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 (BMP_S)

March 2021

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:

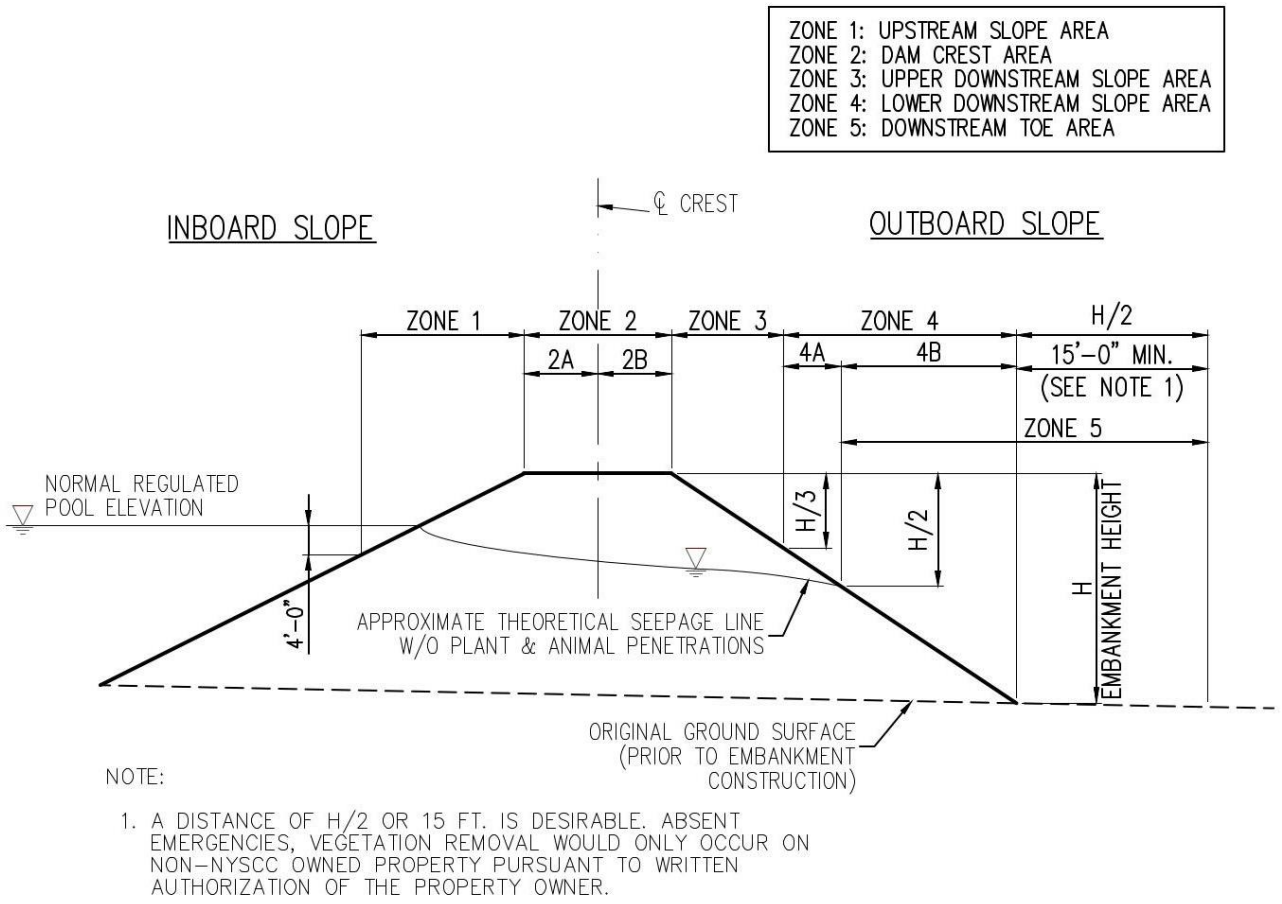
- **The best practices and suggested details contained in this manual are general and may require modification based on specific site conditions.** As such, some of the recommendations, procedures and details must be reviewed by a licensed professional prior to implementation. **Specific BMPs that require 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.

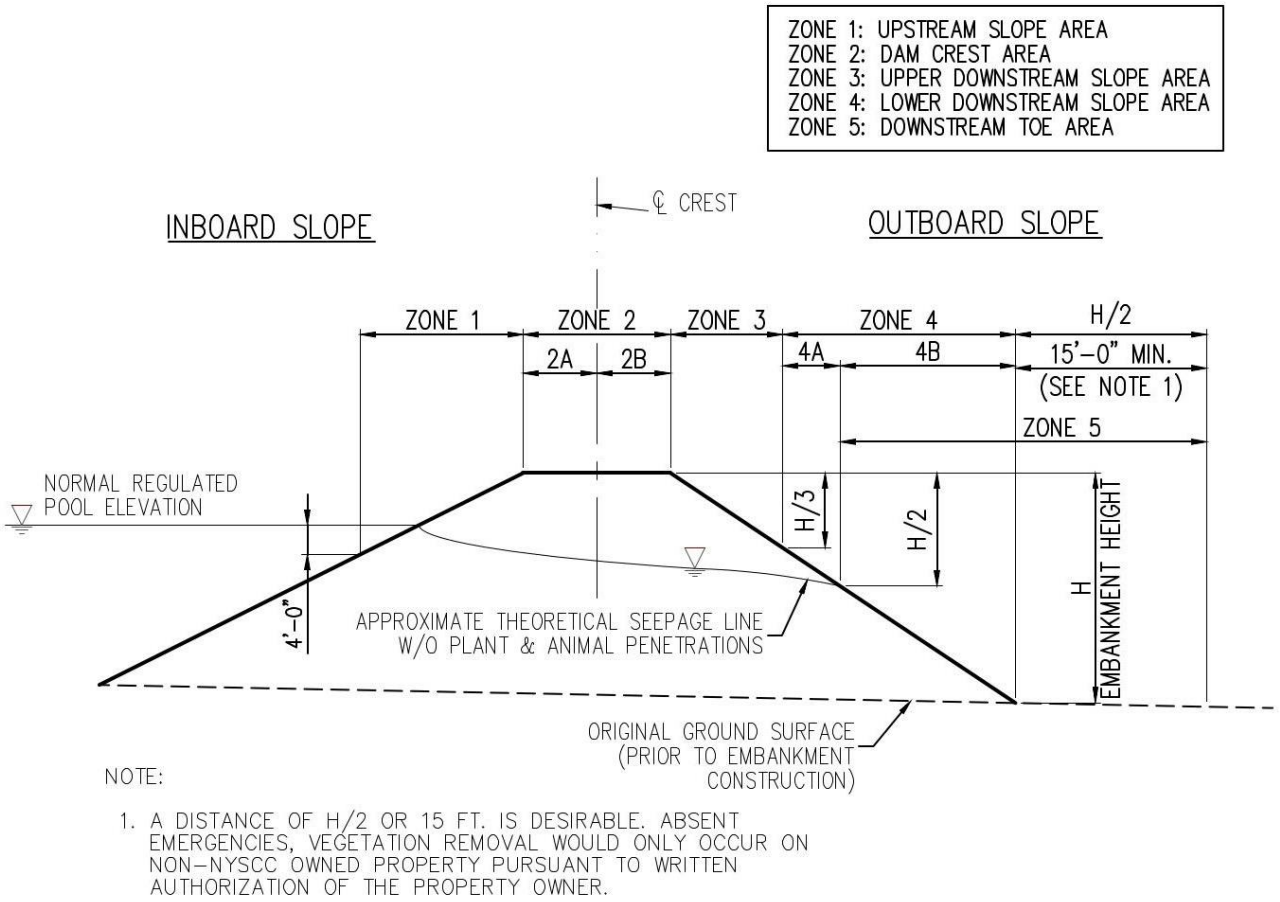
EXCAVATION (PE Review Req'd)

