STANDARD OPERATING PROCEDURE
FOR

INSTALLING PIPES ACROSS LEVEE ALIGNMENTS

(28 November 2023)

1. **INTRODUCTION**:
The purpose of this SOP is to summarize EM 1110-2-2902 concerning the acceptable methods for installing pipes across existing levee alignments to help initiate the design and plan against unnecessarily disturbing the levee or promoting seepage. It is neither intended nor desired that this SOP be copied directly onto plan sheets. Unless specifically stated as embankment or floodwall, the use of the term levee applies to both. The following guidance assumes that the necessary approvals (33 USC 408, EPA, PHMSA, etc.) have been obtained for the method of installation chosen. USACE reserves the right to deny request that are determined to increase the risk beyond an acceptable level, particularly for non-essential pipes.

2. DESCRIPTIONS & CRITERIA:
Pipes crossing levee alignments may do so by going over it (aka, elevated), through it (directly or articulated), or beneath it (trenched or trenchless). A "carrier" pipe conveys the utility (water, gas, fiber optic lines, etc.); a "casing" pipe is installed across the levee alignment or through a barrier (floodwall, closure sill, etc.) to provide a means for future replacement of the carrier pipe without damaging the levee.

2.1. Pipes Passing Over a Floodwall – Pipes passing over a floodwall, in order of preference, can be frame-supported (unattached to the floodwall with a standoff distance), free-standing, or supported (attached to the floodwall). The benefit of being supported with ample standoff distance is not only that it doesn't affect the floodwall, but it also provides room for inspection and flood-fighting access. Free-standing pipes are not attached to the wall but are likely most appropriate for I-walls since T-wall footings may prevent trenching close to the wall. Free-standing pipes can potentially hinder inspections, access, or disturb toe drains, so they should have sufficient standoff distance to allow easy access to the wall. Pipes can be secured to the floodwall, but the method of attachment must not penetrate deep enough to encounter the wall's reinforcing bars, and the penetrations must be sealed to prevent water intrusion.

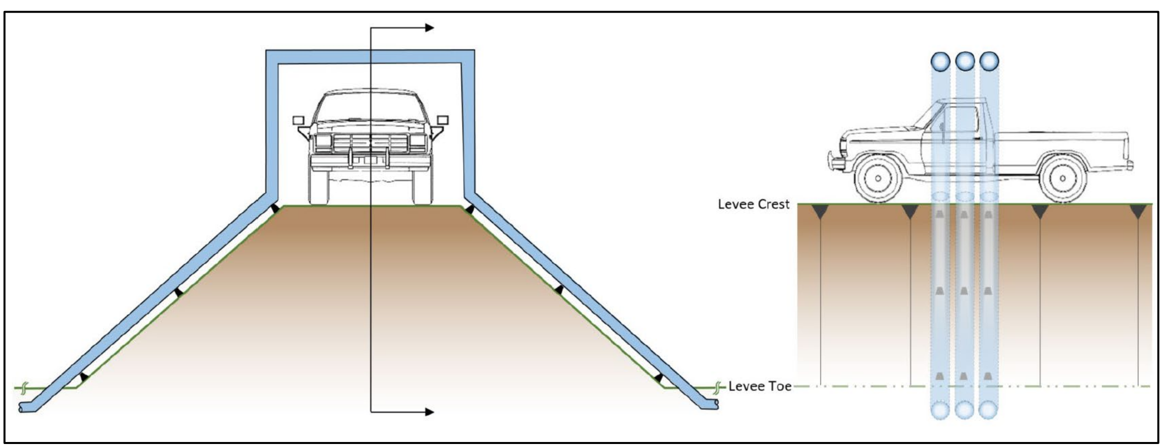
Frame-supported & unattached (left), free-standing (right)

2.2. Pipes Passing Through a Closure – Pipes may be installed through or beneath concrete closure sills, but going through the sill should be avoided unless there is no other option available for an essential pipe. The casing pipe would either be laid in a saw-cut trench, which would almost certainly require severing many reinforcing bars that would have to be repaired, or a specialty contractor would have to drill a horizontal hole through the length of the sill, which may encounter reinforcing bars anyway. Modification requests that do not provide adequate structural capacity will not be approved. The annular space between either the casing pipe and carrier pipe (if installed in a trench) or the carrier pipe and surface of the cored concrete, must be sealed on both ends by modular seals or grout.

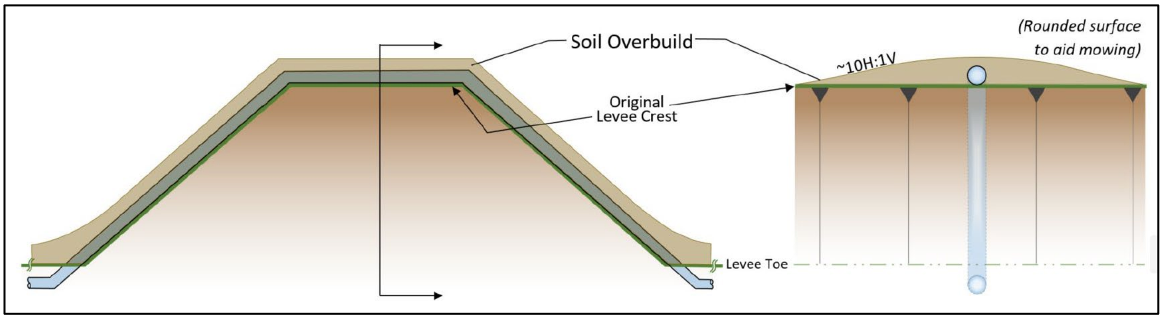
2.3. Pipes Passing Through a Concrete Floodwall – If passing the pipe over the floodwall is for some reason forbidden or problematic, the pipe may pass through the floodwall by filling the annular space with grout or using an expanding modular seal (such as Link-Seal or Pipe Linx). If the hole through the wall is cored smooth enough so that a modular seal can provide full contact without leaking, then a casing pipe is not necessary; otherwise, a casing pipe will need to be grouted in place to provide that smooth surface. If only one seal is used it must be used on the waterside of the wall, but two seals are recommended for stability and redundancy. Coring may compromise no more than two adjacent primary (tension) reinforcing elements without requiring a structural modification of the floodwall. In lieu of a modular seal, a chemical seal (such as SEMCO PR-821) or cementitious grout seal (such as SikaGrout 300 PT) may be used. A sealant or grout mix that does not contain a shrinkage-reducing agent will not be approved. Since the carrier pipe invert is below the top of levee, outlet control is required for pipe that is not continuously pressurized.

