / WELLS / STANDPIPES (PE Review Req'd)

Piezometers are instruments used to measure the water pressure or elevation in the embankment and foundation. Some may be flush mounted at the crest, which is common in pavement or concrete structures, (as shown in the photo to the left) or may also be elevated standpipes located on the outboard face of the embankment, which is common for vegetated or riprap protected slopes (as shown in the photo below).

Sometimes these are called simply piezometers or wells. All three of these terms are used interchangeably.



PIEZOMETER DETAIL
N.T.S.

CONSTRUCTION:

- Piezometers should only be designed and installed under the direction of the competent licensed engineer.
- Coordinate with the appropriate internal resources.
- Install locking caps on piezometers in all locations.

INSTALLATION LOCATIONS:

The location of new piezometers should be determined by a competent licensed professional (P.E.). For area on or adjacent to the Canal Trail, these guidelines should be considered:

- Flush mounted caps should be located ideally a minimum of 3' outside of the trail to allow for future trail maintenance activities.
- If a piezometer is planned that does not meet the above criteria, it must be reviewed by canals internal staff (Canal Design and Canal Section)

VIBRATING WIRE PIEZOMETER:

A vibrating wire piezometer is another instrument that can be used in a geotechnical boring to measure water level.

For this type of instrument, a sensor is installed that reads the water pressure directly. It can be used to measure the water level in a standpipe piezometer or can be installed in other ways to determine water pressures in specific zones or soil & rock strata.

Vibrating wire piezometers require special instruments to read the signal provided. Any such instrumentation should be installed and read under the supervision of a P.E.

INSTALLATION AND INITIAL DEVELOPMENT:

Regular monitoring and documentation of monitoring wells is necessary to evaluate and determine that the wells are functioning properly. During the installation and initial well development, the following information should be collected:

- Well depth prior to development
- Water level prior to development
- Volume of water removed during development
- Visual characteristics of the water removed (clear, translucent, opaque, etc.) before and following development
- Amount of time to develop well
- Water level post development
- Well depth post development

MONITOR:

- Piezometers should be monitored on a regular basis and records kept of their readings as well as concurrent readings of the canal water level. An example of an electronic water level indicator is shown below.
- The water level indicator has a sensor that signals when water is reached on a lead marked with depth increments. The sensor is dropped into the standpipe until it beeps which indicates the water level in the piezometer.
- All inspections forms have a location for recording the piezometer and canal water levels. This information is to be provided to the **Dam Safety Engineer** for inclusion in the record monitoring of the embankment and evaluation.
- Monitoring wells used to determine water quality exist on and near embankments, but these types of wells are not covered by this BMP.

DATA COLLECTION:

During subsequent monitoring events at the well, the following information should be collected and compared to the original installation data:

- Well depth
  - ◊ A decrease in depth from the originally installed depth may indicate sediment infilling the well.
- Water level
  - ◊ A change in water level may be due to a change in the well's condition.

Changes in these parameters may indicate that the well needs to be redeveloped (generally through pumping or bailing) to remove sediment and return it to its initial state. For critical wells to be maintained over a long period of time, the permeability of the surrounding formation should be measured about every 5 years after an initial measurement is taken to be used as a baseline for comparison. This can be accomplished with rising/falling head (i.e., slug) tests. A reduction in the measured permeability could indicate that fine-grained material has accumulated in the well pack.

If it Is identified that sediment has accumulated in the well or surrounding pack, the well should be redeveloped.

USE OF VENTED CAP ON THE PVC INSERT:

When installing either flush mount wells or above ground riser pipes (with or without an outer casing), a vent hole should be drilled into the top of the well casing cap to permit pressure equalization. The top of the standpipe should be covered by an end (screw) cap, expansion plug, or wooden plug through which a small hole should be drilled or cut a notch to allow air into the pipe this allowing the water level to reach its natural head.

INTERIOR WELL MAINTENANCE:

The interior of the well should be visually inspected for debris collection and animal activity to verify that there are no blockages present.

EXTERIOR WELL MAINTENANCE:

The exterior of the well should be inspected for cracks, corrosion, a locking cap, and overall proper function. The well should be cleaned, and caps replaced as needed.

REPLACEMENT:

If, at any point, the well is no longer functioning, has been backfilled or vandalized, or is unable to be rehabilitated through the methods described above, it should be assessed whether the well needs to be abandoned and a new well installed.

DEVELOPING AND REDEVELOPING A WELL:

Developing a monitoring well is the process of removing water from the well in order to remove the residual materials remaining in the well after installation. Developing also assists to re-establish the natural hydraulic flow conditions of the formations which may have been disturbed in the vicinity of the well due to construction of the well. A new monitoring well should be developed until the column of water in the well is free of visible sediment.

A malfunctioning well might need to be redeveloped if it has infilled with sediment. This can be accomplished with a low flow pump or, more commonly, a bailer (shown in photo to right). To aid in removing fines from the well, the bailer can be used to agitate the water and sediment in the well, creating a slurry with the fines that will allow them to flow into the bailer. Water should be removed from the well until: the turbidity decreases to about its post-initial development level, sediment has been removed from the well bottom, and/or the measured permeability returns to about its initial range. If the well is bailed dry, prior to redevelopment being completed, it may be necessary to return at a later time to continue developing the well.

CLEANING, AIRLIFTING & OTHER METHODS REQUIRING SPECIAL ASSISTANCE:

- Cleaning a well of sediments can be accomplished by pumping clean potable water into the bottom of the well.
- Airlifting is the process of feeding air into the bottom of a well to cause bubbles, which cause the well water to rise and transport heavier particles with it. Special assistance with those familiar with this process is needed to avoid permanent damage to the well.
- Methods that add water or other fluids to the well or use air for development have the potential to alter ground-water quality and should not be used. Jetting, airlift pumping, and air surging should only be used if they offer site-specific advantages, extreme care is taken to prevent air from contacting the screened interval, and those methods should only be performed by an experienced operator.

FLOW MEASUREMENT

V-notch weirs are an inexpensive way to measure quantities of flow. These may be constructed downstream of seepage areas or toe drain outfalls to help measure seepage discharge rates.

Frequency: As Needed

CONSTRUCTION:

- V-notch weirs should be constructed at locations designated by the **Regional Canal Engineer, Dam Safety Engineer**, or authorized representative for determining quantities of seepage flow.
- Temporary weirs may be constructed from 1/2" plywood or sheet metal. The notch should be constructed so that the angle is 90°. Additional information on temporary weir installations can be found on page 7-27 of the USBR's Water Measurement Manual https://www.usbr.gov/tsc/techreferences/mands/wmm/index.htm Permanent weirs should be either prefabricated boxes or concrete and approved by the **Dam Safety Engineer.**
- Configurations will vary depending on site conditions and quantity of discharge. Weirs should be supported by embedment in banks, box configuration, support stakes or other means. Weirs must be positioned perpendicular to the line of flow. Weirs must be plumb. Weirs must also be embedded such that flow is not able to circumvent the weir either by the sides or beneath the weir plate.
- The weir plate should be relatively thin, but rigid enough to prevent damage.
- In order to get accurate measurements, it is necessary to carefully construct these weir structures.

