APPENDIX B
EDITH CAVELL REHABILITATION
EROSION AND SEDIMENTATION
CONTROL PLAN

REPORT

Parks Canada Agency
Jasper National Park of Canada

Edith Cavell Rehabilitation
Erosion and Sediment Control Plan
Revision 1

February 2017

ISO 9001 and 14001 Certified | An Associated Engineering Company

Parks Canada Agency
Jasper National Park of Canada

Edith Cavell Rehabilitation
Erosion and Sediment Control Plan
Revision 1

Edith Cavell Rehabilitation ESC Plan	DOCUMENT NO.	REV.
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	Sheet 1 of 1	

REV	DATE	REASON FOR REVISION	BY	CHECK
0	August 2016	Issued for Review / Initial Construction	JG	KA
1	February 2017	Issued for Construction	JG	KA

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1 Introduction

Associated Environmental Consultants Inc. has prepared this erosion and sediment control (ESC) plan for construction works planned at the Mount Edith Cavell Rehabilitation project (the project). This plan will address temporary ESC requirements (practices and strategies to be implemented during construction), and permanent ESC requirements (to be incorporated in the final construction work). The objective of ESC at Edith Cavell is to protect materials that are at risk of erosion, thus reducing the need to control sediment. Sediment control measures will be considered as secondary control options in the event that erosion control measures are inadequate to protect erodible materials.

All ESC recommendations made in this plan are in accordance with the ESC requirements of the Basic Impact Analysis (Associated Environmental Consultants Inc. 2015). This ESC Plan is accompanied by the Edith Cavell Rehabilitation Restoration Plan which should be reviewed and understood by all construction personnel on the project.

1.1 BACKGROUND

Infrastructure at Edith Cavell was damaged in 2012 by a surge of water created by the calving of Ghost Glacier into Cavell Tarn below. Damaged infrastructure includes the parking lot, access road, and lower (south) trails. The tidal wave scoured and deposited significant quantities of rock till in the lower potions of the parking lot and access road, causing a 2-week closure of the site to the public. Although the area re-opened after the depositional till was cleared, a portion of the parking lot and access road had washed away.

With the planned rehabilitation, several long-term upgrades to the area are proposed to be completed. The proposed infrastructure is located outside of the local geohazard zone and outside of Cavell Tarn Creek, which flows past the existing parking lot.

The following infrastructure upgrades are proposed:

- Expand the parking area by constructing a new parking lot north of the existing parking lot;
- Re-route Cavell Road near the parking lot to avoid the geohazard zone to the west and abandon the portion of road in the geohazard zone; culverts will be required for water drainage;
- Construct a new trail connecting to the existing Cavell Meadows Trail;
- Repair the existing trail network;
- Construct a new scenic viewpoint and access trail;
- Install barricades and site furniture at the existing lookout; and
- Construct two to three outhouses at the parking lot.

1.2 SENSITIVE AREAS AND CONSIDERATIONS

There is a small water seep which surfaces in two locations east of the project area. The seep drains in a small depression in the project area, ponds within the project area, and drains into the ground in a location on the east side of the project area. This seep will likely continue to flow during construction and has the potential to cause sediment laden water to leave the construction area. As such, the management of this area will be considered important during the course of the project.

Cavell Tarn Creek flows from the tarn at the base of Angel Glacier towards the project area. The creek flows north past the project area. Cavell Tarn Creek is, at its nearest, 12 m from the project area. Teahouse Creek, a tributary to Cavell Tarn Creek, flows from the east through trails of the project area under two clear span pedestrian crossings. Teahouse Creek and Cavell Tarn Creek join and flow north past the parking lot and along Cavell Road, into Cavell Lake. Beyond Cavell Lake, the creek joins the Astoria River and eventually reaches the Athabasca River. There is potential for sediment-laden water generated during construction to enter Cavell Tarn Creek by surface flow.

In addition, the following were considered in the preparation of this ESC Plan:

- Moist areas within and/or nearby the project area;
- Topographical features that convey water;
- Stockpiled erodible materials; and
- Erodible surfaces exposed by vegetation clearing, topsoil and subsoil stripping, and grading activities.