2.4. Pipes Passing Over an Embankment -- Elevated pipes cross the levee alignment without entering the designed embankment prism and subcategories include: 'Passable (Raised)'; 'Passable (Overbuilt)'; and 'Non-passable'.

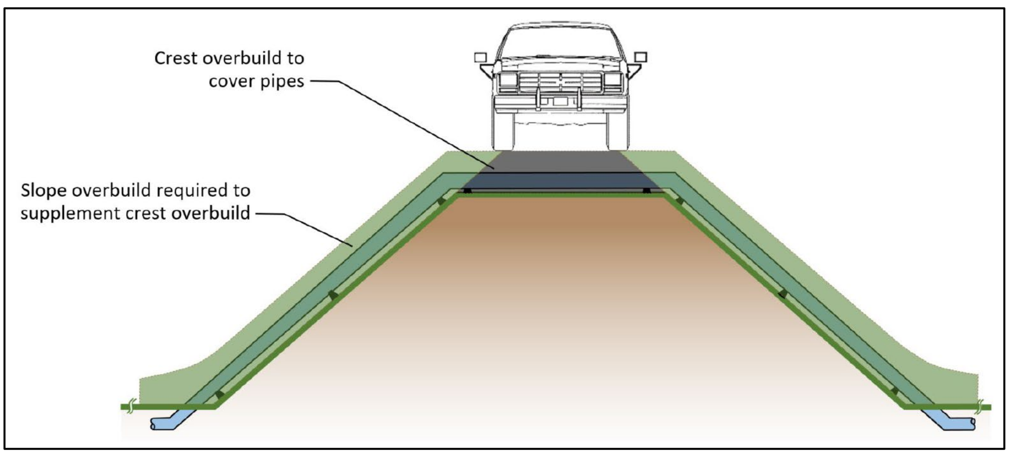
<u>Passable (Raised)</u>: Pressurized pipes in this configuration allow vehicular traffic upon the crest to pass without altering the levee geometry or causing significant disturbance to the embankment; only isolated shallow foundations for support structures should be required. This crossing method is typically only used for continuously pressurized pipes in a closed-system, so no backflow preventative measures would be needed in such a case. Continuous, hardened features underlying the pipe (such as a paved ditch) are discouraged since they often promote soil erosion beneath them and along their sides. If underlayment below the pipe is desired, crushed rock with an underlying bedding stone or geotextile separation layer is preferred.



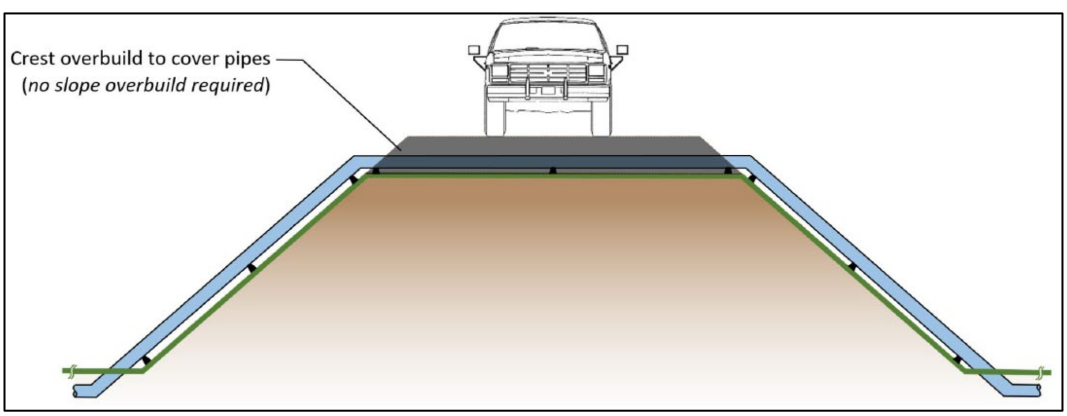
Passable (Overbuilt): Pressurized pipes in this configuration allow traffic to pass over the top of the pipes by providing sufficient soil cover to prevent overstressing the pipes; therefore, calculations or the manufacturer's literature should be provided to demonstrate that the soil cover is sufficient to avoid damaging the pipe and causing leakage that may lead to saturation and instability of the embankment.



Overbuilding the side slopes is usually required since most crests are not wide enough to support vehicular traffic after an overbuild, but this is not a USACE requirement.