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.*

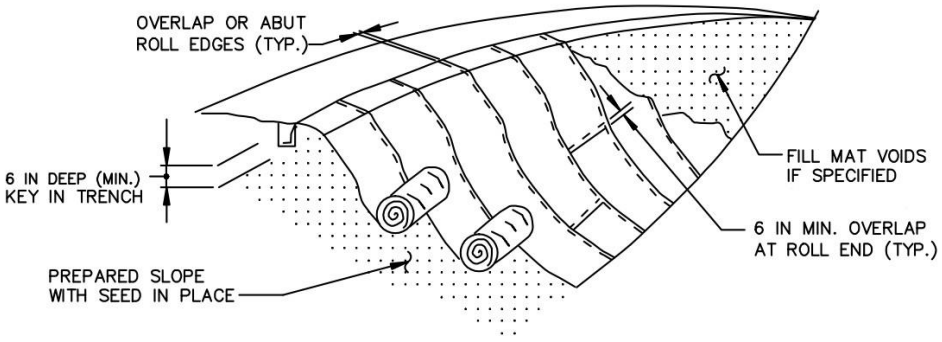
PURE LIVE SEED (PLS):

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.

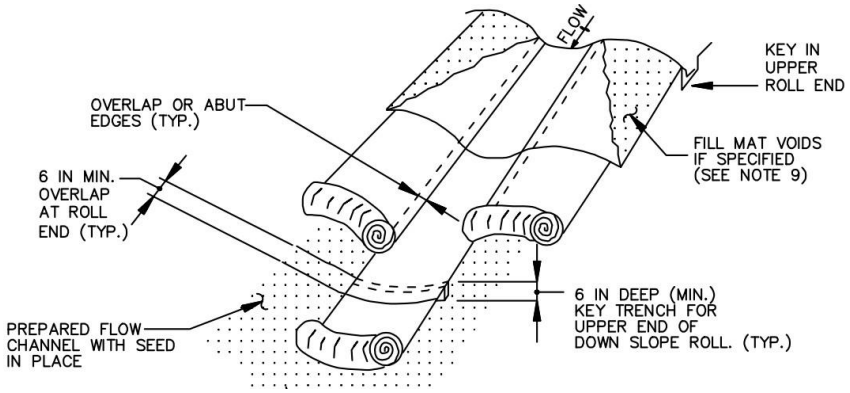
$$\text{Pure Live Seed (PLS)} = \frac{\%\ \text{Germination} \times \%\ \text{Purity}}{100}$$

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)

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

Alumroot *(Heuchera americana)*
Beebalm *(Monarda didyma)*
Black-eyed Susan *(Rudbeckia hirta)*
Butterflyweed *(Asclepias tuberosa)*
Heath Aster *(Sympotrichum ericoides)*
Hyssopleaf Thoroughwort *(Eupatorium hyssopifolium)*
Labrador Violet *(Viola labradorica)* *
Prairie Phlox *(Phlox pilosa)*
Smooth Aster *(Symphyotrichum laeve)*
Tall White Beardtongue *(Penstemon digitalis)*
Wild Bergamot *(Monarda fistulosa)*
Wild Columbine *(Aquilegia canadensis)*
Woodland Sunflower *(Helianthus divaricatus)*
Zig Zag Goldenrod *(Solidago flexicaulis)*

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. Mowing of the pollinator plants is required at least once per year to prevent the growth of woody vegetation.

Pollinator plantings provide much needed food and shelter for our native pollinators. Embankment vegetation management practices are friendly to pollinator landscapes.

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
- 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.

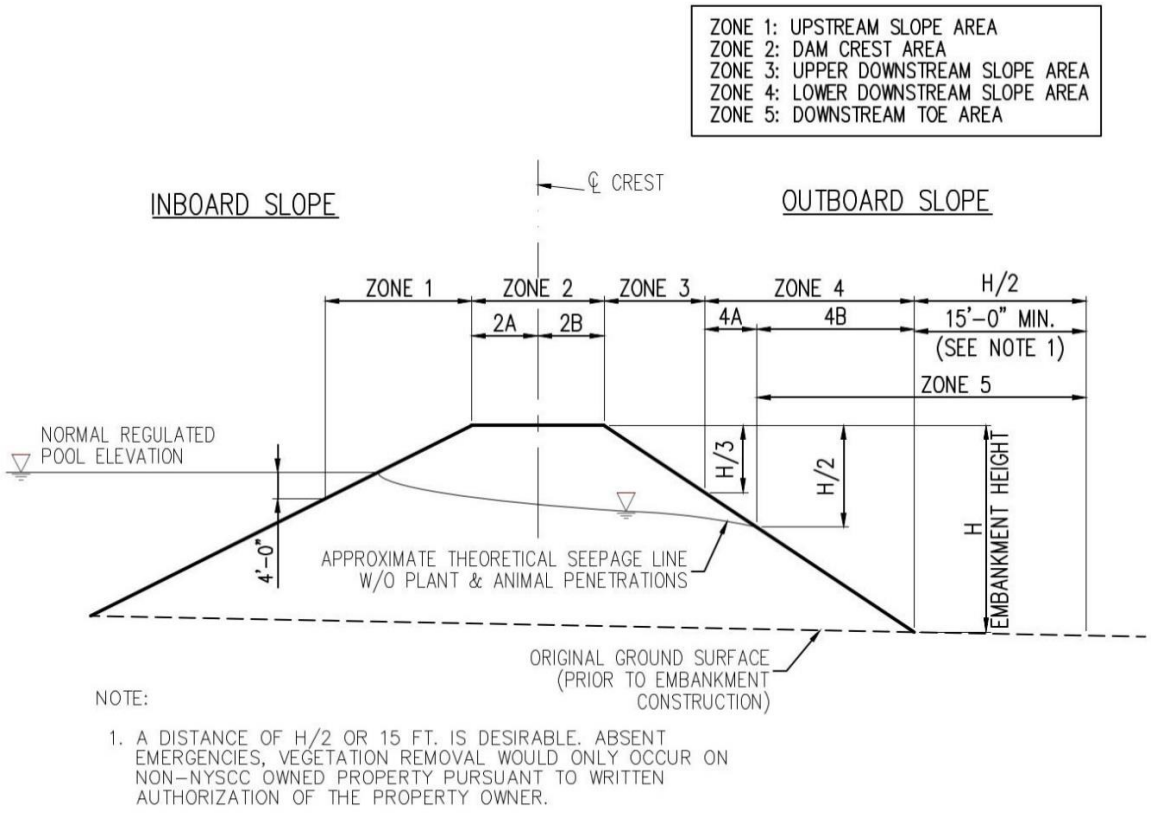
RECOMMENDED PROCEDURE

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.