2 Theory and Guiding Principles of Erosion and Sediment Control

Erosion is the mechanical weathering of a material causing the mobilization of particles; these particles once mobilized are referred to as sediment when they are transported by wind, water, or other means. As such, ESC strategies aim to prevent or minimize erosion, thus reducing the need to control sediment. While erosion control aims to limit the mobilization of particles, sediment control encourages the process of sediment deposition, i.e., the immobilization of particles from the medium in which they are transported.

In an effort to minimize erosion, ESC must be proactive (planned and installed to prevent an erosion event) rather than reactive (in response to an erosion or sediment release event). Appropriate ESC measures should be applied as necessary prior to beginning construction in an area, and should ensure that at a minimum, sediments do not migrate from the construction site or into any waterbody. ESC should be reassessed during construction and added/maintained as required. Upon completion or suspension of work, appropriate ESC should be installed as required to meet the aim of preventing or minimizing erosion, and immobilizing sediment.

Construction areas are dynamic and conditions change frequently. Construction personnel should be familiar with procedures to identify ESC needs and notify appropriate parties when corrective actions are

required. Personnel tasked with the installation of ESC should be able to field fit ESC devices to ensure their proper functioning. Routine inspections, and contractor awareness will identify deficiencies and maintenance needs so that corrective actions can be prescribed and undertaken, thus achieving the aim of preventing or minimizing erosion, and immobilizing sediment.

The guiding ESC principles considered in the development of this document are:

- Surface cover will be maintained or established as soon as possible following ground disturbance. Maintenance of surface cover will be facilitated by limiting vegetation stripping to necessary areas only; vegetation that does not require removal will be flagged and protected.
- Water sources (such as groundwater seeps surfacing near the project area) will be protected where they pond or flow through the project area. A swale, pipe, or other conveyance feature will be provided to manage water draining through the project area.
- Sediment barriers will be used to contain sediment laden water and allow enough residence time for sediment to fall out of suspension so that it is not transported to other areas. Careful management of captured sediment is required to minimize potential for resuspension or release.
- Monitoring, maintenance, and documentation of inspections and repairs is critical to ensuring the continued function of ESC measures for the duration of the project.
- All ESC devices and structures that will remain on the project area after completion of the work are to be constructed of natural materials or comprised of biodegradable or photodegradable materials unless specified otherwise in this ESC Plan or the construction drawings. Biodegradable and photodegradable products must have a minimum service life of three years to provide erosion protection while vegetation is being established.
- All ESC measures will be free of hay and straw to prevent the spread of non-native seeds and the prevent attracting wildlife.

3 Project Schedule and Construction Sequence

The construction sequence for the project is spread over three construction seasons. Scheduling is influenced by environmental factors such as rare plant and animal species, migratory birds, soil handling practices, reclamation considerations, the Delayed Access Period for protection of woodland caribou, and logistical factors including the seasonal operating period of Cavell Road (**Tables 1a, 1b, and 1c; Appendix A**).

3.1 2016 – CLEARING AND GRUBBING

Construction will begin in fall 2016 with the protection of existing vegetation where possible, and necessary removal of vegetation. Topsoil stripping will occur following removal of vegetation. Key ESC tasks that will take place during the 2016 construction sequence include:

- Installation of silt fence along the perimeter of the new parking lot area and along Cavell Tarn Creek;
- Installation of surface cover if necessary; and
- Protection of drainage flows and upslope seeps, and/or installation of drainage / conveyance features in the cleared area.

3.2 2017 – PRIMARY CONSTRUCTION

The bulk of the construction will take place during the spring, summer, and fall of 2017. Surface grading, parking lot, and road construction will take place during this period. Trail improvement and construction work will take place in the late summer and fall. Key ESC tasks that will take place during the 2017 construction sequence include:

- Ongoing installation and maintenance of silt fence,
- Construction / installation of surface drainage infrastructure including ditches, perforated subdrains, and culverts,
- Installation of temporary ESC measures in ditches including: bio/photodegradable semi-permeable ditch barriers, fibre rolls, etc. if required,
- Installation of permanent ESC measures in ditches including bioengineering vegetative measures, and riprap,
- Spread of topsoil with native seed bank over final grade,
- Installation of log pond sediment control structure in moist areas on slopes east of the proposed Cavell Road,
- Installation of restoration features such as: grass and forb seeding (only if necessary), willow staking, tree planting, and placement of large woody debris, as per the restoration plan, and
- Installation of water conveyance and crossing structures (such as rock waterbars or stepping stones) on trails where wet locations exist.