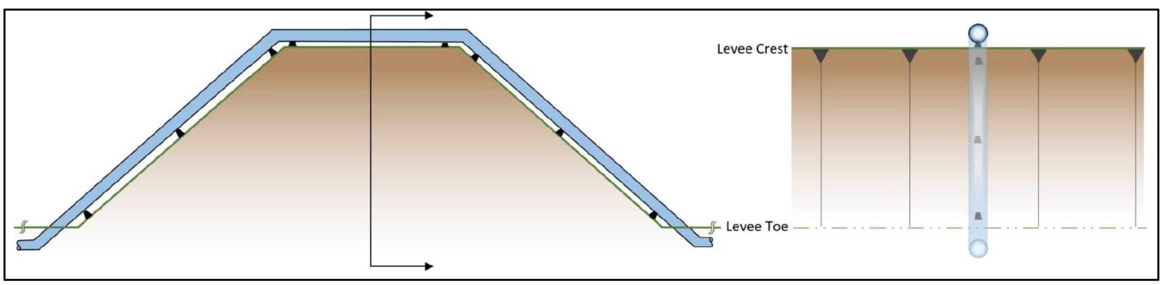


Sometimes a levee crest is wide enough to support vehicular traffic after an overbuild without overbuilding the side slopes, but it is recommended that the side slopes around the pipe(s) be overbuilt anyway to maintain the original crest width and facilitate maintenance mowing.



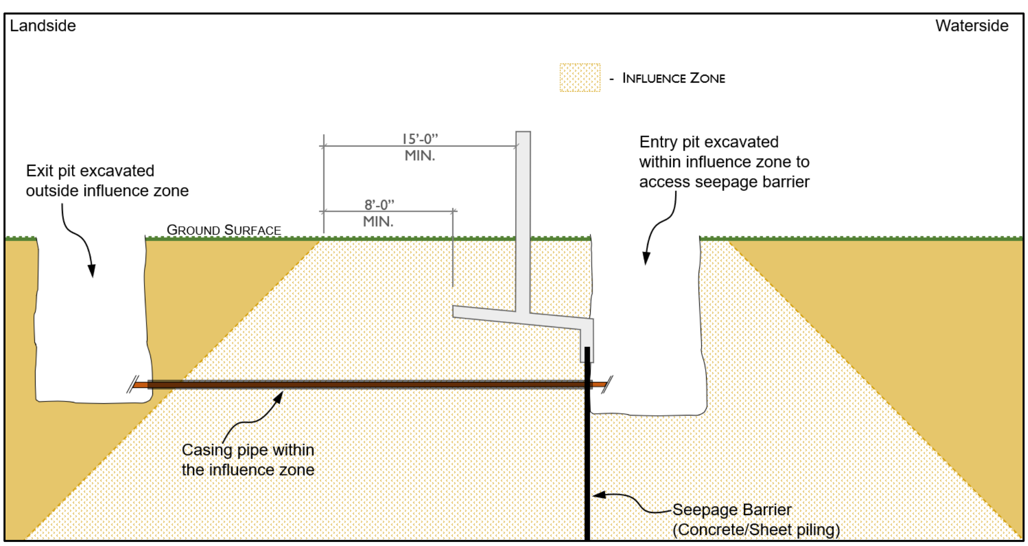
The overbuild should be sloped gradually in all directions to prevent mowing equipment from gouging or scalping the turf. This crossing method is typically only used for continuously pressurized pipes in a closed-system, so no backflow preventative measures would be needed in such a case. Likewise, no outlet control is required on the open end of pump station discharge pipes in this configuration since backflow prior to overtopping is not possible, but automatic flap gates can be used to supplement anti-siphon devices. Since the crossing is above the designed levee prism, encapsulating the pipe in a controlled low-strength material (CLSM) is not required to deter seepage, but the designer may need to include it to reduce stress on the pipe.

Non-passable: While this configuration would not allow traffic to pass on the crest at the crossing, it requires only minor disturbances of the embankment to install isolated footings and eliminates the need for overbuilding the embankment or creating an elaborate elevated piping system. This method is typically only used for continuously pressurized pipes in a closed-system, so there would be no need for backflow preventative measures. Likewise, no outlet control is required on the open end of pump station discharge pipes in this configuration since backflow prior to overtopping is not possible, but automatic flap gates can be used to supplement anti-siphon devices. Continuous, hardened features underlying the pipe (such as a paved ditch) are discouraged since they often promote soil erosion beneath them and along their sides. Crushed rock with an underlying bedding stone or geotextile separation layer is preferred.