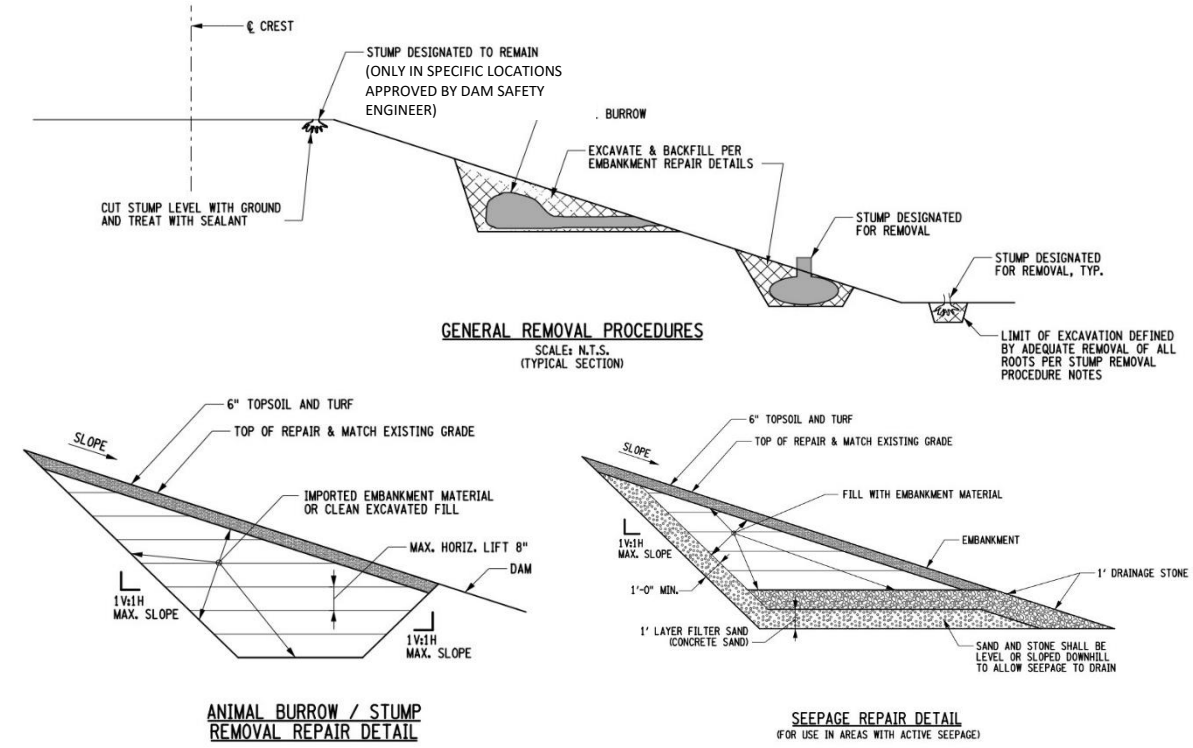
TREE REMOVAL PROCEDURES:

- 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.

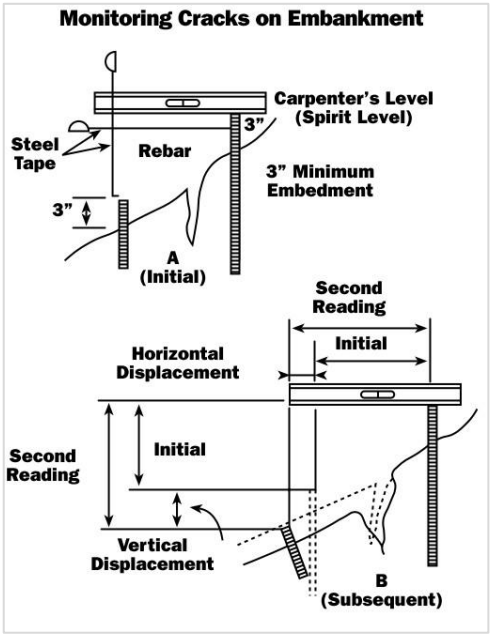
EMBANKMENT CRACKS

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

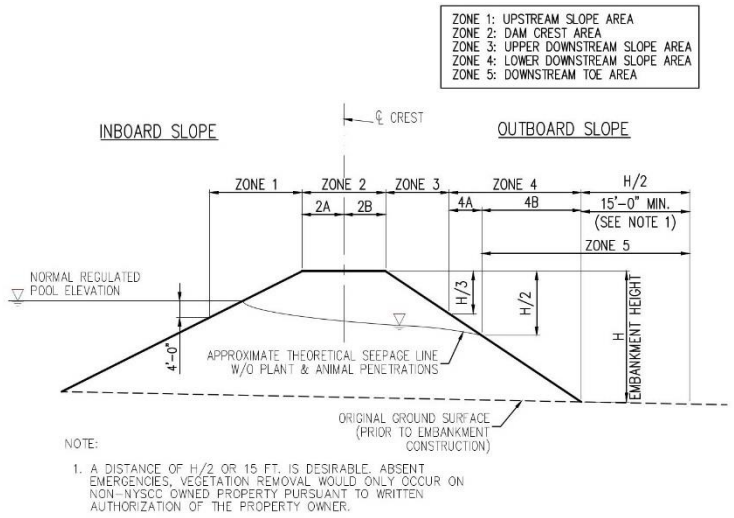
- Animal burrow entrances, mounds of excavated soil, debris, cracks, depressions, erosion, sinkholes, paths and ruts, sloughs, slides, and scarps near the inboard shoreline and crest.
- Concentrated seeps, wet/spongy areas, cracks, depressions, erosions, sinkholes, paths and ruts, sloughs, slides, and 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 discourages 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.

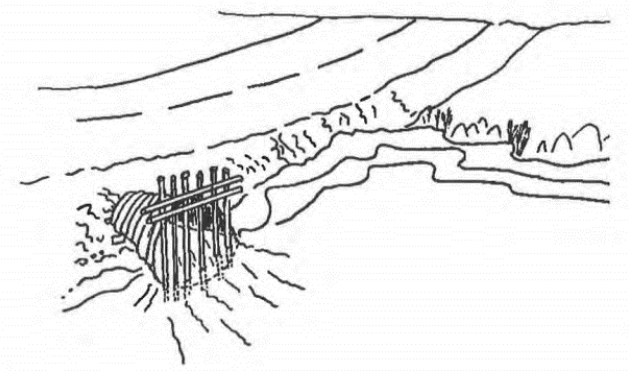
The *Beaver Damage Control Techniques Manual* (NYSDEC, 1996) was developed to provide information on the most effective techniques available for resolving beaver/human conflicts. A summary of standard procedures for handling beaver nuisance complaints are as follows:

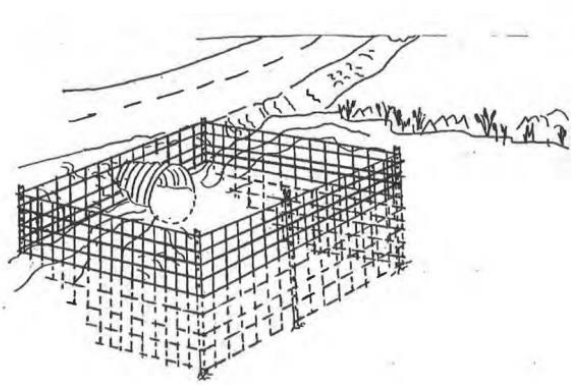
- A "Nuisance Beaver Permit" needs to be acquired from the NYSDEC to permit to kill or harass destructive wildlife pursuant to Environmental Conservation Law 11-0521. The permit may authorize agents certified by NYSDEC for lethal removal (via firearm or trapping), disturbance or removal of any beaver 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.





