

## Design and Planning

In addition to the typical Best Management Practices (BMPs) employed during construction, MaineDOT incorporates appropriate avoidance and minimization measures (AMM) during project design and planning to help avoid and minimize effects to the environment. MaineDOT provides bridge design guidelines for different structure types (see link below).

<http://maine.gov/mdot/bdg/docs/Complete2003BDG.pdf>

MaineDOT bridge design accommodates for flood events and analyzes scour susceptibility on flows up to 500 year floods. Designing crossing structures large enough to meet flooding standards benefits aquatic organisms by creating conditions that provide passage at variable flows. MaineDOT restores disturbed areas below the bankfull width (BFW) to maintain aquatic organism passage through structures. In natural streams, the existing substrate is a function of parent materials, stream gradient, stream width, stream flows, and resulting water velocities.

When replacing bridges, MaineDOT either constructs the new bridge on the existing road alignment, or offset to a new alignment. Building on a new alignment allows the contractors to use the existing structure to maintain traffic flow while the replacement structure is constructed adjacent to the existing alignment. Replacement of a structure on existing alignment poses the challenge of maintaining traffic. Depending on the bridge design, contractors may work around alternating traffic, or require complete closure of the bridge, forcing traffic to detour.

### **Instream Work Window**

When feasible, in-water construction activities will occur during low stream flow conditions (standard in water work window is July 15 to October 1). This time of year restriction avoids and minimizes impacts to stream resident salmonids and reduces impacts associated with isolating and diverting water. In addition to reducing potential effects to fish, construction during lower water conditions makes downstream flow maintenance, cofferdam installation, and in-water construction less challenging.

Often construction of large stream crossings extends beyond the standard 2.5 month in-water work window and some large projects can last more than a year. When needed, MaineDOT may propose a larger in-water work window for projects with extended schedules. However, an extended work window may include a time of year restriction to avoid impacts on sensitive fisheries. These determinations are made on a site specific basis. On larger projects, MaineDOT may complete dryland work prior to the start of the in-water work window including, construction of the staging area, installation of a temporary detour, and removal of the bridge decking.

### **Soil, Erosion Water Pollution Control Plan (SEWPCP) Review**

All proposed crossing projects require the contractor to complete a SEWPCP and submit it to the Resident Engineer (Resident) overseeing the project. The Resident relies on the MaineDOT ENV field representatives to review and approve the plan ensuring planned construction components are in compliance with the contract stipulations and AMMs. Review of the SEWPCP and planning the use of

each BMP is a critical point of construction management. The SEWPCP contains the contractors' planned cofferdam locations, cofferdam materials, dirty water treatment design and location, downstream flow maintenance plan, temporary soil erosion control methods, and spill prevention control plan.

## **Construction**

Construction of stream crossings over 20 feet wide requires a higher level of engineering to effectively complete the project, maintain safe work conditions, and minimize effects to the surrounding environment. The following descriptions include common methods for controlling water on bridge replacement projects.

### **Cofferdams**

Cofferdams are watertight temporary structures enclosing a part of a waterbody to enable it to be pumped dry for construction purposes. Cofferdams are typically comprised of sandbags, concrete barriers, sheet piles, or manufactured devices. Isolation and dewatering provides a dry working area and is often necessary to prevent adverse environmental impacts from the construction activities. All cofferdams shall conform to applicable standards specified in MaineDOT Standard Specification 511–Cofferdams.

Prior to construction, contractors submit working drawings, showing the materials and proposed method of construction to MaineDOT. Contractors must construct cofferdams deep enough to protect the bottom of the bridge abutment footings and high enough to prevent overspill. If needed, contractors may brace cofferdams to withstand pressure without buckling, or may secure cofferdams in place to prevent tipping or movement. Cofferdams must be as watertight as necessary for the safe and proper construction of the substructure work inside them. With the exception of construction of a concrete foundation seal placed under water, the interior dimensions of cofferdams must be designed to allow sufficient clearance for the construction. Contractors are responsible for the righting and resetting of cofferdams that have tilted or moved laterally, as required for construction.