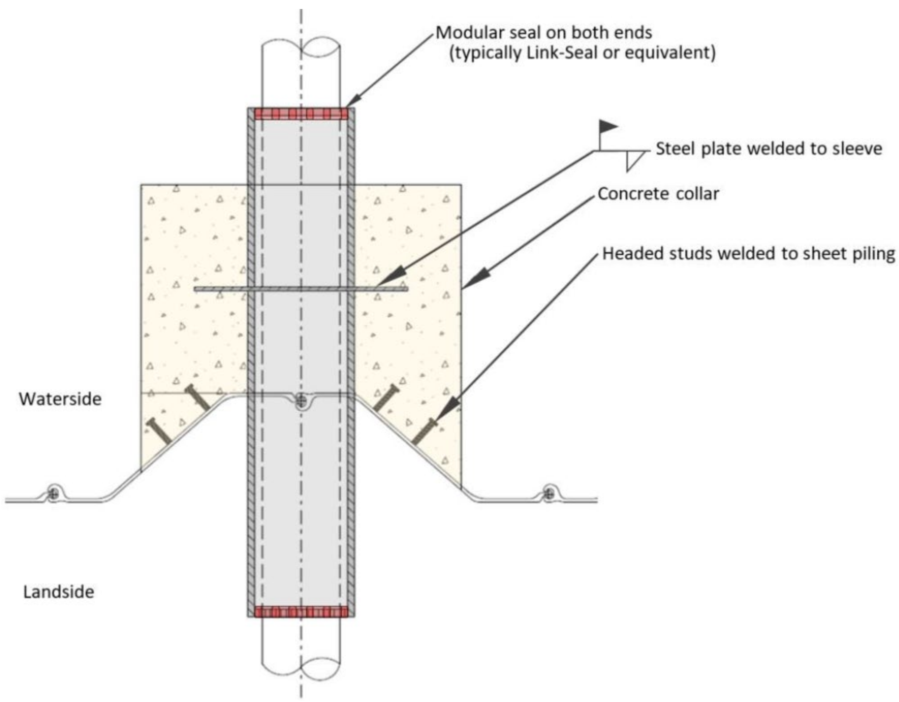


2.5. Pipes Passing Beneath a Floodwall

Beneath a Floodwall with Sheet Piling: Where sheet piling is part of the wall, a pit must expose the sheet piling so a hole can be created (as shown below).

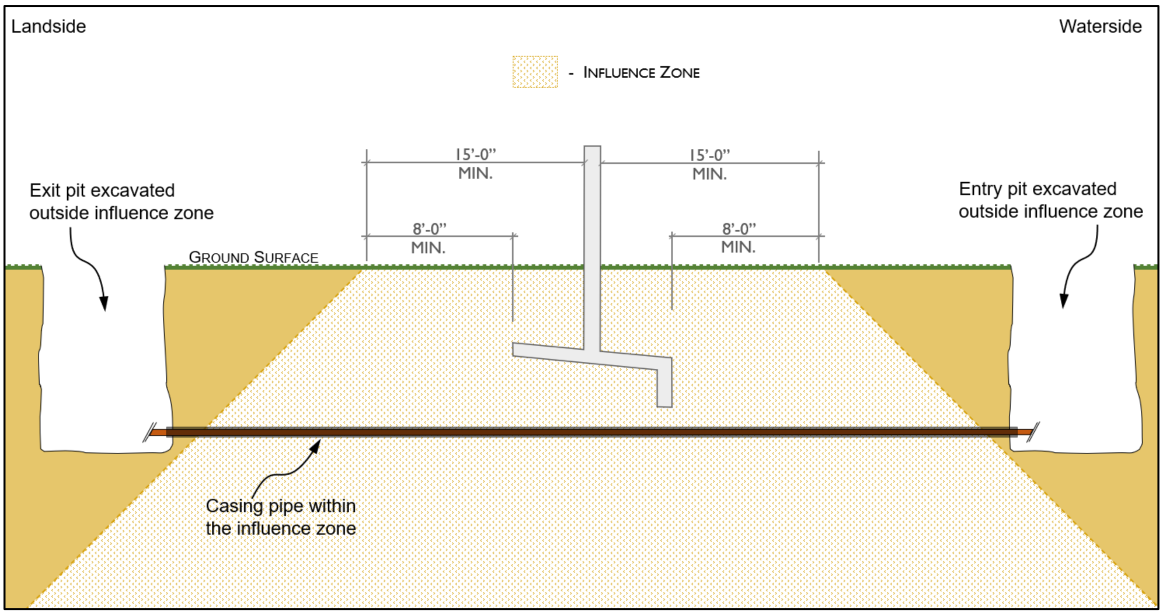


The purpose of sheet piling is to deter seepage, so pipes penetrating this feature must include safeguards against creating seepage paths. Penetrating the sheet piling is sometimes necessary since the elevation at which a pipe crosses the levee alignment can be dictated by the slope necessary to induce gravity flow, or by the need to maintain a certain thickness of overburden for protection of critical infrastructure, or from freezing, and cannot be raised without great expense, but passing the pipe through a less critical location is preferred. When possible, the pipe should penetrate Z-piling through its flat portion to better control the size of the overcut that must be sealed. The preferred penetration is a steel casing pipe through a hole in the sheet piling that is just large enough that the entire overcut can be sealed by a single-bead weld. In cases where the opening has been overcut too far to bridge by welding, or the casing pipe is greater than 10 inches in diameter, or the casing pipe is not weldable (which is usually the case when the utility is a cable inside a PVC pipe), the penetration must be sealed by a cementitious mass surrounding the area. A concrete collar, like that shown in the following image, is recommended for areas subject to movement and/or vibrations (near heavily trafficked roads or railroads) but may be used anywhere. For areas with little or no anticipated movement, surrounding the penetration with at least 12 inches of CLSM all around should be sufficient. The exposed sheet piling should be pressure washed to ensure a good bond of the CLSM to the sheet piling. When approved by USACE and used carefully, hydrovacing can excavate the necessary void and clean the sheet piling and casing pipe in one effort.