MONITOR:

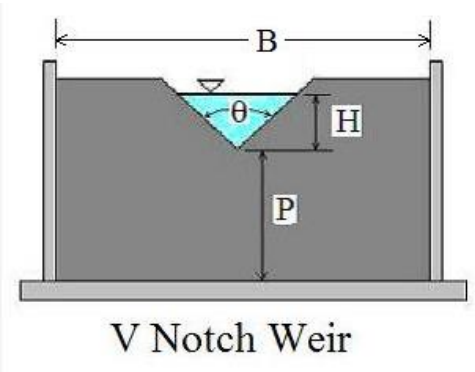
- V-notch weirs should be monitored on a regular basis. The Enhanced Embankment Monitoring / Quarterly Inspection Form has a location for recording readings from the weir.
- Remote monitoring of the weir is possible via monitoring equipment and can be used in remote locations or locations where having access to current data is critical.
- The height of water in the canal is important and affects the amount of seepage flow. Seepage flow rates should only be compared for similar canal water elevations, therefore, when a flow measurement is obtained, a canal water surface elevation should also be obtained.
- Significant changes in the flow rate could indicate a problem with the embankment.
  - ⇒ *Increase* in flow could mean a change internally at the embankment. Contact the **Dam Safety Engineer**.
  - ⇒ *Decrease* in flow could mean the pipe is becoming clogged. The drain pipe should be cleaned. If not associated with a pipe, could mean change internally and seepage directed to a new location along the embankment. Contact the **Regional Canal Engineer**. Be sure to conduct an investigation for additional/ changed seepage.
  - ⇒ *No Flow* - and has never flowed, could mean the drain was designed or installed incorrectly. Contact the **Regional Canal Engineer.**

MONITOR CONT'D:

⇒ *No Flow* - and flowed at one time, could mean the drain is clogged, which could cause seepage to exit in other locations or increase the internal pressure. Drain pipe should be cleaned. If not associated with a pipe, could mean change internally and seepage directed to a new location along the embankment face. Be sure to conduct an investigation for additional/changed seepage.

- Monitor for changes in turbidity, or amount of sediment in the water or deposited in the weir box. The presence of turbidity or sediment could indicate erosion within the embankment.
- Monitor for erosion downstream of the weir. If the flow is causing erosion at the outlet, stone protection should be placed to stabilize the outlet. If erosion is present where it was not previously, it could be an indicator of increased flow and velocity from the seep.

The following equation should be used to calculate the discharge over the weir when the water elevation is within the limits of the notch:



V Notch Weir

$$Q = 2.49 \times tan\left(\frac{\theta}{2}\right) \times H^{2.48}$$

Where:

Q = Discharge rate in cubic feet per second (cfs)

Θ = Angle of notch in degrees

H = Height in of water above notch in feet (as measured on the upstream side)

P = Ponding depth behind weir (not used in calculation)

B = Width of weir crest (not used in calculation)

Weir notches may be constructed so that the notch is a 90° angle. If this is true, the equation can simplify to:

$$Q = 2.49 \times H^{2.48}$$

Often, gallons per minute (gpm) is a more common unit of measurement for seepage rates. One cfs is approximately equal to 450 gpm.

The following page provides a table for discharge rates for a 90° V-notch weir at varying upstream water surface elevations.

The following images show examples of v-notch weir configurations:

Temporary

Prefab

Precast

V Notch Weir (90°)			$Q = 2.49 \times H^{2.48}$		
Head* (in)	Flow		Head* (in)	Flow	
	cfs	gpm		cfs	gpm
0.25	0.0	0.1	6.25	0.5	222
0.5	0.0	0.4	6.5	0.5	244
0.75	0.0	1.2	6.75	0.6	268
1	0.0	2.4	7	0.7	294
1.25	0.0	4.1	7.25	0.7	320
1.5	0.0	6.4	7.5	0.8	348
1.75	0.0	9.4	7.75	0.8	378
2	0.0	13	8	0.9	409
2.25	0.0	18	8.25	1.0	441
2.5	0.1	23	8.5	1.1	475
2.75	0.1	29	8.75	1.1	511
3	0.1	36	9	1.2	548
3.25	0.1	44	9.25	1.3	586
3.5	0.1	53	9.5	1.4	626
3.75	0.1	62	9.75	1.5	668
4	0.2	73	10	1.6	711
4.25	0.2	85	10.25	1.7	756
4.5	0.2	98	10.5	1.8	803
4.75	0.3	110	10.75	1.9	851
5	0.3	130	11	2.0	901
5.25	0.3	140	11.25	2.1	952
5.5	0.4	160	11.5	2.2	1006
5.75	0.4	180	11.75	2.4	1061
6	0.4	200	12	2.5	1118

* Vertical measurement of flow height above bottom of notch in inches.

FLOAT METHOD

The float method (also known as the cross-sectional method) is a way to determine the flow rate for larger rivers and streams or where the flow is too great to reliably determine using the bucket method, described below. Using this method, the flow rate is found by multiplying a cross sectional area of the stream by the velocity of the water. To measure the flow rate using the float method:

Type of stream	Velocity correction factor	Accuracy
A rectangular channel with smooth sides and bed	0.85	Good
A deep, slow moving stream	0.75	Reasonable
A small stream with a smooth bed	0.65	Poor
A quick, turbulent stream	0.45	Very poor
A very shallow, rocky stream	0.25	Very poor

The equation to calculate the flow is:

$$Q = A_{ave} \times V_{surface} \times \text{Correction Factor}$$

where

Q= Flow rate (m^3/s)

A_{ave}= Average cross-sectional area (m^2)

$V_{surface}$= *Surface velocity (m/s)*

1) Locate a spot in the stream that will act as the cross section of the stream.
2) Measure the depth of the stream at equal intervals along the width of the stream. This method is similar to hand calculating a Riemann sum for the width of the river.
3) Once this data is gathered, multiply each depth by the interval it was taken in and add all the amounts together. This calculation is the area of a cross section of the stream.
4) Decide on a length of the stream, typically longer than the width of the river, to send a floating object down (oranges work great).
5) Using a stopwatch, measure the time it takes the float to travel down the length of stream from step 4.
6) Repeat step five 5-10 times and determine the average time taken for the float to travel the stream. Throw the float into the water at different distances from the shoreline in order to gain a more accurate average.
7) Divide the stream length found in step 4 by the average time in step 6 to determine the average velocity of the stream.
8) The velocity found in step 7 must be multiplied by a friction correction factor. Since the top of a stream flows faster than the bottom due to friction against the stream bed, the friction correction factor evens out the flow. Velocity correction factors should be used as described in the table to the right with a great deal of engineering judgement.

9) The corrected velocity multiplied by the cross-sectional area yields the flow rate in volume/time. (Be sure to keep consistent units of length/distance)

BUCKET METHOD

The bucket method is a simple way to determine flow in low-flow areas where it is possible to catch all of the flow in a container of known volume, such as a 5-gallon bucket.

1) Measure the volume of the bucket or container. Keep in mind that a typical 5-gallon bucket is often actually less than 5 gallons. Note that high precision is not the intent and the slight variation in bucket size is likely negligible.
2) Find a location along the stream that has a waterfall or create one using a weir.
3) With a stopwatch, time how long it takes the waterfall to fill the bucket with water. Start the stopwatch simultaneously with the start of the bucket being filled and stop the stopwatch when the bucket fills. The bucket should not be filled by holding it below the surface of the stream because it is not the true flow rate.
4) Record the time it takes to fill the bucket. Repeat steps two and three about six or seven times and take the average. It is a good idea to do a few trial runs before recording any data so that one can get a feel for the timing and measurements required.
5) Only eliminate data if major problems arise such as debris from the stream interfering with the flow.
6) The flow rate is the volume of the bucket divided by the average time it took to fill the bucket.