3.3 2018 – FINAL CONSTRUCTION AND REMEDIATION

Construction activities in 2018 will be limited to final work that could not be completed during the previous construction season. Key ESC tasks that will take place during the 2018 construction sequence include:

- Restoration and reclamation activities including any seeding (only if necessary), willow, and tree planting, and placement of large woody debris not completed during previous construction season,
- Removal of temporary ESC measures where possible, and
- Installation and maintenance of permanent ESC measures not installed during previous construction season.

4 Erosion and Sediment Control Measures and Strategies

Several ESC best management practices (BMP) have been published by Alberta Transportation (AT) and contain design, installation, and inspection/performance measures for ESC (Government of Alberta 2011). Certain AT BMPs are noted in the following section and available in **Appendix B**; these are provided solely as guidance to the contractor; ESC design, installation methods, and performance measures contained in this ESC plan and in the Edith Cavell Basic Impact Analysis supersede those noted in the AT BMPs.

4.1 STRIPPING AND GRADING (2016)

Removal and grubbing of vegetation will occur in fall 2016 to avoid the general nesting period (April 20 to August 17; A4 bird conservation region) for migratory birds under the *Migratory Bird Convention Act*. Stripping of topsoil will also occur following the removal of vegetation. As maintenance of vegetation and surface cover is a guiding ESC principle:

- Prior to removal of vegetation, the limits of disturbance and protected trees / areas will be marked to the satisfaction of the Environmental Surveillance Officer (**Figure 1**, **Appendix A**).
- Strip topsoil as directed in the design drawings. Apply ESC measures to stockpiles as indicated **Section 4.3** of this ESC Plan.
- Install sediment control berms as necessary throughout the stripped and graded area. Where 2017-2018 construction activities require removal of these berms, install silt fence or suitable sediment control devices to protect at-risk environmental sensitives noted in **Section 1.2**.

4.2 CONSTRUCTION SITE ISOLATION (2016 – 2018)

Install perimeter control devices along the top of slopes above the parking lot area construction site, and along Cavell Tarn Creek to prevent sediment-laden water from entering the watercourse (**Figure 1, Appendix A**). By preventing surface water from entering the construction site, the amount of water that

must be managed within the construction area is reduced. Perimeter control devices can be used to deflect, slow, and control storm water runoff around the project area. Perimeter controls devices include:

- Wire backed silt fence ([AT BMP 1; **Appendix B**), and/or
- Continuous perimeter control structures (AT BMP 4; **Appendix B**).

4.3 STOCKPILING AND DUST SUPPRESSION

Topsoil will be salvaged, stockpiled, and preserved for use in restoring native vegetation following construction. The local topsoil stripped during initial site operations will contain the native plant seed bank and as such is the preferred medium for establishing plant growth on disturbed areas, thereby providing erosion protection. Stockpiling of topsoil will occur as follows:

- Topsoil will be stockpiled on a hardened gravel surface in the laydown area.
- Locate stockpiles in locations that avoid high water velocities and avoid impeding natural drainage patterns.
- Grade topsoil side slopes no steeper than 2:1 (horizontal to vertical).
- Topsoil stockpiled within the project area will be covered with filter cloth, or RECP for dust suppression and protection from wind and rain erosion. Plastic sheeting may be used in lieu of the aforementioned covers for a period no longer than two weeks.
- All earthmoving equipment will be cleaned of mud, soil, clay, and dust before mobilizing to, and demobilizing from the construction site.
- Install wind protection fences in wind exposed areas as needed to minimize the risk of wind erosion.
- Install stabilized construction entrances to limit mud tracking onto public roads (AT BMP 33; **Appendix B**).