A modular seal (such as Link-Seal or Pipe Linx), chemical seal (such as SEMCO PR-821), or cementitious grout seal (such as SikaGrout 300 PT) is required within the annular space between the casing and carrier pipes on the waterside. Sealing the landside (beyond the influence zone) is not required but is highly recommended for redundancy and to keep the inside of the casing pipe clean. Since the purpose of a casing pipe is to allow the future replacement of the utility without disturbing the area nearest the wall, an additional dedicated casing pipe is not necessary when the pipe penetrating the sheet pile serves as a casing pipe for a utility and fully extends from one control point to another (such as between sealed junction boxes), but the ends of the conduit serving as a casing pipe must be sealed if they daylight below the top of the levee.

Beneath a Floodwall without Sheet Piling: If there is no sheet piling, the casing pipe should begin and end outside the influence zone (next image). This method ensures the foundation of the floodwall and the access corridor adjacent to it on both sides will not be compromised either during initial installation or if there is a future need to replace the utility/carrier pipe. It is preferred that a trenchless installation method that does not require an overbore or the use of fluids to install the casing pipe be used, but if the chosen method requires fluids for lubrication and/or grouting, Section 5.6 of EM 1110-2-2902 must be followed, which includes following the requirements of ER 1110-1-1807. For horizontal auger borings, the swing out teeth on the cutting head should be removed or tack-welded so that no overcutting is produced; this prevents creating a preferential seepage path around the perimeter of the pipe that would have to be filled with grout.

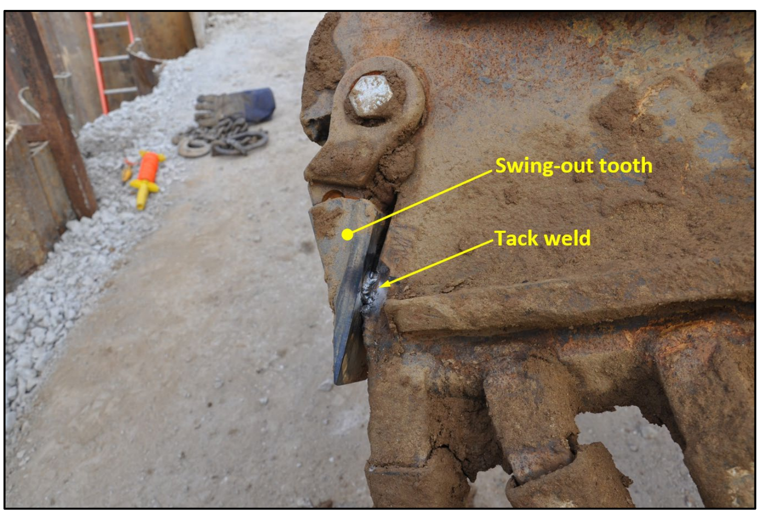


2.6. Pipes Passing Beneath an Embankment -- As with pipes passing through the embankment near the contact with the native ground, there is a transitional zone based on the levee height and pipe depth where it is not obvious whether it is more advantageous to install a pipe beneath a levee by trenched or trenchless methods. Once a Sponsor has expressed the desire to install a pipe through an embankment, the District should partner with the Sponsor to choose a method of crossing that present the least amount of risk. In general, and to limit the vulnerability of the levee system to flooding, installing a pipe beneath a levee by trenchless methods is usually preferred to excavating a large passage through the embankment unless the levee is relatively short and/or the installation can be accomplished quickly; however, there may be instances where the depth of the pipe and surface obstructions will not allow this, especially when drilling/grouting fluids are required.

Trenched Installation Beneath an Embankment: The installation of pipes by trenching requires an emergency closure plan and should be limited to months with the least likelihood of flooding, particularly for tall embankments. To discourage construction during months where the likelihood of high water increases, the District may impose more stringent requirements for maintaining on-site closure materials and/or shorter time frames for acquiring those materials if the construction starts or extends into the general flood season of mid-November to mid-May. Trenched installations should also be limited to periods where temperatures are above freezing. It is preferred that the placed pipe be encased by no less than 12 inches of CLSM within at least the influence zone, but soil may be used if the joints within the influence zone are wrapped with a secured non-woven geotextile or other approved “coupler” system, such as from MarMac Construction Products. Trenches less than 20 feet deep should be in compliance with 29 CFR 1926 Subpart P, but excavations greater than 20 feet are required to be designed by an engineer. The minimum widths of trenches receiving soil backfill will be wider than those receiving CLSM since room must be created to operate the compaction machinery. The sides of the trench are not necessarily required to be benched, but benches must be cut into the exposed embankment soil while replacing the embankment material when closing the excavation. Pipes installed beneath a levee that do not daylight may still pose a seepage concern if the cohesive confining layer outside the levee toes are not restored to at least its original thickness. Without a detailed seepage analysis, the distance beyond the landside toe for which seepage is a concern is uncertain; therefore, it is recommended that the cohesive layer be restored within the excavation to at least its original condition for no less than 100 feet or as dictated by the history of seepage for that area.

<u>Trenchless Installation Beneath an Embankment</u>: Traditional Horizontal Directional Drilling typically pulls the carrier pipe through the drill hole with no casing pipe, but the joints are fully welded and the annual space is grouted. Follow Section 5.6 of EM 1110-2-2902 for any method requiring fluids for lubrication or grouting, which includes following the requirements of ER 1110-1-1807. CLSM should encase the pipe for at least 5 feet where it penetrates the entry and exit pit walls.