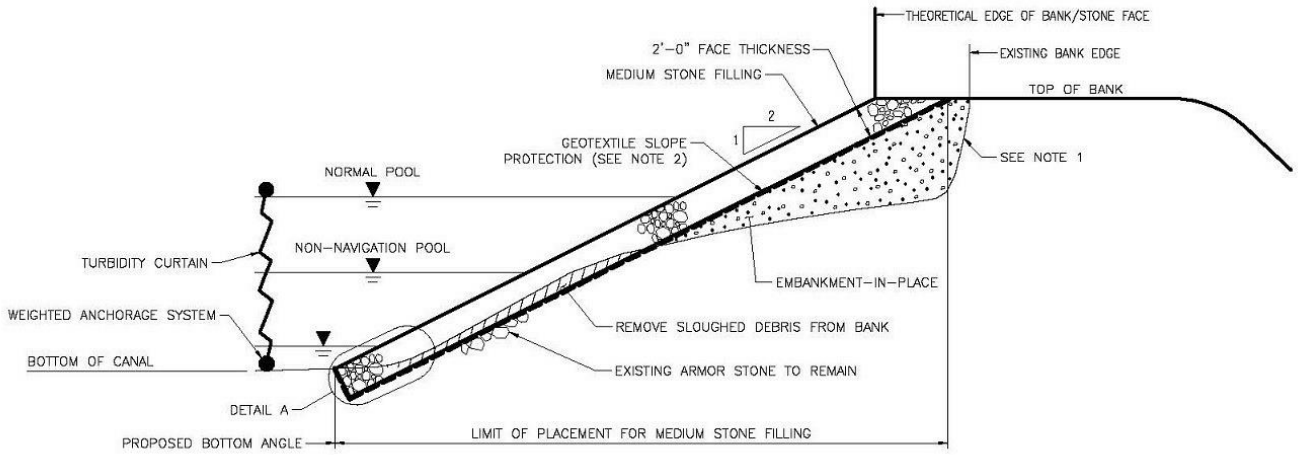
UPSTREAM SLOPE PROTECTION (INBOARD SIDE) (PE Review Req'd)

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.

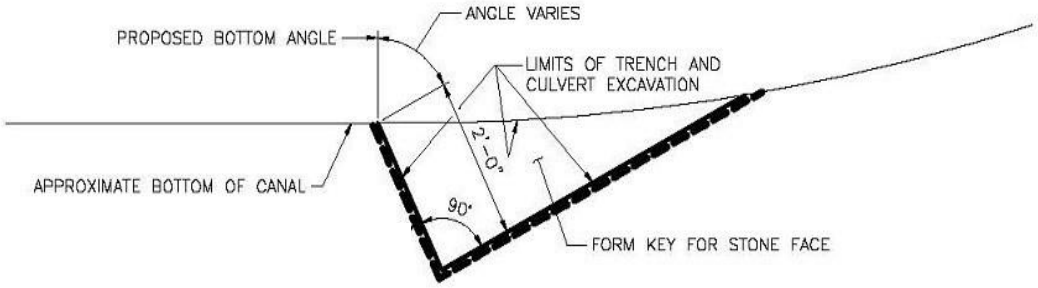


TYPICAL SECTION

NOT TO SCALE

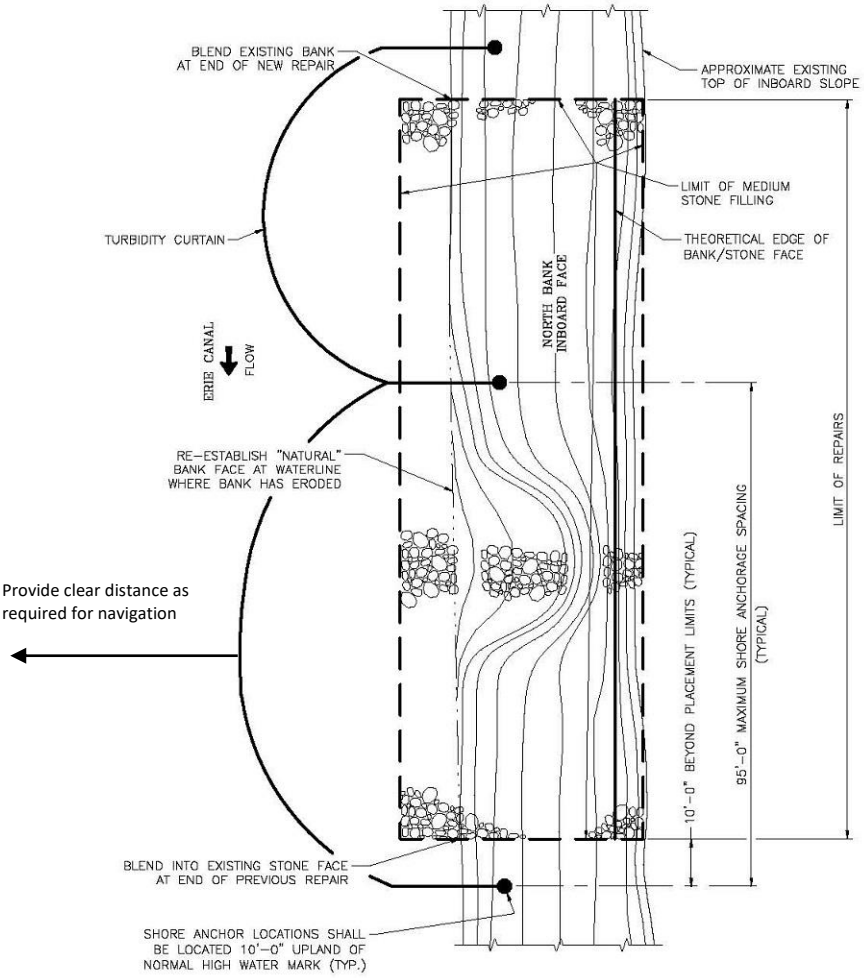
NOTES:

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:

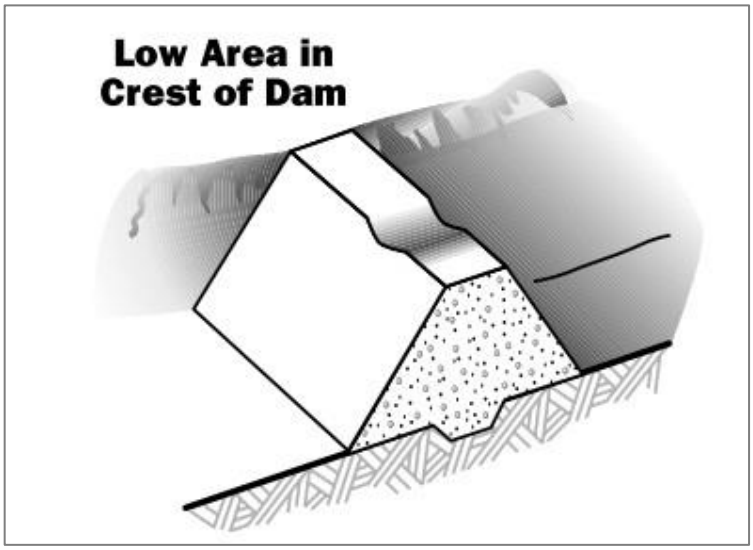
The repair methodology for ruts, surface deformation, and vegetation loss includes the following steps:

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

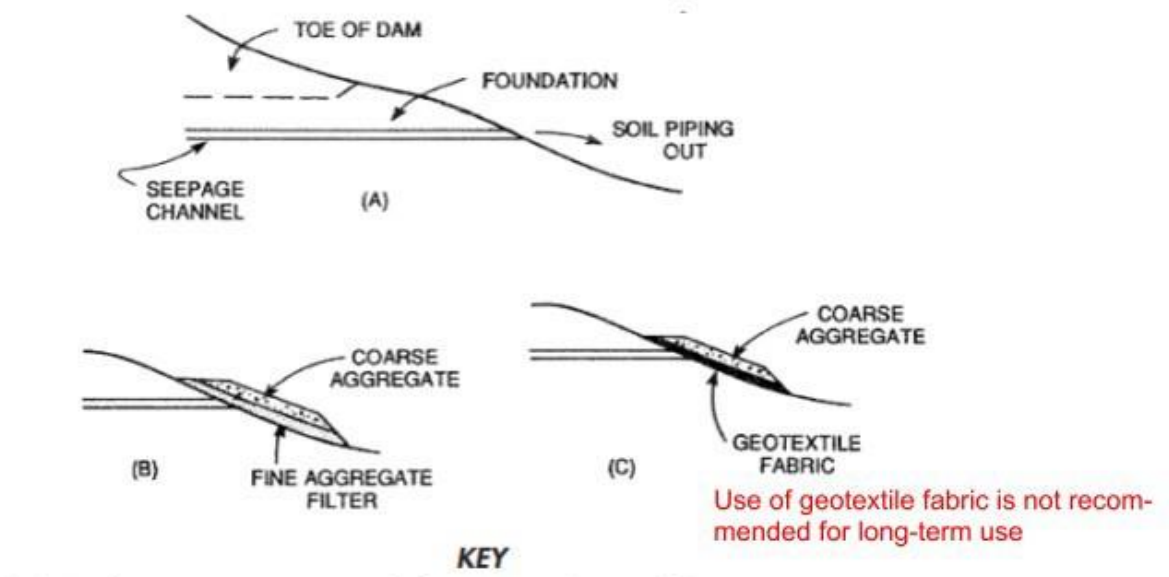
TEMPORARY REPAIRS:

- 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

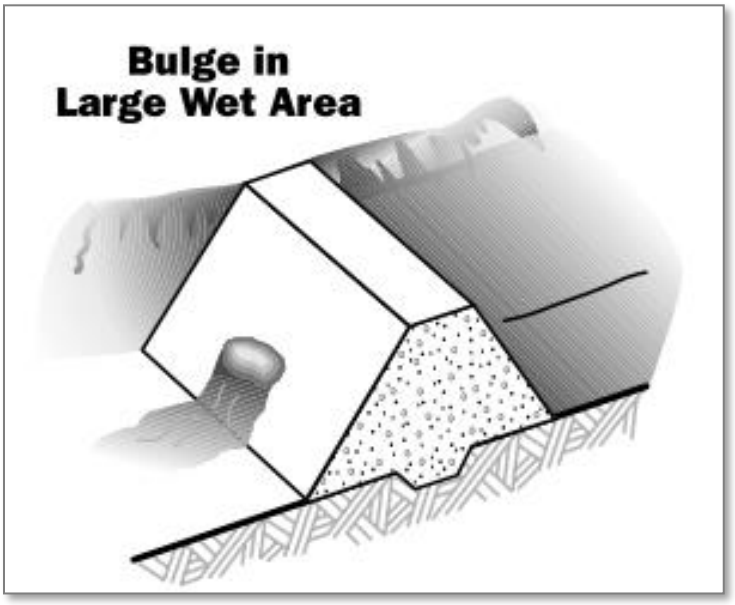
Some seepage is likely to be observed along embankment contact areas such as contacts between cut and fill sections of the embankment, and in areas where the earthen embankment meets structures such as lock walls, waste weirs, spillways, etc. Evidence of seepage may vary from soft, wet areas to a flowing 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)

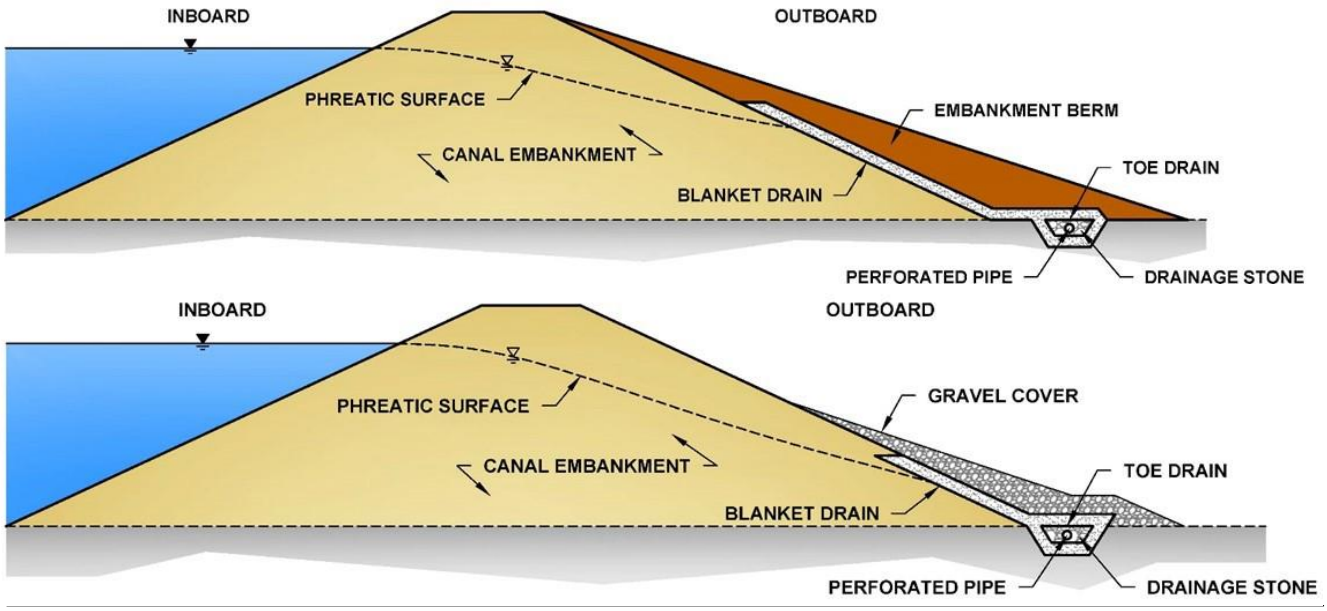
Drainage blankets are a common method for control of seepage through an embankment by collecting seepage in a granular filter from the outboard slope and conveying it downslope to a toe drain. Blanket drains are typically constructed with a sand layer adjacent to the embankment to serve as a filter to 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:

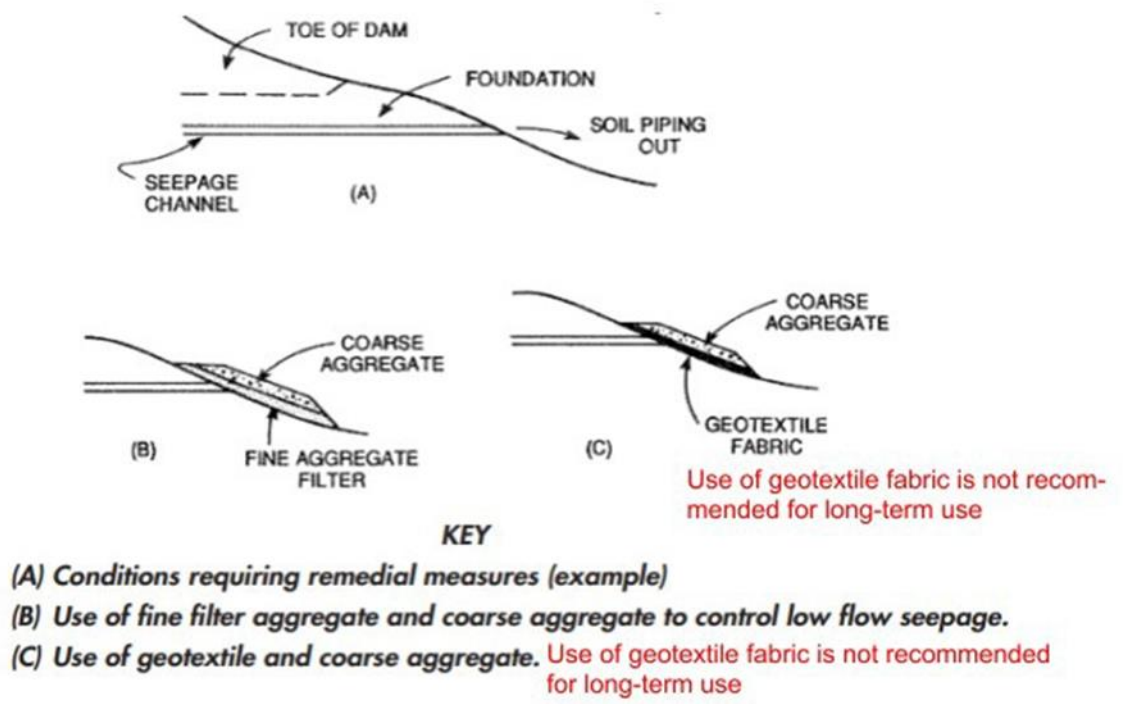
Blanket and toe drains should only be designed, installed or modified under the direction of a competent Professional Engineer (P.E.) and in consultation with the **Dam Safety Engineer**. If seepage is a maintenance issue at the embankment, contact the **Regional Canal Engineer** to request further evaluation.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

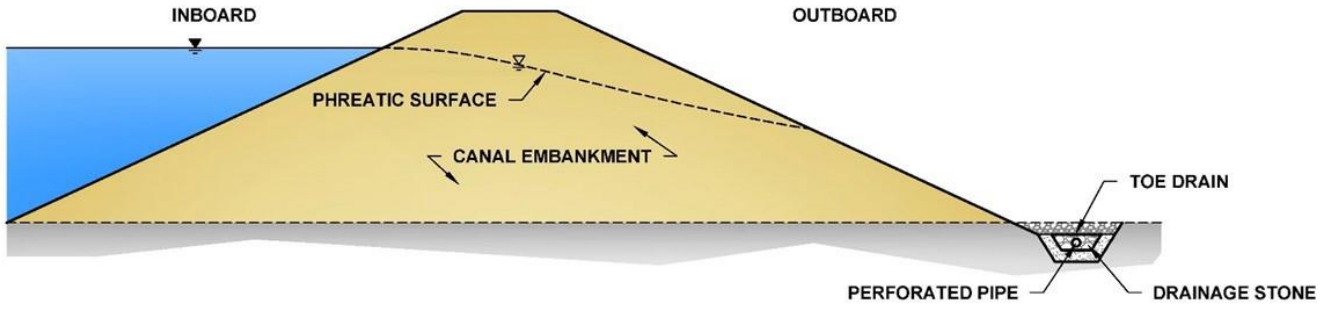
  ⇒ *No Flow* - and has never flowed, could mean the drain was designed or installed incorrectly. Contact the **Regional Canal Engineer.**

  ⇒ *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.

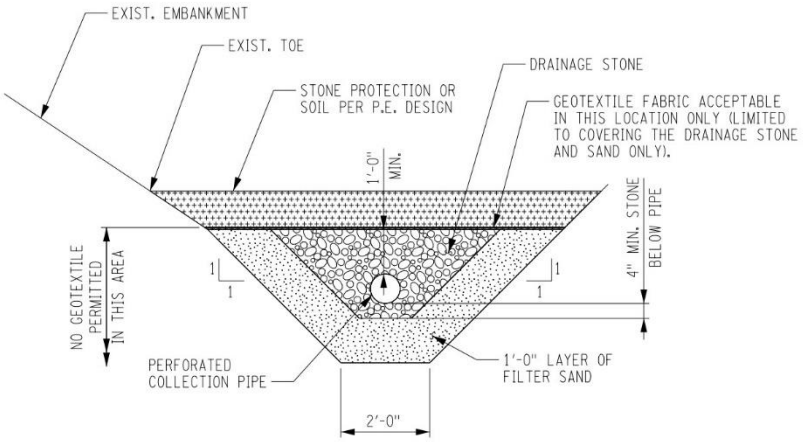
  ⇒ Significant difference in water surface elevation referenced to a datum between adjacent manholes of an underdrain line could indicate a blockage in that section of the system between the manholes.

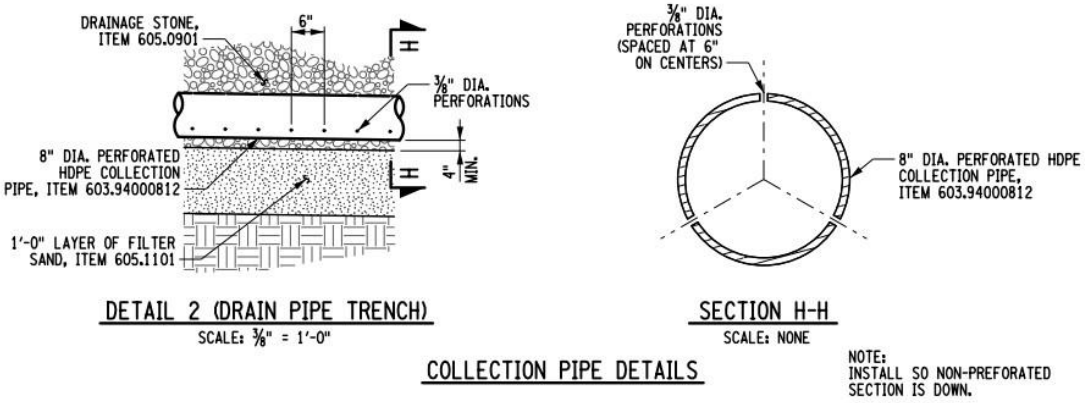
  ⇒ If water surface elevation referenced to a datum, between adjacent manholes of an underdrain line are increased and nearly equal, this indicates there could be a downstream blockage.



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.