STAFF GAUGES

Staff gauges are a tool used for measuring water depths. Different staff gauges may be used to measure different water depths, such as depth of water over the crest or depth of water ponded behind the embankment.

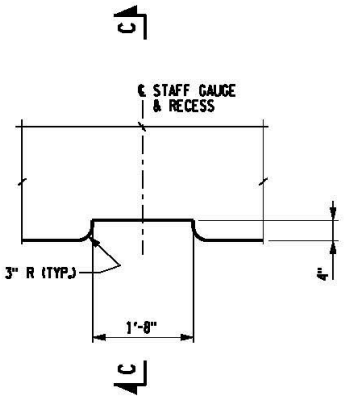
Frequency: As Needed

CONSTRUCTION & REPAIR:

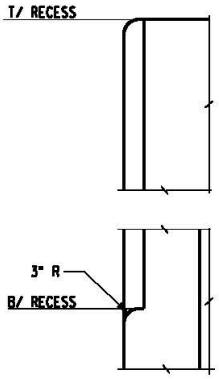
- Staff gauges are readily available from a variety of manufacturers. The gauges should be permanently fixed to a structure such as the embankment walls or a rod securely embedded into the bottom of the canal or feeder. If located within the canal or feeder, gauges should be marked, flagged and protected from boat traffic.
- Gauges should be plumb, free of debris and have large enough print to see from the necessary vantage point.
- Staff gauges should be calibrated to a known reference point such as the existing Barge Canal Datum (BCD) or NAVD88, which is used for flood warning system gages. The conversion between these datums varies by site. Contact the **Water Management Engineer** for the specific datum used and the conversion between datums.

MONITOR:

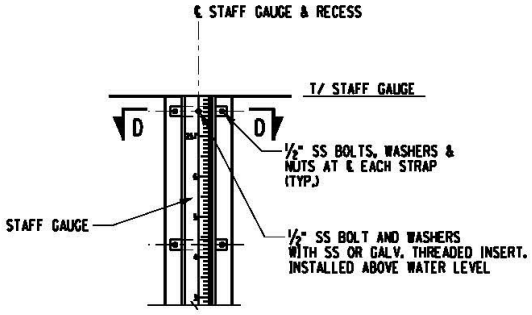
- Staff gauges should be monitored on a regular basis.
- Canal or feeder elevations will vary depending on time of year, gate/lock positions, and outflow conditions. These readings will play an important role in determining the conditions at the embankment for other monitoring devices such as seepage monitors.
- Unexpected changes in canal water level should be reported immediately to the **Regional Canal Engineer** for further analysis.
    - Unexpected *Rising Canal Levels* could mean an outlet is blocked. An investigation should be conducted, cleaning of conduit or removal of debris from the outlet may be required.
    - Unexpected *Falling Canal Levels* could mean a breach in the embankment such as piping or an increase in seepage indicating potential failure or a change in inflow or outflow of the system. An investigation should be conducted, and the situation reported directly. Care should be taken during the investigation.

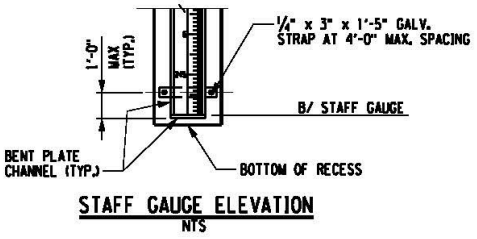


STAFF GAUGE RECESS
NTS



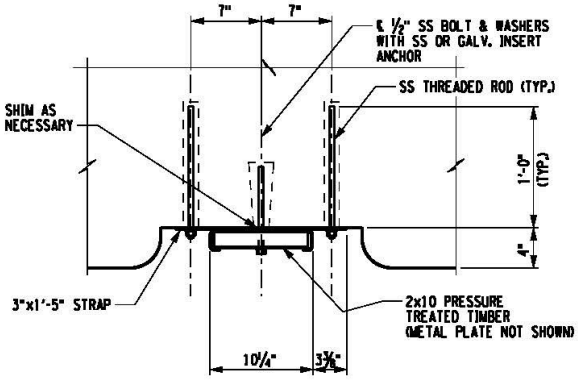
SECTION C-C
NTS



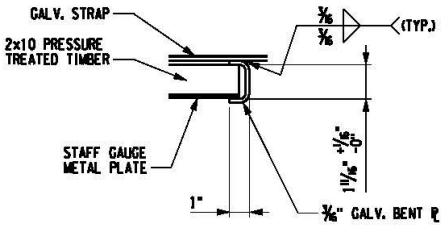


STAFF GAUGE ELEVATION
NTS

STAFF GAUGE NOTES:
1. STAFF GAUGE METAL PLATE WILL BE FURNISHED & PLACED ON THE TIMBER PLANK BY CANAL CORP.
2. UNLESS OTHERWISE APPROVED, WOOD SHALL BE TREATED SOUTHERN YELLOW PINE.
3. WOOD PLANK WITH METAL PLATE SHALL BE TIGHT FIT INSTALLED WITHIN THE BENT PLATE CHANNELS.
4. RECESS SHALL EXTEND TO TOP OF CONRETE FACE.



SECTION D-D
NTS



DETAIL 1
NTS

6 CONCRETE REPAIRS

CONCRETE SPALLING (PE Review Req'd)

Spalling is the process by which concrete chips and breaks away as a result of freezing and thawing, impact, expansion of underlying concrete or rusted reinforcement, or other distress. Because spalling usually only affects the surface of a structure, it is usually deemed not to be dangerous. If allowed to continue though, cracks could become large enough to cause structural damage and expose the rebar in the concrete.

Frequency: As Needed

IDENTIFICATION:

Spalling may be caused by a variety of processes and identifying the source is pertinent to its disposition, especially if it is pervasive and/or associated with significant cracking or joint movement. The **Regional Canal Engineer** should be consulted to establish the cause, need and approach for maintenance or repair. Further guidance may also be found in *EM 1110-2-2002 "Evaluation and Repair of Concrete Structures,"* USACE.

ENVIRONMENTAL AND HISTORIC PRESERVATION:

- The cement in fresh concrete and mortar is toxic to aquatic life. No wet or fresh concrete, mortar, or wash water should be allowed to escape directly or indirectly into any waterbody or drainage structure (stream, wetland, ditch, pond, etc.).
- Coordination with Environmental Health & Safety is required to address potential historic preservation concerns such as color and material match, extent of demolition, etc.

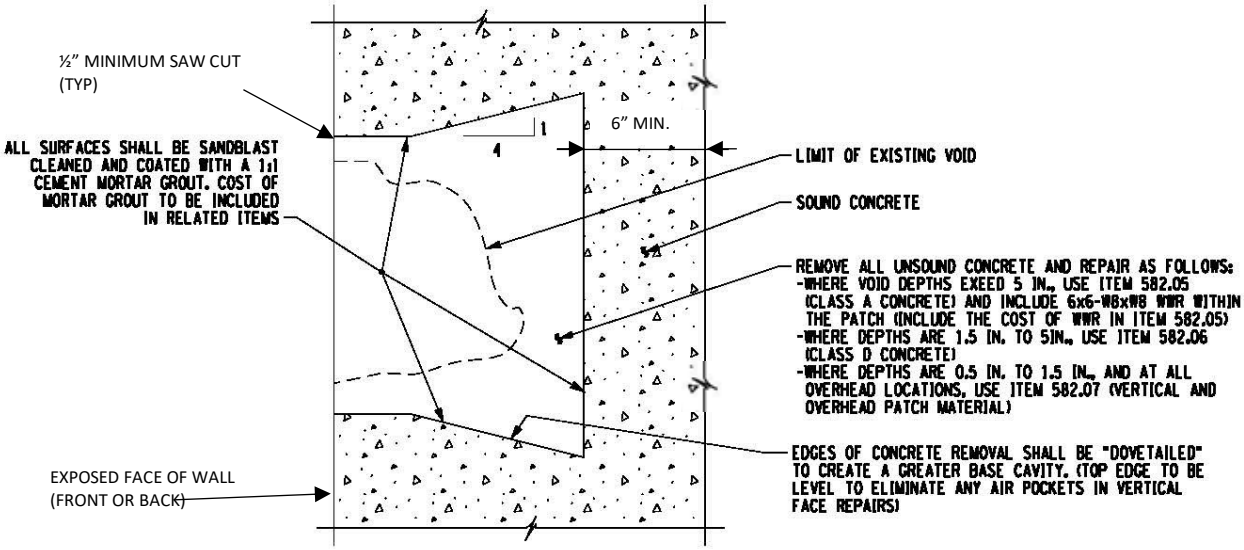
REPAIR:

Repair selected concrete spalls as directed by the **Regional Canal Engineer.** For further guidance, review the GSA Technical Document "Patching Spalled Concrete" and *NYSDOT Standard Specifications*. Typically, this work will be conducted under contract maintenance or capital improvement.

- Review of record plans is recommended to be aware of existing wall thickness and details.
- Cut back the damaged concrete until sound material is reached. Roughen this surface with a hammer and chisel in order to create a better bonding surface. Recommended distance from back of wall to cut line (i.e., concrete thickness remaining) should not be less than 6 inches.
- When rebar is exposed, remove 1" or more behind rebar for concrete or repair mortar, depending on mix and aggregate size. Careful attention should be given to not to damaging existing rebar.
- Remove all rust from any exposed rebar and paint the cleaned surface with epoxy coating in order to prevent further corrosion. If any rebar is severely corroded it should be cut out and replaced.
- If the patch is excessively large, drill holes into stable concrete and insert stainless steel pins anchored with epoxy.
- Remove all dust and debris by water blasting, air blasting, or with a broom or vacuum. Prepare surface in

accordance with repair mortar manufactured for concrete, in accordance with NYSDOT Standard Specifications.

- Apply the repairing mortar, with a trowel, following mortar manufacturer's written recommendations or install formwork and place concrete in accordance with NYSDOT Standard Specifications and the detail following.



CONCRETE SURFACE REPAIR DETAIL

(SECTION VIEW)

CONCRETE JOINT SEEPAGE (PE Review Req'd)

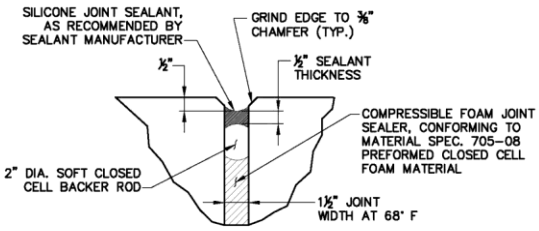
Joints in a concrete structure (typically slope paving in canals and feeders) are the most common place for seepage to occur. Seepage can occur when the sealant between the expansion joint has deteriorated. Joint seepage can lead to rapid erosion and ultimately can cause walls to tip in and over. It is therefore desirable that repairs are conducted as soon after joint seepage is detected as practicable.

Frequency: As Needed

CONCRETE JOINT REPAIR:

Minor touch ups of small gaps and soft or hard spots in field-molded sealants can usually be made without replacing the entire joint. If the joint seepage is extensive however, the existing sealant should be entirely removed and replaced.

- Fill non-moving joints with a proprietary prepackaged concrete repair, following the manufacturers written instructions.
- Seal moving joints (e.g., expansion or contraction), that will not be subjected to the flow of water, with a 2-part polyurethane caulk following the manufacturer's written instructions. Clean out debris and install a backer rod with a nominal diameter of 1.25 to 1.5 times the width of the joint. Apply the caulk with a thickness at the center of the joint of about one half of the joint width.
- Seal moving joints that will be subject to low- to moderate-velocity flowing water in a similar fashion, except that the neck of the sealant shall be at least 1" thick.
- Moving or non-moving open joints may also be sealed using a polyurethane grout (gel) that expands to fill the entire joint. See *Cracking* for additional detail.



JOINT SEALING DETAIL

Repair concrete joints as directed by the **Regional Canal Engineer.** For further guidance, refer to *NYSDOT Standard Specifications* and *Bridge Detail Standard Sheets*

CONCRETE JOINT VEGETATION

Growth of vegetation in the cracks of concrete can exacerbate degradation and can lead to structural damage. Root systems of trees and shrubbery can create deep penetrations in the concrete, which with added freeze/thaw action, can create large cracks in the structure. The management of vegetation on concrete elements is therefore pertinent to structural integrity. Control and removal of vegetation should be done routinely as part of the embankment maintenance program.

Frequency: Annually, As Needed during non-navigation season (without shutdown)

VEGETATION REMOVAL:

- In New York State, NYSDEC refers to pesticides and herbicides collectively as pesticides and their application is regulated.
- The use of pesticides for vegetation removal must be reviewed and approved by the **Director of Environmental Health & Safety.**
- All pesticides must be applied by a licensed certified applicator.
- All pesticides must be applied in accordance with manufacturer's written instructions.
- For weeds and smaller vegetation, apply approved pesticide in accordance with manufacturer's instructions. Once the plant has dried out, remove the vegetation and repair the concrete accordingly.
- For larger, established vegetation, cut the trunk of the plant 4 inches above the roots and for vines and other crawlers remove a 6-inch section of the stem above this cut. Make vertical slices through the bark of the stump and peel back the bark back, exposing at least 1 inch of the cambium.
    - ♦ Apply acceptable root killing material to the exposed inner wood, in accordance with manufacturer's instructions.
    - ♦ Allow the vegetation above the 6" cut to die naturally. After allotting sufficient time for the vegetation to dry out, remove the remaining plant material using high pressure air.

All pesticides used onsite to remove vegetation should be on the approved lists of both the USEPA and NYSDEC. Follow the manufacturer's instructions closely and take precautions to prevent the pesticides exposure to water bodies. A pesticide that is permitted for aquatic use should be chosen if exposure is inevitable.

For further guidance, review the GSA Technical Document "Removing Climbing Plants and Creepers from Masonry" for information on vegetation removal.

CONCRETE JOINT REPAIR:

Repair concrete joints as directed by the **Regional Canal Engineer.**

- Fill non-moving joints with a proprietary prepackaged concrete repair, following the manufacturers written instructions. See *Spalling.*
- Seal moving joints (e.g., expansion or contraction), that will not be subjected to the flow of water, with a 2-part polyurethane caulk. See *Joint Seepage.*

CONCRETE CRACKING (PE Review Req'd)

Cracked concrete is the result of movement, shrinkage or stress. Cracks generally grow gradually starting off hairline and can become large over time. If left untreated, cracks in a concrete facing can lead to seepage, infiltration, freeze-thaw damage and ultimately failure of the structure.

Frequency: As Needed

IDENTIFICATION:

Cracking may be caused by a variety of processes and identifying the source is pertinent to its disposition. For example, shrinkage or drying cracks from the original construction may be stable and non-moving, whereas flexural cracks or thermal shrinkage cracks may continue to move with changes in load or temperature. Similarly, some cracks may have no harmful effects on the structure, especially those without seepage, water infiltration or detrimental movement and need not be addressed, while others may need correction to mitigate further deterioration or to strengthen or stabilize a structure.