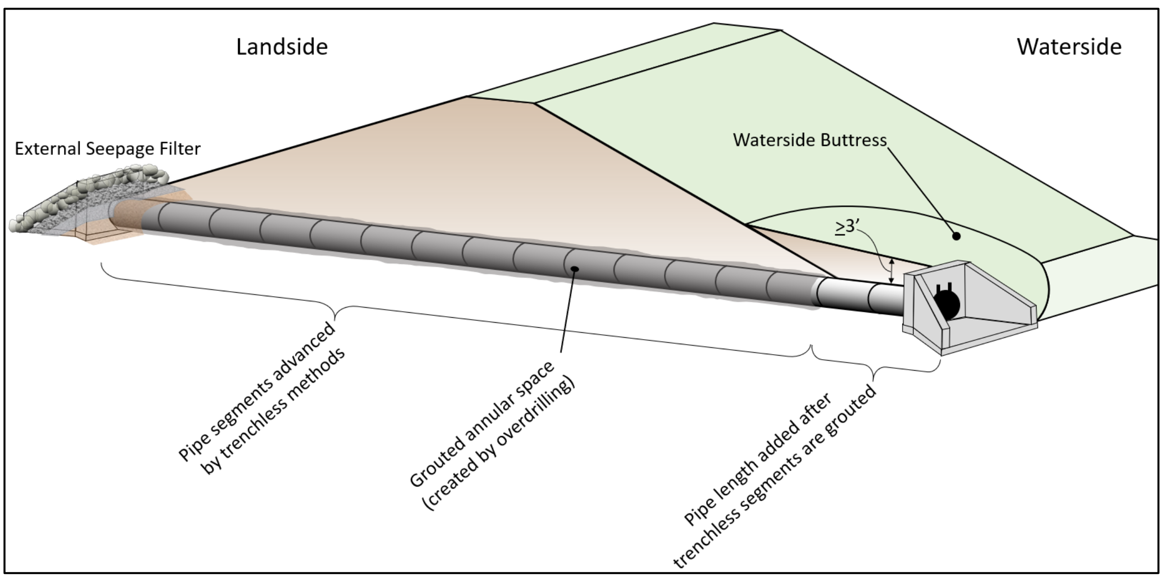
For horizontal auger borings, the “swing-out teeth” on the cutting head must be removed or tack-welded so that no overcutting is produced; this reduces the chance of creating a preferential seepage path around the perimeter of the casing pipe and avoids the need to grout an annular space or receive approval through the process found in ER 1110-1-1807. The entry and exit pits for horizontal auger borings should be outside the influence zone, but if that is not possible, any pipe joints exposed within the influence zone of the pits must be encased in CLSM unless they are fully welded. Even with the pits outside the influence zone, CLSM filling of the pits may be required.



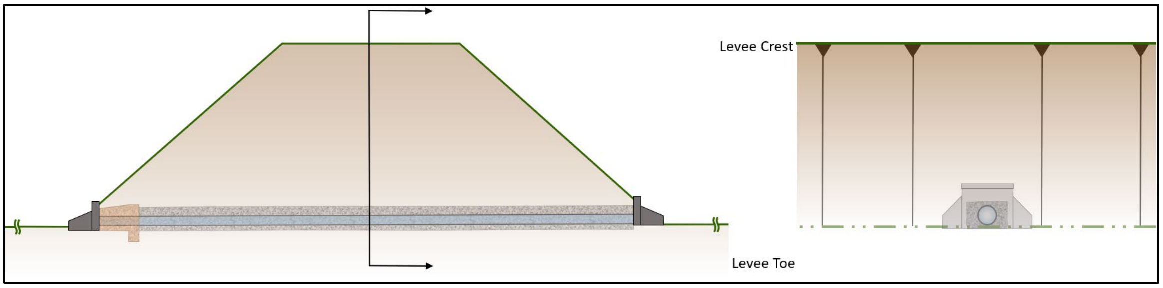
2.7. Pipes Passing Through an Embankment -- Pipes that cross the levee alignment by passing through the embankment prism can do so by going straight through (typically for gravity drainage from the landside to riverside levee toe), or in an articulated fashion roughly following the profile of the levee embankment (typically for pressurized pipes where passing through the “freeboard” has been required.

Through Pipe Within Embankment: Pipes installed in this configuration typically serve as gravity drains and can be installed by trenched (open-cut) or trenchless (directional drilling) methods according to EM1110-2-2902. The approval process for trenchless installations can be more technically challenging than that for trenched methods when there is a need to demonstrate that hydrofracturing the embankment and foundation will not occur when grouting the annular space; however, a trenched installation involves removing a significant portion of the embankment, so the levee is vulnerable for a longer time and the emergency closure plan requirements can be more demanding. Due to the relative difference in time that the levee is vulnerable (directional drilling being completed faster than open-cutting the levee) compared to the requirements of an emergency closure plan for each procedure (open-cut being more demanding), it is typically advantageous to use an open-cut installation in shorter embankments and trenchless installations in taller embankments. This choice is of course predicated on there being enough room to trenchlessly install the pipe. CLSM encasement of the pipe, internal seepage filtering, structural backfilling, outlet control, and acceptance testing in accordance with Chapter 5 of EM 1110-2-2902 are required for trenched installations (trenched installations should be limited to when temperatures are above freezing and during months with the least likelihood of flooding).

Trenchless installations, requiring a Drilling and Invasive Program Plan, sometimes overbore the alignment and leave an annular space that must be grouted in accordance with ER 1110-1-1807 and EM 1110-2-2902, but the horizontal auger boring method is preferred since it leaves no annular space to grout. Whether the trenchless installation method creates an overbored annulus or not, a landside external seepage filter and waterside soil buttress are required for daylighting pipes.