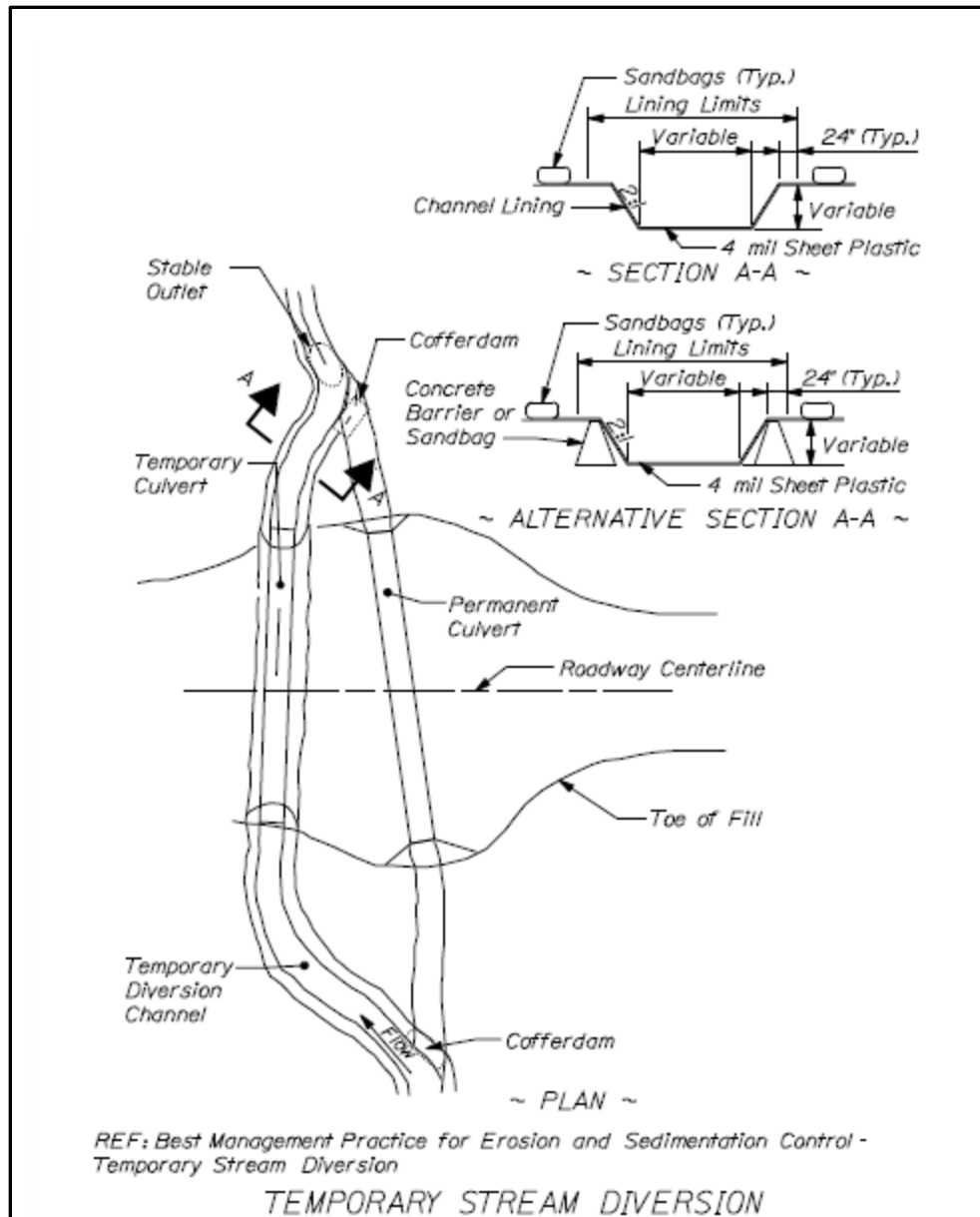
The following are brief descriptions of cofferdam types typically used to control water on bridge replacement projects. Any of the methods could serve as either a partial or complete diversion method to move water away from construction.

### **Cofferdam Installation**

The sequence of activities is critical to minimizing environmental impacts. In general, the upstream cofferdam is installed first, then the downstream cofferdam. After completion of the work, the sequence is reversed and the downstream cofferdam is removed before the upstream.

The following conditions apply during cofferdam use:

- Stream flow shall be maintained at a rate similar to natural conditions.
- Timing of the installation of cofferdams is critical to minimize impacts on fish and other aquatic life.
- Cofferdams cannot be used across a streambed during times when fish passage is an issue. Sometimes cofferdams can be placed around the abutments to allow for fish passage during construction.
- In-stream work windows are defined by the Environmental Office for most in-water work activities.
- Because the potential for washout is high, the cofferdam must be carefully monitored, and must not be left unattended for any 24-hour period. Weather reports must be monitored. If a storm event is expected, the site must be stabilized in preparation for it.
- Turbid water within the cofferdam should be pumped into a temporary sedimentation basin or tank truck, and should not be allowed to discharge directly to any protected natural resource.
- Dual cofferdams (upstream and downstream) are generally necessary in situations that require blocking off the entire stream channel (Figure 1).
- Refer to MaineDOT's **Dewatering** BMP for guidance on dewatering activities (<http://www.maine.gov/mdot/env/docs/bmp/BMP2008full.pdf>)



Temporary Stream Diversion with Cofferdams.