The **Regional Canal Engineer** should be consulted to establish the cause, need and approach for maintenance or repair. Further guidance may also be found in *EM 1110-2-2002 "Evaluation and Repair of Concrete Structures,"* USACE.

ENVIRONMENTAL AND HISTORIC PRESERVATION:

- The cement in fresh concrete and mortar is toxic to aquatic life. No wet or fresh concrete, mortar, or wash water should be allowed to escape directly or indirectly into any waterbody or drainage structure (stream, wetland, ditch, pond, etc.).
- Coordination with Environmental Health & Safety is required to address potential historic preservation concerns such as color and material match, extent of demolition, etc.

REPAIRS:

Repairs can fall into two basic categories: structural and non-structural.

Structural Repairs:

Structural repairs typically lock the adjoining concrete sections together and may involve grouting, reinforcement and/or concrete replacement. Grouting methods depend on the width of the crack. Structural repairs may also require stabilization of a crack by installing grouted dowels and/or by selective concrete removal and replacement with reinforced concrete. The approach needed for any particular crack is situation-specific and should be determined by the **Regional Canal Engineer, Director of Design** or authorized representative.

Non-Structural Repairs:

Non-structural crack sealing can be performed using a variety of proprietary sealants that are suitable for a wide range of crack widths. Depending on crack width, and aesthetic needs, the products may be fed directly into the crack by gravity or caulking guns. Other situations may warrant routing out the crack for a depth of 1" or more and installing a backer rod and sealant similar to that described under *Joint Seepage*. With the possible exception of

direct surface caulking, any type of crack repair is therefore typically done by contract agreement or part of a capital improvement program.

More extensive non-structural repairs may include concrete surface sealers and non-structural grouts. The approach needed for any particular crack is situation-specific and should be determined by the **Regional Canal Engineer, Director of Design** or authorized representative.

7 MASONRY REPAIRS

JOINT VEGETATION REMOVAL AND REPOINTING (PE Review Req'd)

Growth of vegetation in the joints of masonry can exacerbate degradation and can lead to structural damage and instability. Root systems of trees and shrubbery can create deep penetrations in the masonry, which with added freeze/thaw action, and can create large cracks in the structure. The management of vegetation in masonry is therefore pertinent to structural integrity. Control and removal of vegetation should be done routinely as part of the maintenance program.

Frequency: Annual Vegetation Removal, Repair as Needed

VEGETATION REMOVAL:

- In New York State, NYSDEC refers to pesticides and herbicides collectively as pesticides and their application is regulated.
- The use of pesticides for vegetation removal must be reviewed and approved by the **Director of Environmental Health & Safety**.
- All pesticides must be applied by a licensed certified applicator.
- All pesticides must be applied in accordance with manufacturer's written instructions.
- For weeds and smaller vegetation, apply approved pesticide in accordance with manufacturer's instructions. Once the plant has dried out, remove the vegetation and repair the masonry accordingly.
- For larger, established vegetation, cut the trunk of the plant 4 inches above the roots and for vines and other crawlers remove a 6-inch section of the stem above this cut. Make vertical slices through the bark of the stump and peel back the bark back, exposing at least 1 inch of the cambium.
    - ♦ Apply acceptable root killing material to the exposed inner wood, in accordance with manufacturer's instructions.
    - ♦ Allow the vegetation above the 6-inch cut to die naturally. After allotting sufficient time for the vegetation to dry out, remove the remaining plant material.
    - ♦ Gently scrub the wall with a stiff, non-metallic bristle brush and clean, clear water (sprayed up to 400 psi) to remove any remaining dried plant material.

All pesticides used onsite to remove vegetation should be on the approved lists of both the USEPA and NYSDEC. Follow the manufacturer's instructions closely and take precautions to prevent the pesticides exposure to water bodies. A pesticide that is permitted for aquatic use should be chosen if exposure is inevitable. Typically, this work for larger vegetation will be conducted under contract agreement by a certified applicator.

For further guidance, review available NYSCC special specifications and GSA Technical Document "Removing Climbing Plants and Creepers from Masonry." Where the NYSCC and GSA differ in practice, the NYSCC specification should take precedence.

ENVIRONMENTAL AND HISTORIC PRESERVATION:

- Fresh concrete is toxic to aquatic life. No wet or fresh concrete, mortar, or wash water should be allowed to escape directly or indirectly into any waterbody or drainage structure (stream, wetland, ditch, pond, etc.).
- Coordination with Environmental Health & Safety is required to address potential historic preservation concerns such as color and material match, extent of demolition, etc.

MASONRY REPAIR:

- Repoint all masonry damaged by invasive roots as directed by the **Regional Canal Engineer** or authorized representative.
- Cut and rake old mortar from existing joints by hand using a hammer and chisel to a depth of 1" or a depth greater than 2.5 times the joint width (whichever is greater). Do not use power chisels and power saws.
- Carefully clean out the prepared face with a soft or stiff bristle brush or blow the joints clean with low-pressure compressed air (40-60 psi).
- Once the joint has been thoroughly cleaned and dampened with water, apply ASTM C270 Type N mortar to the joint in layers no thicker than 1/2" thick. Compact each layer and allow the mortar to set until thumbprint hard before the next layer is applied. Fill the joints such that they are slightly recessed from the masonry face.
- New mortar shall be given at least 72 hours to cure, by periodically misting with water, covering with wet burlap and/or covering with plastic sheeting to preclude premature drying.
- Remove and replace any masonry units that have been damaged by hand.

For further guidance, review available NYSCC special specifications. Typically, this work will be conducted under contract.

PARGING (PE Review Req'd)

Parging is the process of covering masonry units with a thin layer of mortar mix. The parge coat forms a water resistant, protective barrier that helps prevent water penetration, improves rainwater runoff and can help protect the masonry units from weathering. Parging can also improve the aesthetics of a dilapidated structure.

Frequency: As Needed

An alternative to parging for excessive deterioration is to construct a reinforced concrete facing in front of the deteriorated area. The design and detailing of such a repair are outside of the scope of this BMP and should be performed by a professional engineer. For any such facing, a 12-in. minimum facing thickness is recommended. It is important to consider the potential effect on water conveyance structures as any added thickness may reduce the cross-sectional area available for flow. Flow capacity with this reduced area must be checked to confirm sufficient capacity.

IDENTIFICATION:

- Areas with general surface deterioration that traps water, has become slightly porous or possess a tripping hazard, yet are otherwise sound, are suitable conditions for parging.

ENVIRONMENTAL AND HISTORIC PRESERVATION:

- The cement in fresh concrete and mortar is toxic to aquatic life. No wet or fresh concrete, mortar, or wash water should be allowed to escape directly or indirectly into any waterbody or drainage structure (stream, wetland, ditch, pond, etc.).
- Coordination with Environmental Health & Safety is required to address potential historic preservation concerns such as color and material match, extent of demolition, etc.