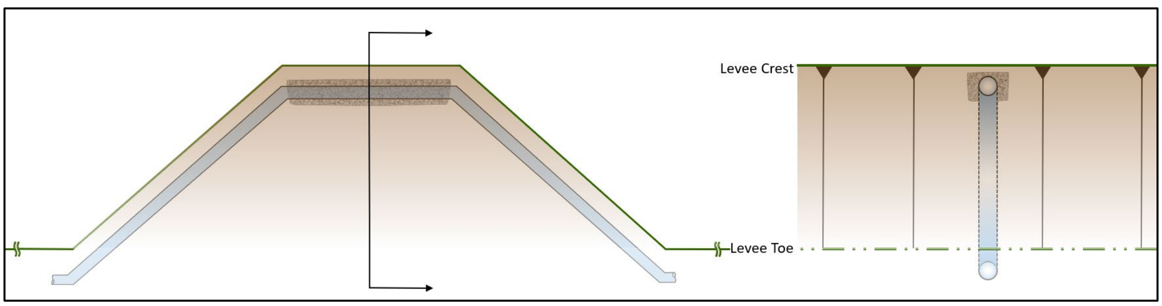


Trenchless placement



Trenched placement

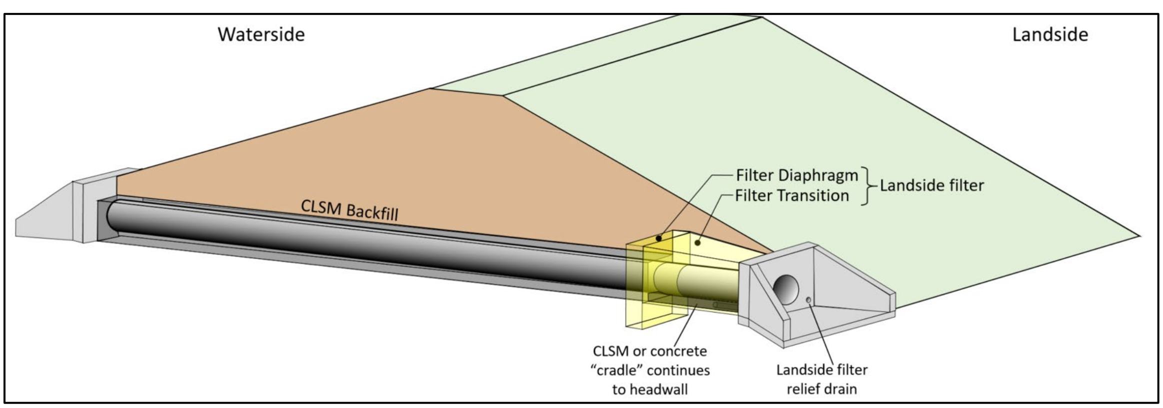
Profile Pipe Within Embankment: This configuration crosses the alignment within the embankment essentially following the levee profile to ultimately allow unimpeded traffic along the crest while preventing exposure of the pipe. It is preferred that the pipe cross the alignment as high as possible within the embankment to lower the likelihood of the disturbed area being hydraulically loaded, and the horizontal portion of the pipe must be encased with at least 12 inches of CLSM all around. This crossing method is typically only used for continuously pressurized pipes in a closed-system, so no backflow preventative measures would be needed in such a case; however, since the pipe invert is below the top of the levee, any daylighting pipe (such as pump station discharge pipes) are required to include outlet control and anti-siphon devices.



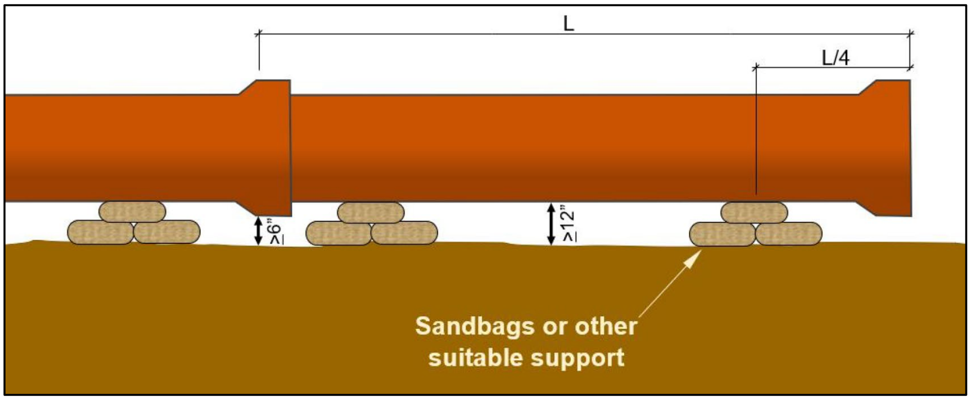
Shallowly-trenched articulated placement

3. DETAILS OF FEATURE REQUIREMENTS AND INSTALLATION CONSIDERATIONS

3.1. Typical Gravity Drain Details – Encasing the pipe between the waterside headwall and the landside seepage filter with 12 inches of CLSM all around (as shown in the following figure) is the most common form of backfilling a new gravity drain through an existing levee.