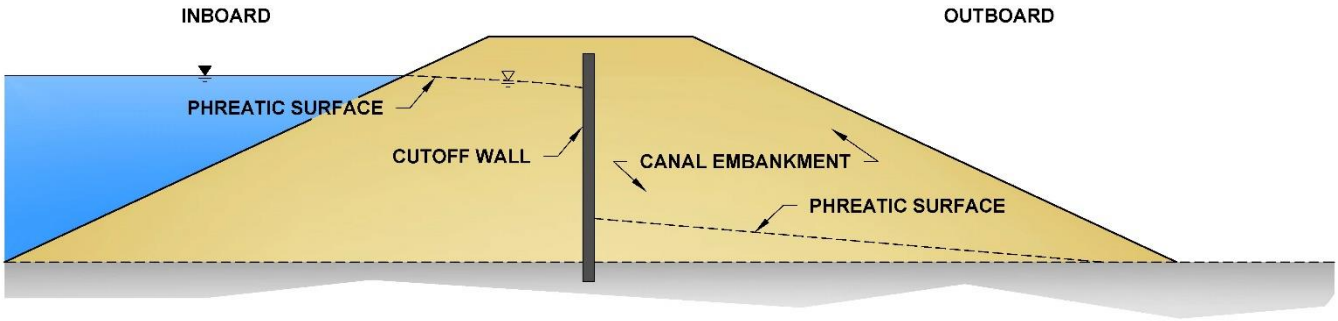


Pipe Diameter may vary depending on length
Perforation diameter should be sized for compatibility with Drainage stone

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.

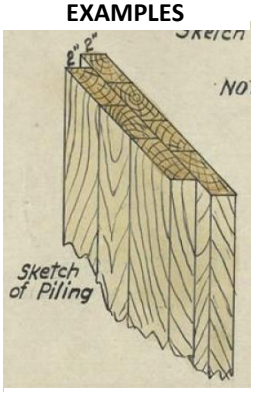
Sheet piles can also be used to as a means of retaining soil (retaining wall). This BMP does not cover the use of sheet piles for soil retention and retaining walls.

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.

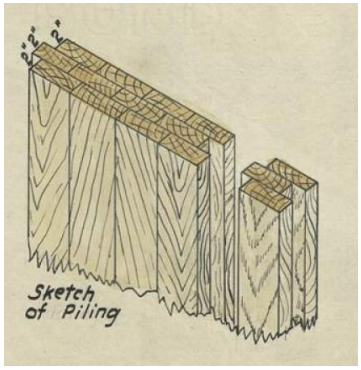
TIMBER SHEETING EXAMPLES



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.



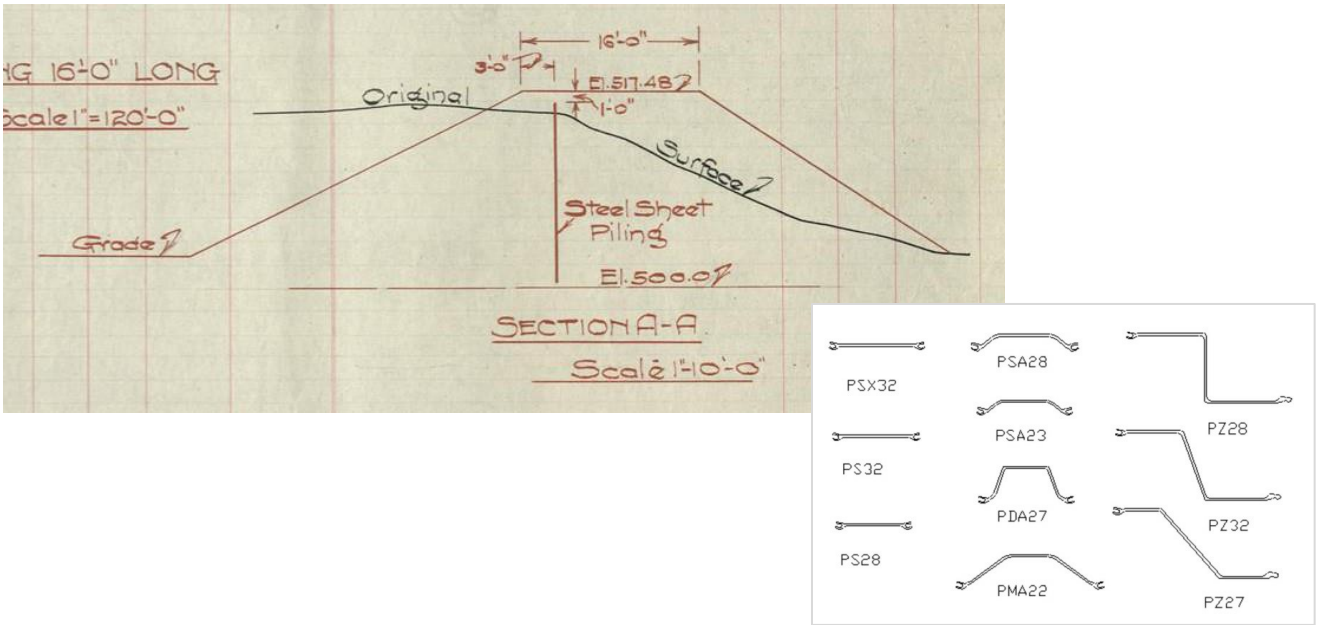
Triple-Lap Timber Sheeting (Wakefield Sheeting

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.

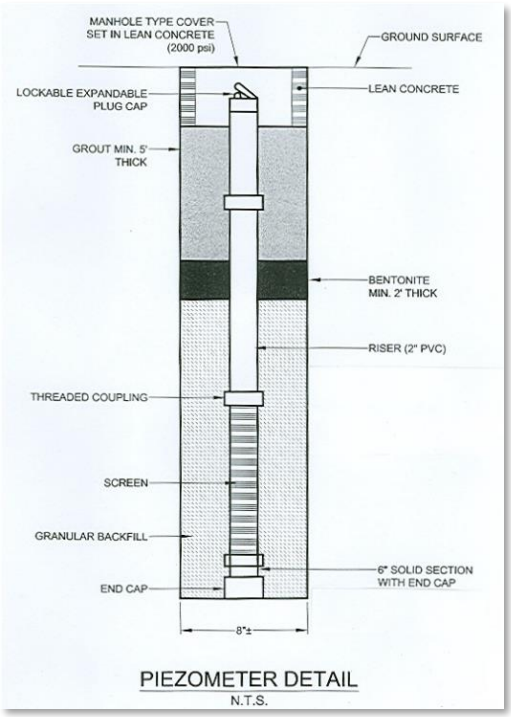
Continued use of this method of addressing seepage is not recommended without careful consideration and if used, it should be performed only under the direct supervision of a licensed professional engineer with extensive experience with geotechnical engineering and dam safety.

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:

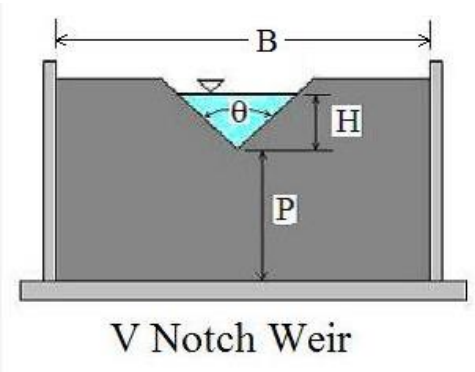
- V-notch weirs should be monitored on a regular basis. The Enhanced Embankment Monitoring / Quarterly Inspection Form has a location for recording readings from the weir.
- Remote monitoring of the weir is possible via monitoring equipment and can be used in remote locations or locations where having 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.