THREE COAT PROCESS:

- Clean out all dust, dirt, and any loose material with a wire brush. The substrate must be sound prior to any parging. Any loose masonry units should be repaired, and any degraded joints should be repointed.
- Dampen surface of mortar units using low water pressure and a misting technique.
- Apply the first coat of Type S Mortar 3/8" to 1/2" thick. Crosshatch the first coat of mortar with a trowel to provide good keys for the second coat.
- Allow to cure for 18 to 24 hours, keeping the surface damp using a hose with low water pressure using a misting technique.
- Once cured, apply another coat of mortar mix 3/8" to 1/2" thick to the surface.
- Finish the second coat with a wood float that has a small nail driven through it (only the nail tip protrudes) to provide good keys for the finish coat. Allow to cure for several days, keeping the surface moist as to avoid cracking.
- Dampen the surface with water and apply the top coat to a thickness of at least 1/8" and wait 1-3 hours. For texture and aesthetic purposes, wire brush, float, or trowel top coat using mild pressure. Walking surfaces should be broomed or otherwise textured for traction. Horizontal surfaces should be shaped for drainage.

Parging should be conducted as directed by the **Regional Canal Engineer, Director of Design** or authorized representative. This work will typically be conducted under contract agreement or capital improvement.

DISPLACED STONES (PE Review Req'd)

Stones in masonry structures can become displaced or damaged overtime due to weathering. Freeze thaw action can crack, split, spall, and shift stones out of place. If left untreated, the structure will become deficient and unstable as more stones are displaced.

Frequency: As Needed

INSPECTION:

- Inspect surrounding area to identify cracked or deteriorated joints through which water may be entering to cause observed deterioration.
- Identify whether seepage is apparent around displaced stone.

Consult with the **Regional Canal Engineer** to determine whether seepage collection or relief measures are needed prior to resetting displaced stones whether degradation has resulted in instability requiring structure replacement. For structures that are not culturally or historically sensitive, and where stones are missing or severely damaged, it may be acceptable to fill with reinforced concrete. Refer to **Regional Canal Engineer**.

ENVIRONMENTAL AND HISTORIC PRESERVATION:

- The cement in fresh concrete and mortar is toxic to aquatic life. No wet or fresh concrete, mortar, or wash water should be allowed to escape directly or indirectly into any waterbody or drainage structure (stream, wetland, ditch, pond, etc.).
- Coordination with Environmental Health & Safety is required to address potential historic preservation concerns such as color and material match, extent of demolition, etc.

STONE REPLACEMENT:

- Carefully remove by hand any stone that has deteriorated, shifted or is damaged beyond repair using a hammer and chisel to cut out the joints about its perimeter. If any portion of the stone will still not dislodge, use a masonry saw to make vertical cuts and use a hammer and chisel to break it up.
- Clean the newly created cavity, removing mortar, loose particles, and other debris.
- Fill any large voids behind stone with pre-package grout or mortar in accordance with manufacturer's instructions. Mortar should conform to ASTM C270, Type N requirements.
- Thoroughly wet the cavity with water and dampen the new or salvaged stone with water.
- Spread a 1/2" thick mortar layer, consisting of coarse sand and grit, into the open cavity.
- Set the salvaged or new stone in the cavity. If a new stone is used, it should match the properties of the old stone as closely as possible.
- Fill the joints with a grout that satisfies the requirements of ASTM C76.

For further guidance, review available NYSCC special specifications, such as 560.9902--12 - Remove and Reset Stone Masonry, and 560.9903--12 - Repair Ashlar Stone Masonry - Partial Replacement.

REPOINTING:

- Repoint any deteriorated joints previously identified to mitigate subsequent damage.
- Dampen masonry surfaces, and joints, and using a pointing tool, push the mortar into the joint from a board and iron with the maximum pressure possible. Mortar should be applied in layers with a maximum thickness of 1/2".
- Thoroughly compact each layer of mortar and allow to set until thumbprint hard before applying the next layer of mortar.
- Fill the joints so that they are slightly recessed from the masonry face. Avoid leaving a joint which is visually wider than the actual historical appearance.
- Allow sufficient time for mortar to cure. See *Joint Vegetation Removal and Repointing.*

For further guidance, review the NYSCC specification 560.9907--12—Clean and Repoint Ashlar Stone Masonry and 560.9910--12—Grout Stone Masonry.

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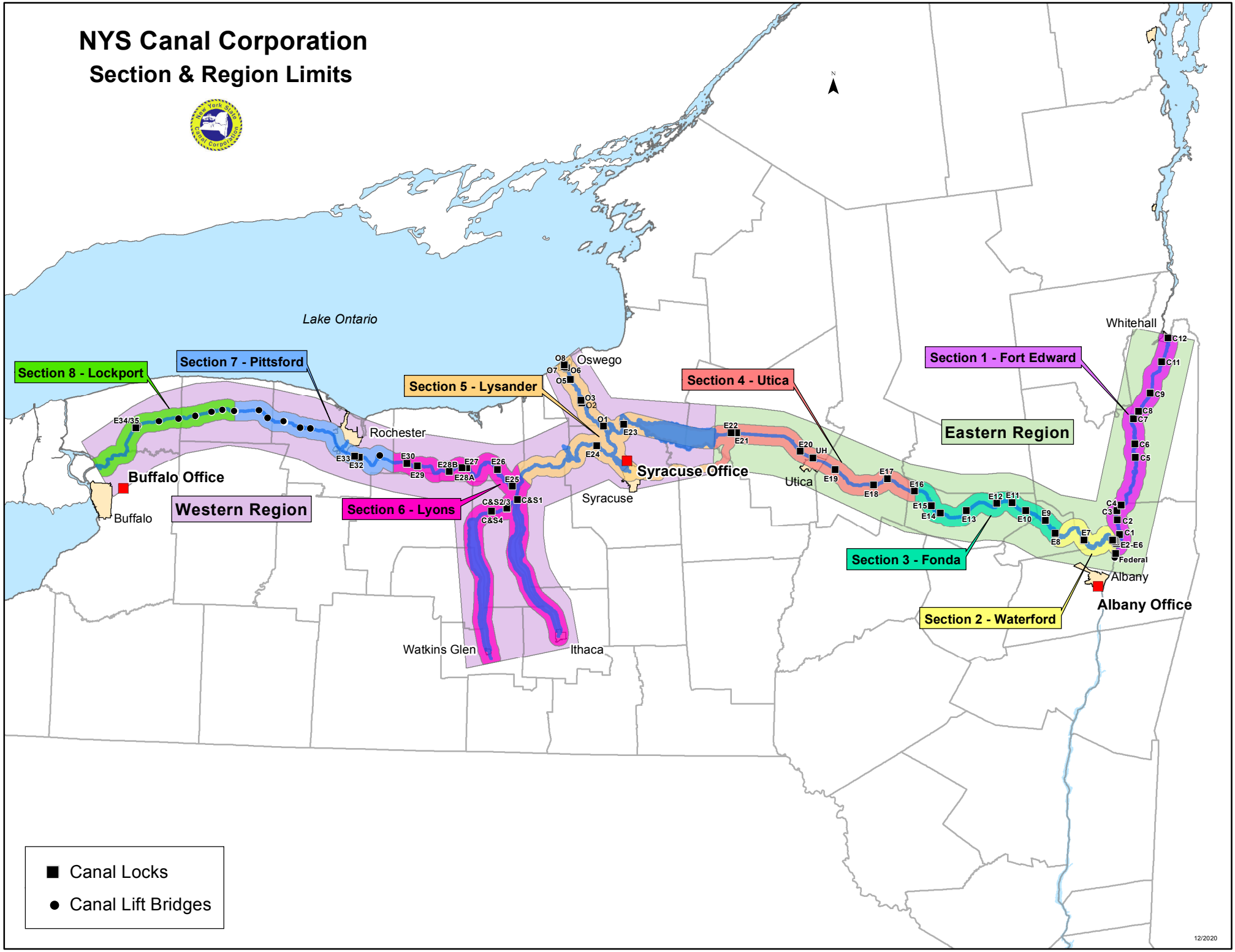
APPENDIX A
EMBANKMENT MAINTENANCE GUIDEBOOK