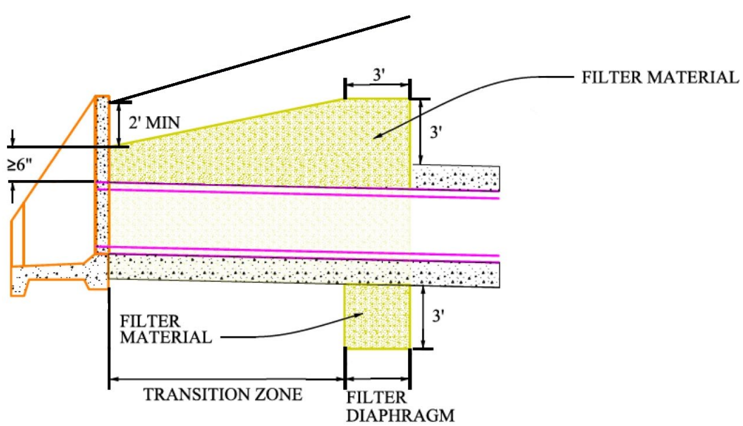


This requires that the pipe be elevated and supported as shown below or as recommended by the pipe manufacturer.

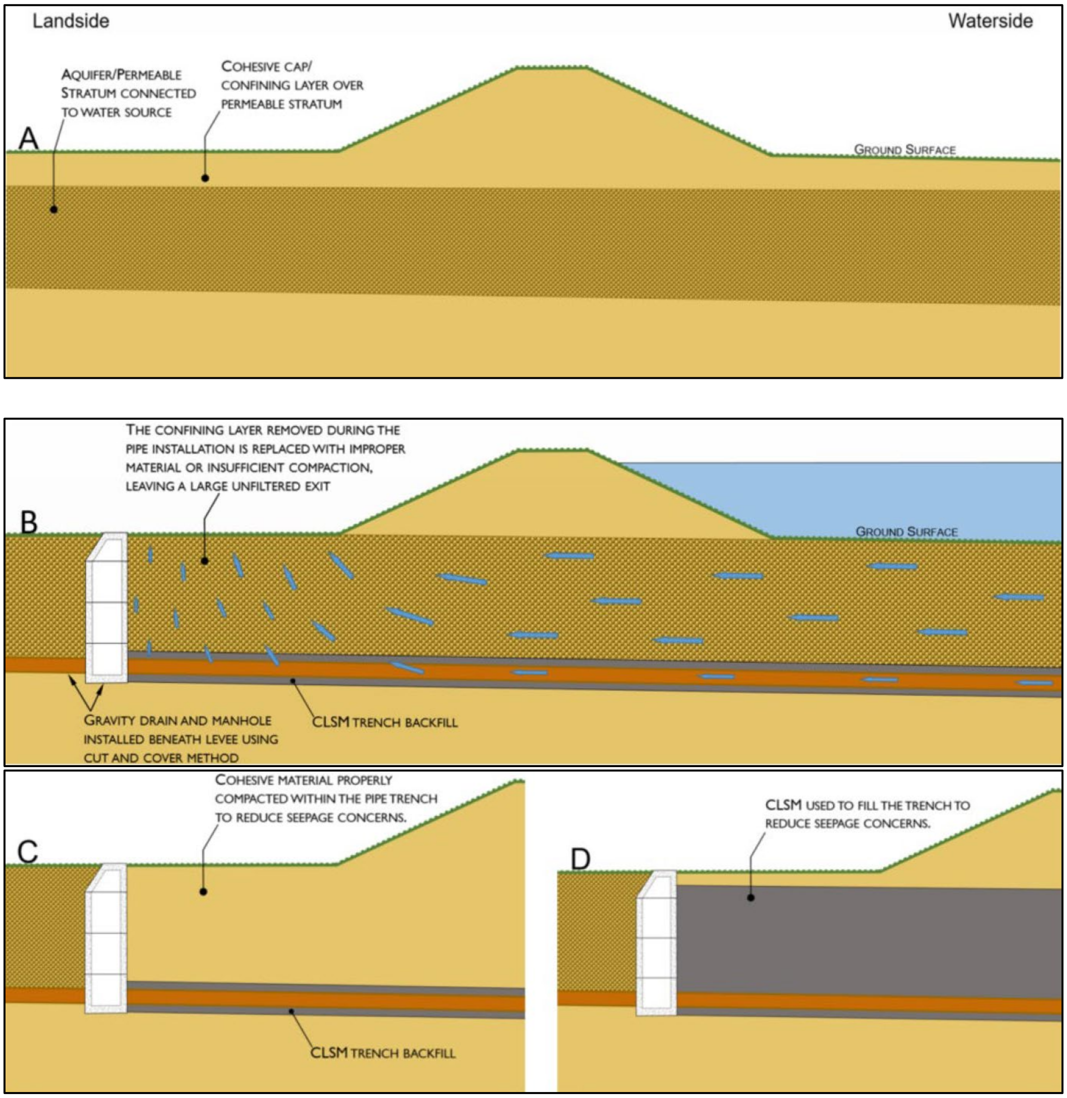


Backfilling with soil is permitted, but requires extensive labor to properly compact the soil in the haunches and along the sides without moving or damaging the pipe, and a wider trench to accommodate the procedure.

In both cases, a landside seepage filter is required when the pipe daylights the embankment.



Any cohesive soil cover overlying a permeable stratum (as shown in ‘A’) whose removal may allow excessive seepage and/or gradients (as shown in ‘B’) must be replaced either in kind, with compacted soil to full depth (as shown in ‘C’), or filled with CLSM (as shown in ‘D’) for at least 15 horizontal feet from the toe, or as otherwise determined, to eliminate the potential for a seepage path.



4. ANCILLARY CONSIDERATIONS

For final design, EM 1110-2-2902 should be consulted for additional requirements related to pressure testing, video inspections, shut-off valve requirements, etc.