## Types of Cofferdams

### Sandbag cofferdams

Sandbag cofferdams are an inexpensive water control method that involves construction of a wall using various sized sandbags. Sandbags are often the preferred method on bridge projects where sheetpile cofferdams are impractical or are not possible because bedrock substrate prevents pile driving. Approved sandbags are made of poly-based materials and filled with clean coarse sand, free from deleterious materials. Contractors are required to drape sandbags with plastic sheeting to minimize

seepage through the cofferdam (See photo below). Contractors anchor sheeting under the base of the cofferdam and wrap it up over the top of the cofferdam. Where there is an unacceptable level of seepage through the substrate, contractors may extend the plastic sheeting upstream along the bottom of the stream perpendicular to the cofferdam. Sandbag cofferdams should not be taller than 3 ft. tall. Contractors will create a low flow channel within the top of the berm to direct overtopping flood flow in the case of a high water event. See MaineDOT BMP manual for a full description of sandbag cofferdam materials and user.



Bridge abutment construction behind a cofferdam constructed of industrial sandbags

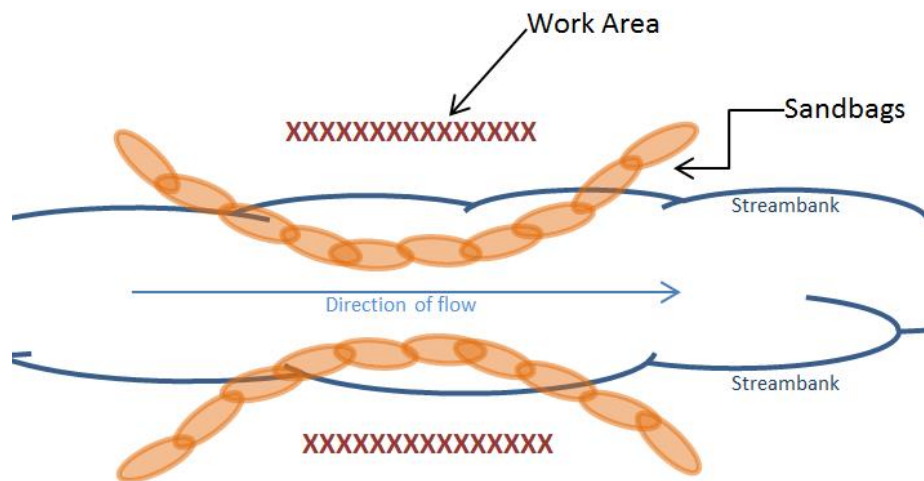


Figure 2- Diagram of cofferdams around two bridge abutments

## Portable Cofferdam

A Portadam® is a temporary, portable cofferdam for use in open water up to 12 feet deep. The Portadam® uses a free-standing steel support system that rests on the channel bed. The steel supports are draped with impervious fabric membrane to create a work area where water levels can be controlled during construction without excavation or fill. As with other cofferdam methods, the work area inside can never be totally 'dry', but pumps can ensure the area is largely dry and water is flowing into the cofferdam (not out). Portadam® is a self-contained system and eliminates the need for pile driving, cross-bracing, or anchorage.



Work behind a Portadam® cofferdam.

## Sheetpile cofferdam for Bridge Replacement.

Sheetpile cofferdams are a rigid wall system used on bridge projects requiring robust water control during construction. The need for sheet pile cofferdams is determined by many factors included distance to bedrock, subsurface soil conditions, and pier size. The structure uses interlocking steel H-piles, supported by a bracing frame, and sealed at the base of the sheet with either a concrete seal or piled sandbags. When substrate conditions allow, the sheets are driven to a stable depth, usually with a

vibratory or impact hammer. If the underlying substrate is bedrock, contractors may cut sheet piles to fit the contour of the rock and braced in place. Figure X below, shows how H-piles driven into templates that are created to ensure proper spacing of the H-piles.



Example of the inside of a sheetpile cofferdam with extensive bracing.