ATTACHMENT 2
MAP OF NYSCC REGION AND SECTION LIMITS

November 2022


NYS Canal Corporation
Section & Region Limits
Lake Ontario
Section 8 - Lockport
Section 7 - Pittsford
Section 5 - Lysander
Section 4 - Utica
Section 1 - Fort Edward
Eastern Region
Western Region
Section 6 - Lyons
Section 3 - Fonda
Section 2 - Waterford
Buffalo Office
Syracuse Office
Albany Office
Buffalo
Rochester
Oswego
Syracuse
Utica
Whitehall
Albany
Watkins Glen
Ithaca
Federal
UH
E34/35
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C&S1
C&S4
C12
C11
C9
C8
C7
C6
C5
C4
C3
C2
C1
Canal Locks
Canal Lift Bridges
12/2020

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APPENDIX A
EMBANKMENT MAINTENANCE GUIDEBOOK

ATTACHMENT 3
TABLES OF CANAL SECTIONS FOR ISOLATION AND DEWATERING

November 2022

Champlain Canal Isolation and Dewatering Segments

South Segment Limit Structure	South Segment Limit Canal Milepost	North Segment Limit Structure	North Segment Limit Canal Milepost	Isolated Length (mi)	River or Canal Segment	Segment Dewatering Features and Outlets	Notes
Hudson River, Troy Lock, USACE	-2.07	Lock C1, Waterford	3.43	5.5	River		Includes junction with Erie Canal/Mohawk River to Hudson River, controls at Troy Lock and Dam by USACE.
Lock C1, Waterford	3.43	Lock C2, Mechanicville	7.37	3.94	River	Fixed crest dam and tainter gates at C1 Waterford Lock C1	
Lock C2, Mechanicville	7.37	Lock C3, Mechanicville	9.92	2.55	River	Fixed Crest Dam and Powerhouse? At C2 Lock C2	
Lock C3, Mechanicville	9.92	Lock C4, Stillwater	11.76	1.84	River	Fixed Crest / Obermeyer Gated Dam and Powerhouse at C3 Lock C3	
Lock C4, Stillwater	11.76	Lock C5, Northumberland	26.17	14.41	River	Fixed Crest Dam and Powerhouse North of C4? Lock C4	
Lock C5, Northumberland	26.17	Lock C6, Fort Miller	29.9	3.73	River	Sluice Gate, Junction Lock Bypass, Schuylerville Lock C5	
Lock C6, Fort Miller	29.9	Guard Gate, Crocker Reef	31.84	1.94	Canal	Lock C6	
Guard Gate, Crocker Reef	31.84	Lock C7, Fort Edward	37.03	5.19	River	None	Includes junction with Hudson River.
Lock C7, Fort Edward	37.03	Lock C8, Fort Edward	39.21	2.18	Canal	Fort Edward Siphon Spillway Culvert and Sluice Gate Lock C7	
Lock C8, Fort Edward	39.21	Lock C9, Smith's Basin	45.04	5.83	Canal	Siphon spillway at C9 Lock C8 Bypass Lock C8 Lock C9	Inflow from Glens Falls Feeder Canal
Lock C9, Smith's Basin	45.04	Lock C11, Comstock	54.28	9.24	River	Fixed crest dam at C11 Lock C11	Includes junctions with Big Creek, Winchell Creek, and small streams
Lock C11, Comstock	54.28	Lock C12, Whitehall	60.72	6.44	River	Tainter gate and sluice gate at C12 Lock C12	Includes junction with Mettawee River
Lock C12, Whitehall	60.72	Poultney River to Lake Champlain		N/A	River		Cannot isolate at Poultney River/Lake.

Notes and Assumptions:

It is assumed that any and all navigation locks can be cross fed to pass water downstream and they are listed as dewatering/outlet features for upstream segments.

Canal mileposts taken from www.canals.ny.gov boating information tables and online map

Listing of dewatering features and outlets in each segment are preliminary and subject to review and revision. The feasibility of safely dewatering the segments listed is not assured and should be evaluated by staff familiar with the operation and limitations of the segment and applicable features.

Sections are classified as a canal if it is anticipated that essentially all inflow to the section can be stopped using existing controls, otherwise segments are considered rivers, which includes sections with smaller flows fed by streams or coincedent with lakes.

Cayuga and Seneca Canal Isolation and Dewatering Segments							
West Segment Limit		East Segment Limit		Isolated Length (mi)	River or Canal Segment	Segment Dewatering Features and Outlets	Notes
Isolation Structure	Canal Milepost	Isolation Structure	Canal Milepost				
Seneca Lake		Lock and Dam CS4	12.31	N/A	River	Tainter gates (to powerhouse forebay?) at dam Lock CS4	Cannot isoalate at Lake.
Lock and Dam CS4	12.31	Lock and Dam CS2	8.01	4.3	River	Powerstation, obermeyer gates, sluice gates at CS2 Lock CS2	
Lock and Dam CS2	8.01	Lock and Dam CS1	4.04	3.97	River	Tainter gates at dam Lock CS1	Includes junction with Cayuga Lake.
Lock and Dam CS1	4.04	Erie Canal	0	4.04	River	None in C&S Canal Length. See Erie Canal dewatering of Section between Lock E24 at Baldwinsville and Lock E25 and Movable Dam 18 at Mays Point	

Notes and Assumptions:

It is assumed that any and all navigation locks can be cross fed to pass water downstream and they are listed as dewatering/outlet features for upstream segments.

Canal mileposts taken from www.canals@ny.gov boating information tables and online map

Listing of dewatering features and outlets in each segment are preliminary and subject to review and revision. The feasibility of safely dewatering the segments listed is not assured and should be evaluated by staff familiar with the operation and limitations of the segment and applicable features.

Sections are classified as a canal if it is anticipated that essentially all inflow to the section can be stopped using existing controls, otherwise segments are considered rivers, which includes sections with smaller flows fed by streams or coincedent with lakes.

Oswego Canal Isolation and Dewatering Segments

South Segment Limit Structure	South Segment Limit Canal Milepost	North Segment Limit Structure	North Segment Limit Canal Milepost	Isolated Length (mi)	River or Canal Segment	Segment Dewatering Features and Outlets	Notes
Erie Canal	0	Lock O1, Phoenix	2.15	2.15	River	Spillways and Tainter Gates at Phoenix Dam at Lock O1 and Lock O1. Powerhouse at dam? See Erie Canal dewatering of segment between Lock E24 at Baldwinsville and Lock E23 at Brewerton (and Caughdenoy Dam and Guard Gate)	Includes flows from Oswego River fed by Oneida River, Seneca River, and Onondaga Lake
Lock O1, Phoenix	2.15	Lock O2, Fulton	11.48	9.33	River	Fixed Crest and Tainter Gated Dam O2 at Fulton Powerhouse at dam? Lock O2	Includes Oswego River
Lock O2, Fulton	11.48	Lock O3, Fulton	12.06	0.58	River	Fixed Crest Dam O3 at Fulton Powerhouse at dam? Lock O3	Includes Oswego River
Lock O3, Fulton	12.06	Lock O5, Minetto	18.49	6.43	River	Fixed Crest Dam 05 at Minetto Powerhouse at dam? Lock O5	Includes Oswego River
Lock O5, Minetto	18.49	Lock O6, High Dam	21.78	3.29	River	High Dam (Fixed Crest at O6) Powerhouse at dam? Lock O6	Includes Oswego River
Lock O6, High Dam	21.78	Lock O7, Oswego	22.45	0.67	River	Curved Dam (Fixed Crest at O7) Powerhouse at dam? Lock O7 Bypass Culvert and Sluice Gate Lock O7	Includes Oswego River
Lock O7, Oswego	22.45	Lock O8, Oswego	22.89	0.44	Canal	Side Spillway between O7 and O8 Sluice gate above O8 Spillway above O8 Lock O8	Canal parallels Oswego River bewteen structures.
Lock O8, Oswego	22.89	Lake Ontario		N/A	River		Cannot isolate at Lake Ontario. Includes Oswego River.