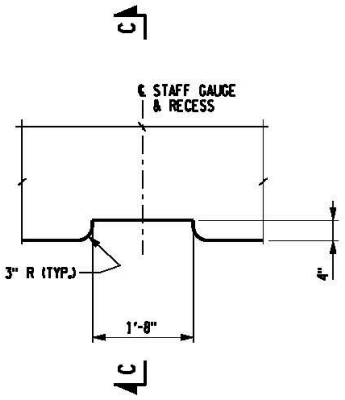
Frequency: As Needed

CONSTRUCTION & REPAIR:

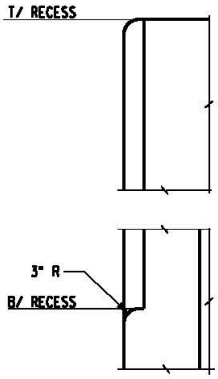
- Staff gauges are readily available from a variety of manufacturers. The gauges should be permanently fixed to a structure such as the embankment walls or a rod securely embedded into the bottom of the canal or feeder. If located within the canal or feeder, gauges should be marked, flagged and protected 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
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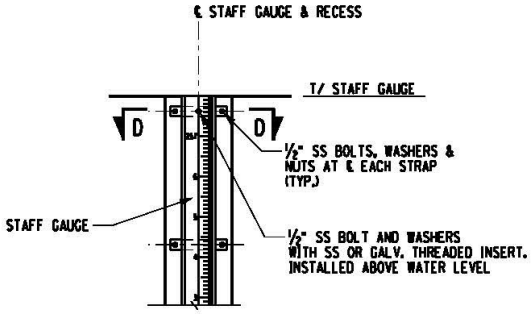
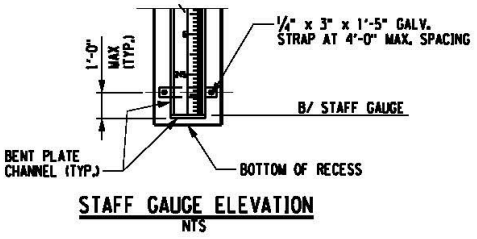
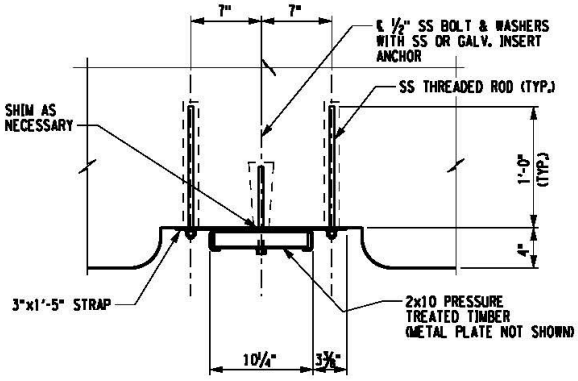




STAFF GAUGE ELEVATION
NTS

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
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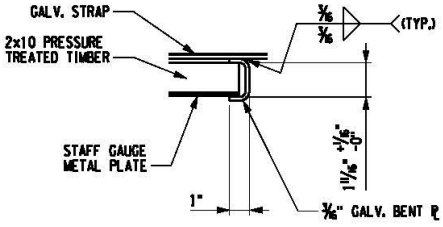


DETAIL 1
NTS

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.

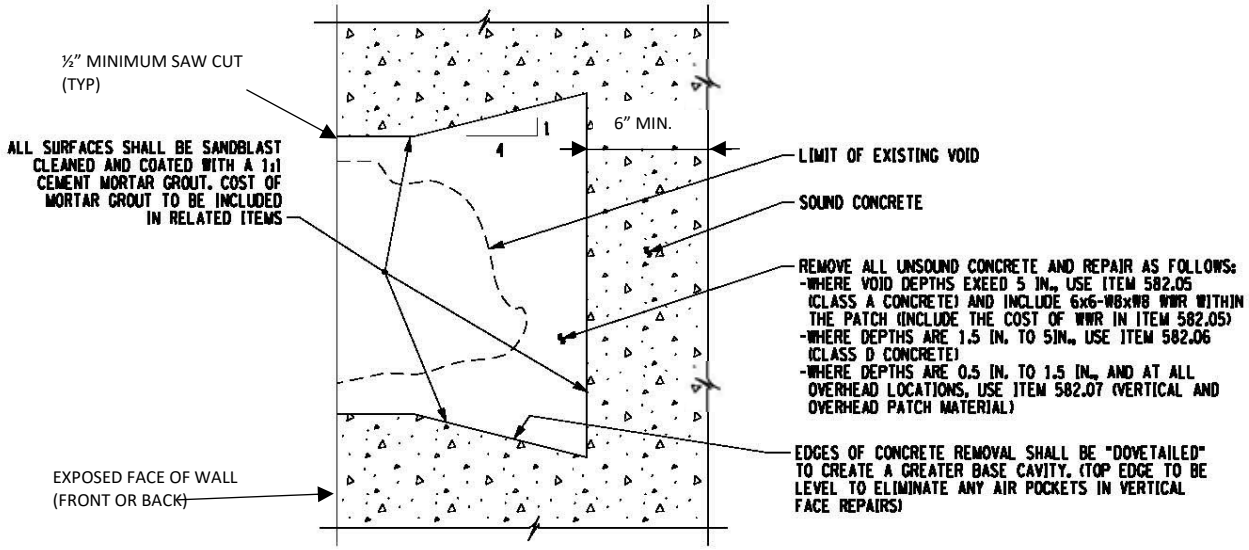
REPAIR:

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)

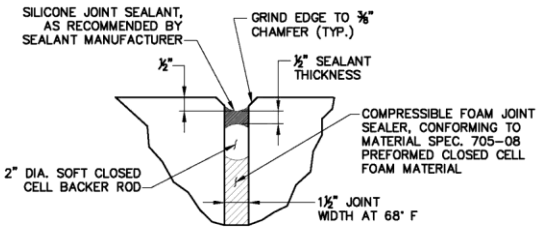
Joints in a concrete structure (typically slope paving in canals and feeders) are the most common place for seepage to occur. Seepage can occur when the sealant between the expansion joint has deteriorated. Joint seepage can lead to rapid erosion and ultimately can cause walls to tip in and over. It 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:

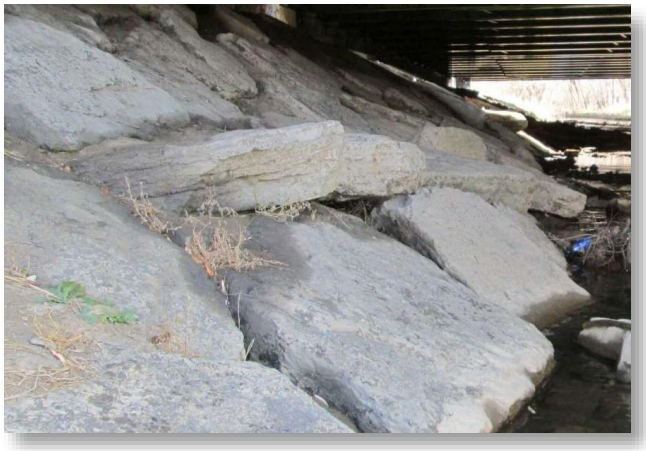
- The cement in fresh concrete and mortar is toxic to aquatic life. No wet or fresh concrete, mortar, or wash water should be allowed to escape directly or indirectly into any waterbody or drainage structure (stream, wetland, ditch, pond, etc.).
- Coordination with Environmental Health & Safety is required 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.