After any necessary material has been excavated from the cofferdam, a concrete seal must be poured to help maintain a dry work area for construction. Concrete is placed across the entire bottom inside of the sheetpile cofferdam (see photo below). During installation, the cofferdam is usually not watertight until the seal is in place, meaning contractors must pour the concrete seal under water. After the seal is placed, the contractor must wait until the pH of the water inside of the cofferdam is within 1 pH unit of the background in the stream. Waiting for an allowable pH also gives water inside the cofferdam time to settle fine material out of suspension, reducing potential turbidity effects. If needed, a maintenance pump will inject freshwater from the surrounding stream into the cofferdam to help neutralize pH levels. Once the pH is within 1 pH unit of the stream and cofferdam water turbidity appears similar to the stream, the water is pumped overboard directly into the stream. Contractors will pump any water not meeting the pH and turbidity criteria to a sediment basin for treatment. The concrete seal and sheetpiles may not create a consistent water-tight seal, meaning maintenance water pumping may be required while work occurs inside the cofferdam (see photo below).



Maintenance water pumping inside sheet pile cofferdam.

### **Cofferdam Failure Procedures**

Cofferdam failures can occur, particularly in exceptional high-water events or even accidentally, and they can occur relatively quickly. In the event of a cofferdam failure, the contractor will attempt to move all equipment away from the stream. The contractor will attempt to minimize turbidity releases as much as possible. After the high-water or accidental event subsides, the site will be stabilized as soon as safely possible. The cofferdam will be inspected for condition and presence of fish, and pumping procedures will start over as described above. Failure of a bypass channel may include the loss of material that is used to stabilize the channel (poly lining). If unexpected high flows arise and the lining of the bypass channel is lost, the contractor will attempt to reinstall the lining when it is safe to enter the water again.

### **Bridge Demolition**

Once the cofferdam has been established, removal of the existing bridge can begin. The description below outlines a likely construction sequence, which may vary slightly depending on the selected contractor, new bridge design, and construction plan. The contractor must submit a demolition plan for MaineDOT review prior to the start of demolition. The plan will include measures the contractor plans to implement to contain demolition debris. As a component of the Soil Erosion and Water Pollution Control Plan (SEWPCP) required for each project, the contractor must follow the standard specification 656.3.6 (f), which states: the contractor shall contain all demolition debris (including debris from wearing surface removal, saw cut slurry, dust, etc.) and shall not allow it to discharge to any resource.



## **Deck Removal**

Demolition may begin by removing the bridge deck. The bridge deck will likely be cut into pieces that can be removed with an excavator. Measures will be taken to ensure debris is not dropped into the river during demolition. These measures include lifting the bridge away from the river and containing debris with items such as tarps hanging under the bridge or a scow barge under the structure to minimize debris entering the resource.

## **Support Pile Removal**

After the bridge deck has been removed, the contractor will remove the existing support piles. The piles may be removed one of the following three ways; using a vibratory extractor to break apart concrete or stone structures, pulling the piles out with an excavator, or cutting them flush with the surrounding substrate using an underwater saw. Support pile materials of site conditions and resources considerations may make one method preferred over others. For example, vibratory extraction could cause noise impacts to surrounding aquatic organisms. Or, pulling a pile may disrupt substrate and have a greater turbidity impact than the other two options. Each bridge site will have a demolition plan specific to that site and will include Avoidance and Minimization Methods to address potential effects.

## **Bridge Abutment Removal**

During bridge demolition, construction plans usually include the removal of existing bridge abutments to provide adequate space for the new design. Contractors may remove portions of the old abutment using an excavator bucket. An excavator mounted hydraulic ram may also be used to break apart large piece of concrete to be hauled from the site. The amount of excavation is dependent upon the new bridge design and construction plan, as well as the type of abutment being removed. Occasionally, existing abutments may remain in place acting as a cofferdam while the new abutment is constructed behind the existing abutment.

## **Bridge Pier Removal**

Bridge piers are constructed of concrete with internal frames of rebar or stacked granite blocks, often with wooden pilings driven into the substrate. Contractors may use a hoe ram to deconstruct and pull apart bridge piers. Granite blocks will be lifted away from the structure using an excavator or crane. Contractors will either use an excavator to pull wood pilings ensuring the use of proper BMPs to avoid turbidity impacts, or will be cut pilings flush with the substrate. MaineDOT will not complete in-water blasting unless no other option is available.