Notes and Assumptions:

It is assumed that any and all navigation locks can be cross fed to pass water downstream and they are listed as dewatering/outlet features for upstream segments.

Canal mileposts taken from www.canals@ny.gov boating information tables and online map

Listing of dewatering features and outlets in each segment are preliminary and subject to review and revision. The feasibility of safely dewatering the segments listed is not assured and should be evaluated by staff familiar with the operation and limitations of the segment and applicable features.

Sections are classified as a canal if it is anticipated that essentially all inflow to the section can be stopped using existing controls, otherwise segments are considered rivers, which includes sections with smaller flows fed by streams or coincedent with lakes.

Feeder and Remenant Canals Isolation and Dewatering Segments

Feeder or Remenant Canal	Upstream Limit Structure	Downstream Limit Structure	Length (mi)	River or Canal Segment	Segment Dewatering Features and Outlets	Notes
Glens Falls Feeder Canal (GFFC)	Glens Falls Feeder Intake Sluice Gate (1FGFI3D)	GFFC Spillway at Champlain Canal (1F0SW3D) above Lock C-8 at Fort Edward	8.4	Canal	Shut off inflow at Intake Outlet flow at Champlain Canal Other sluice gates upstream of old locks	
Black River Canal	Foresport Feeder at Sargent's Waste Weir (Boonville)	Spillway to Lansing Kill (4F0463D)	3.9	Canal	Limit inflow with control from Foresport Feeder Spillway to Lansing Kill (4F0463D)	
Forestport Feeder	Alder Pond Dam (Forestport)	Black River Canal at Sargent's Waste Weir (Booneville)	10.3	Canal	Obermeyer Gate - Dutch Hill (4F0043C) Sluice Gates - Forestport Feeder Hydro (Head) (4FF483D) Feeder Waste Weir - Williams (4F0026B) Feeder Waste Weir - Nugents (4F0016B)	
Nine Mile Feeder	Nine Mile Feeder Headgates on West Canada Creek (Trenton Falls) (4F0453D)	Nine Mile Feeder Flume (4F0263D)	5.7	Canal	Shut off inflow at Headgates intake Outlet flow at Flume	
Chenango Canal	Woodman Pond Spillway (4F0373D) and Madison Feeder near Woodman Pond	Solsville Spillway at Oriskany Creek (4X0253D)	5.7	Canal	Control inflow from Chenango Feeder, Madison Feeder and Leland Pond Outlet Outlet flow at Solsville Spillway to Oriskany Creek	See limitations on Leland Pond Outlet controls.
Leland Pond Outlet	Leland Pond Dam	Chenango Canal north of Peckport	0.3	River	Limit Leland Pond outflow by closing LLO valves; no control available for stoping or diverting flow at fixed crest spillway.	Connector is only outlet for Leland Pond so functions as river where reservoir ouflow must be passed.
Madison Feeder	Payne Brook Sluice Gates at Madison Feeder	Chenango Canal near Woodman Pond	2.2	Canal	Shut off inflow from Payne Brook at Sluice Gates Outlet into Chenango Canal	
Chenango Feeder	Chenango Feeder Headgates at Chenango River (4F0543D) at Randallsville Dam	Chenango Canal near Woodman Pond	5.9	Canal	Shut off inflow at Feeder Dam Sluice Gate Intake Waste Weir (4F0156B) and Spillway (4F0383D) Feeder Waste Weir - S of Bridge 13A (4F0146B) Outlet into Chenango Canal	
Kingsley (Lebanon) Feeder and Bradley Brook Feeder (AKA continuation of Chenango Feeder)	Kingsley Book and Bradley Brook	Chenango River at Chenago Feeder Head	2.6	N/A	N/A	***Segment abandoned.***
Old Erie Canal Feeder	Butternut Aquaduct at Old Erie Canal Feeder (5F0027A)	Erie Canal in New London	30.9	Canal	Shut off inflow from Butternut, Limestone, Chittenango Feeders Outlet at Aquaduct Sluice Gates - Butternut (5F0023D), Limestone (5F0013D) and at Waste Weirs - Pools Brook (5F0016B), Chittenango Aqueduct (4F0126B), Cowaselon Aqueduct (4F0116B), Durhamville Aquaduct (4F0106B and 4F0096B) Spillway at Verona (4F0683D)	Operation and control of inflow from other feeders is required.

Feeder and Remenant Canals Isolation and Dewatering Segments

Feeder or Remenant Canal	Upstream Limit Structure	Downstream Limit Structure	Length (mi)	River or Canal Segment	Segment Dewatering Features and Outlets	Notes
Butternut Feeder	Diversion Dam on Butternut Creek (5F0B13A)	Butternut Aquaduct at Old Erie Canal Feeder (5F0027A)	2.2	Canal	Shut off inflow at Diversion Dam Sluice Gate (5F0B13D) Outlet flow through Sluice Gate at Butternut Aqueduct (5F0023D) and other waste weirs and sluice gates of Old Erie Canal	
Limestone Feeder	Limestone Feeder Bulkhead (5F0F13D)	Old Erie Canal Feeder	0.9	Canal	Shut off inflow at Bulkhead Waste Weir (5F0F16B) Outlet flow through Sluice Gate at Limestone Aqueduct (5F0013D) and other waste weirs and sluice gates of Old Erie Canal	
Chittenango Feeder	Headgates on Chittenango Creek (4F0513D)	Old Erie Canal Feeder	0.3	Canal	Shut off inflow at Dam Headgates	
Hatch-Bradley Connector	Hatch Lake Reservoir Dam (4Y0593A)	Bradley Brook Reservoir	0.2	River	Limit Hatch Lake outflow by closing headgate valves; no control available for stoping or diverting flow at fixed crest spillway.	Connector is only outlet for Hatch Lake so functions as river where lake outflow must be passed.
Old Champlain Canal	Old Champlain Canal Dry Wall Lock 4 SW Approach (2XSW4D)	North End Abandonment (0.7mi north of STRIN 2OCF46A)	2.1	Canal	Limit inflow from Lock E-3 and closure of intake for Old Champlain Canal (2X0C43E) Drain with E-2 Bypass spillway and crossfeed at Lock E-2	

Notes and Assumptions:

Lengths taken from December 2008 NYSCC Reservoir System Analysis Final Report by Bergmann or aerial pictometry measurements.

Additional small connector canals and natural watercourses used in the canal feeder system may require manipulation of reservoir and watercourse controls in conjunction with the segments noted herein.

Listing of segments and of dewatering features and outlets in each segment are preliminary and subject to review and revision. The feasibility of safely dewatering the segments listed is not assured and should be evaluated by staff familiar with the operation and limitations of the segment and applicable features.

Sections are classified as a canal if it is anticipated that essentially all inflow to the section can be stopped using existing controls, otherwise segments are considered rivers, which includes sections with smaller flows fed by streams or coincedent with lakes.