# **Bridge Construction**

## **Abutment Construction**

MaineDOT uses two primary abutment designs for new bridges: Integral abutments and vertical abutments. Integral abutments are founded on piles that are driven to bedrock or a specified refusal. Refusal is defined by the analysis of how many blows with an impact hammer it takes to move a pile a

specified distance in a specific soil material (e.g. 15 blows to drive the pile 1 inch). After the piles are driven, a concrete abutment is cast to found the bridge deck on.

Vertical abutments are founded on ledge or placed on a spread footing. If founded on ledge, excavation down to the ledge is necessary. Cleaning and flattening the ledge must take place to ensure the abutment is properly founded. In order to flatten the ledge, a hydraulic breaker may be necessary to remove ledge to a consistent elevation. A spread footing foundation requires a large mass of concrete to be placed at approximately 6 feet below the thalweg of the stream being crossed. All of the abutment work will take place behind a cofferdam. MaineDOT Standard specifications do not allow contact of fresh concrete with the waterbody.



Integral Abutment Bridge During Construction



Example of a vertical concrete wall abutment bridge

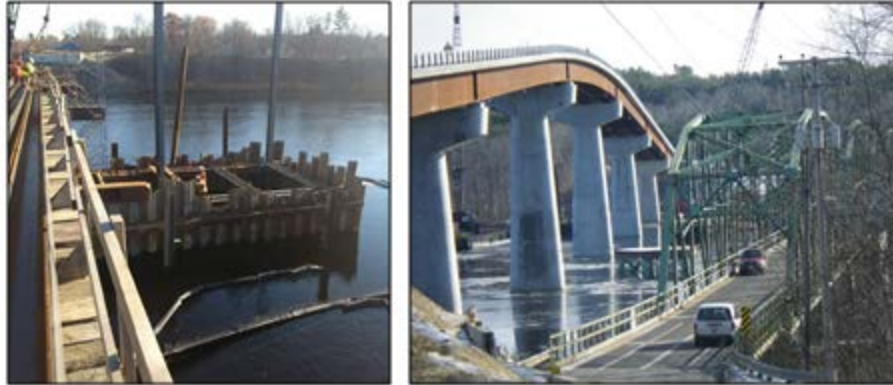
### **Bridge Pier Construction**

MaineDOT bridges are usually support by one of two types of in-water supports; concrete spread footing piers, and pile bents.

### **Concrete Spread Footings**

The construction of a spread footing pier requires the construction of a four sided rectangular shaped cofferdam. These cofferdams are constructed using sheetpiles. The photos below show an example of a bridge with cast in place pier construction as explained above.

The stream substrate inside of the sheetpile enclosure needs to be excavated to a depth that will allow construction of a stable pier footing. The excavated substrate material can be placed onto a barge or on the temporary work trestle for proper disposal. The contractor's proposal for this activity is reviewed as part of the SEWPCP.



Concrete spread footing

### **Pile or Trestle Bents**

Bridge design may occasionally use pile bents to support bridge. Pile Bents may consist of a row of steel or prefabricated reinforced concrete piles aligned with the stream flow and reinforced with a concrete cap. Contractors drive piles to a suitable depth, cut the piles off at a specific elevation, and weld them to the metal portion of the concrete cap tying the structure together. A typical pile bent contains 5 to 7 piles that vary from 18 inch to 30 inch diameter piles. Each pile bent includes battered piles that are inserted at an angle to aid with long term stability of the structure. Contractors use a vibratory hammer to place piles and then use an impact hammer to seat piles to the specified depth. In situations where impact hammers are not appropriate, contractors may drill piles into place.



Steel pile bent showing battered piles and concrete cap

## **Pile driving**

Two different types of pile hammers are used to install piles; vibratory and impact. Vibratory hammers are clamped to the pile being driven. The pile is then driven by using the weight of the driver and random oscillations by mechanisms within the driver itself. Impact hammers used on MaineDOT projects are typically single-acting diesel hammers. These hammer types impact the top of the pile with significant force to drive it further down into the substrate.

FHWA Publication No. FHWA NHI-05-043 *Design and Construction of Driven Pile Foundations* provides photos, diagrams, and concepts of pile driving techniques. Chapter 21 comprehensively explains pile driving equipment including both impact and vibratory hammers. This publication can be found at the link below.

<http://faculty.uml.edu/ehajduk/Teaching/14.528/documents/FHWANHI-05-043DesignandConstructionofDrivenPileFoundations-Volumell.pdf>

Though impact pile driving results in higher levels of hydroacoustic noise and greater potential effects to fish than vibratory driving, it is necessary to ensure the stability of the elements being driven.

## **Drilled Shafts**

Drilled shafts are installed by rotating a large steel tube inside a larger containment tube to seat the shaft into the bedrock to act as a solid foundation. There is currently no established procedure in terms of whether the containment tube is installed first or the shaft is placed in the substrate and a tube put around it. Drilling operations do not take place until the larger containment tube is in place. The drilled shafts have cutting teeth and are drilled into the substrate and bedrock. Water is required inside the shaft for the drilling process; this water and the material (grindings and sediments) from inside the shaft will be pumped out, the water filtered and returned into the stream, and the sediment will be placed onto an upland area to avoid water sedimentation. Pier diaphragm walls and floating caps are expected to be constructed totally in the dry. Drilled shafts can be anywhere from 24 inches to 9 feet in diameter.

## **Superstructure Construction**

After the abutments and support piles are complete, contractors install the superstructure, and complete the approach work. MaineDOT bridge superstructure construction uses a variety of support beam arrangements constructed of steel, concrete, or a composite material. Bridge projects are designed to fit the site and budget constraints and construction plans are implemented as efficiently as possible while minimizing environmental effects.

The deck portion of the project may be contracted out as a 'detail build' so the type of superstructure is unknown. This allows for a contractor to detail a superstructure type that is most cost effective for them to install. Typically support beams are used and structural concrete slabs will be placed on the top of the support beams. Conversely, the deck may cast-in-place, which requires significant form work and bracing to place the concrete deck. Typically, waterproof membrane is applied to the bridge deck and an asphalt wearing surface is installed. There are instances where a cast-in-place deck might receive a tine finish and double as the wearing surface.

## Temporary Access during Construction

MaineDOT has two primary temporary access options; wet roads and work trestles. A wet road is an approach created out of large non-erodible material that allows equipment to access areas necessary to complete the bridge work. These wet roads vary in size with the depth of the water (the deeper the water, the larger the footprint). A work trestle is a pile supported work area that typically has a deck made of wood. They represent a smaller foot print of impact but often have increased hydroacoustic impacts due to the impact pile driving necessary for supports.



Example of a work site containing a wet road



Example of a temporary work trestle being constructed

## Project Completion

Once construction is complete, contractors will remove the entire cofferdam and concrete seal. The cofferdam will slowly fill with water by either turning off the maintenance pump or by removing a portion of one pair of sheets. Sheet piles are typically driven to a depth greater than 25 feet, requiring a vibratory extractor to remove the sheet piles. Once the cofferdam is breached and flooded, remaining sheet piles and bracing are removed. In rare instances, construction plans will include cutting the cofferdam sheet piles to a specific elevation and leaving in-place to aid in scour reduction or to minimize ice damage to abutments or piers.

### Cofferdam Removal

After all work that requires isolation from the stream environment is complete, the cofferdam can be removed to restore stream flow through the structure. Cofferdams that are placed across the entire stream are removed as followed.

1. The diversion pump system will be stopped and the upstream cofferdam will slowly be breached. The first flush of dirty water will be captured by the downstream “dirty water” pump, which will then pump the water into the sediment treatment system.

2. When the water behind the remaining intact cofferdam is visually similar, that dam will be breached as well.
3. The remainder of the upstream cofferdam and the diversion pump system will then be removed.
4. Sandbag cofferdams will be removed by hand, if they are small, or by an excavator working from the stream banks if they are the large industrial-sized sandbags.

Cofferdams that are along the edge of a stream in the middle of a stream (for a bridge pier) will be removed in a similar sequential pattern but there will not be the upstream and downstream cofferdam elements. Cofferdams will slowly be breached, allowed to fill with water, and then totally removed.

### **Post Construction Site Stabilization**

Once water flow is restored to the area inside of the new culvert or bridge and the in-water portion of stream crossing replacement is complete, restoration of the construction site will begin. The contractor will complete final stabilization treatments, restoration of any temporary work areas, and rebuild the roadway on top of the new crossing structure.

### **Final stabilization treatments**

Some final stabilization treatments are part of the design completed by the contractor, and others are reviewed as part of the SEWPCP plan.

Rip rap is used to stabilize areas steeper than 2:1 where long term slope stability is necessary.

Vegetated slope stabilization is implemented on slopes that are more gradual (shallower) than 2:1. This includes placement of a seed mix that will allow for rapid growth and stabilization as well as plants that have substantial root systems for stabilization that take longer periods to be established.