4.4 SURFACE WATER MANAGEMENT MEASURES

Grading of the proposed parking lot area and proposed Cavell Road will include construction of flat-bottomed drainage ditches and swales in the project area. These drainage features will be (**Figure 1; Appendix A**):

- A swale armoured with live silt fence (**Appendix A**), located east of the proposed Cavell Road (receiving water from mountain slopes to the east, and from the proposed Cavell Road, and draining north towards the existing Cavell Road),
- A ditch armoured with live silt fence (**Appendix A**), located west of the proposed parking lot (receiving water from the proposed parking lot and draining north to a culvert under the existing Cavell Road), and
- A ditch armoured with rip rap (AT BMP 14; **Appendix B**), located between the proposed parking lot and the proposed Cavell Road (receiving water from both the proposed parking lot and proposed

Cavell Road, draining north through a culvert under the proposed parking lot entrance, then west under the existing Cavell Road).

Vegetative armouring of ditches and swales will have the following two strategies:

- Use of topsoil containing the native seedbank – this strategy will promote the propagation of native species in drainage features thus increasing the success of vegetating bare soils, and
- Use of live silt fence – these fences will be constructed by installing willow stakes in rows across (perpendicular to) the direction of flow in the swale or ditch. Each row will be spaced no more that 2.0 m from the next row and spacing between rows will be decreased on steeper grades. This strategy will slow the flow of water, promote the deposition of suspended sediments in drainage features, and improve the soil stability in drainage features over time. See **Appendix A** for a sketch of live willow fences.

Willow fences can be installed as live stakes during their dormant period if required. The collection procedures for willow cuttings are provided in the Restoration Plans and will adhere to the conditions of the Basic Impact Analysis:

- Cut locally or from a similar ecosite;
- Cut during the dormant season (after leaf fall and before bud break);
- Not more than 10% of a single plant to be harvested; and
- Not more than 10% of plants in a local population to be harvested.

If erosion in the ditch/swale features is observed before natural vegetation is established, one or more of the following temporary ESC measures will be installed as appropriate:

- Silt fence installed along the top of the ditch side slopes to prevent sediment migration into ditches. Silt fence will be installed in a J-hook configuration if required to prevent sediment migration along the silt fence (AT BMP 1; **Appendix B**);
- Jute matting with wide weave to allow vegetation growth through the blanket. Jute matting to be installed similar to RECP (AT BMP 13; **Appendix B**);
- Rock check dams (these may be left in place as a permanent ESC measures upon completion of the work; AT BMP 7; **Appendix B**);
- Synthetic permeable ditch barriers and/or fibre roll check structures (installed using the same theory as applies to synthetic permeable ditch barriers; AT BMP 10; **Appendix B**).

4.5 CULVERT CONVEYANCE FEATURES

Surface drainage under the proposed parking lot entrance, proposed Cavell Road, and existing Cavell road will be facilitated using culverts. Culvert outlets will be equipped with hardened surfaces (riprap) or energy dissipators to prevent scour at the culvert outlet. Culverts will be located (**Figure 1**; **Appendix A**):

- Under the proposed Cavell Road near its tie-in with the existing parking lot;
- Under the proposed parking lot entrance; and
- Under the existing Cavell Road near its tie-in with the proposed Cavell Road.

4.6 ADDITIONAL CONVEYANCE FEATURES

The groundwater seep originating east of the proposed Cavell Road may discharge surface water that will be managed in the proposed parking lot during construction. The drainage depression that currently conveys water from the seep terminates in a small pool which drains into the ground (**Figure 1; Appendix A**). During construction of the proposed parking lot proposed Cavell Road, perforated subdrains will be constructed to manage water originating from groundwater seeps (**Appendix C**). Water that does not infiltrate the ground near these perforated subdrains will be conveyed to the existing pool which is located in a protected vegetation area to promote ground infiltration. Water that does not infiltrate into the ground from the perforated subdrains will be conveyed into the ditch.

Underground water will be conveyed under the proposed parking lot using perforated subdrains (**Appendix C**). The perforated subdrains have been designed to function in cases where a dynamic ground/surface water balance is present. The perforated sub-drains will work with the ground/surface water balance to promote: collection of ground and surface waters in the project area (groundwater seep areas), infiltration of the waters (groundwater recharge areas), and water conveyance to surface drainage features when groundwater seepage is greater than groundwater recharge in the project area.

4.7 WATER CONVEYANCE OVER TRAILS

Water crosses the Cavell Meadows Trails in several locations that have been historically crossed on-foot by recreational users. This unprotected method of crossing has resulted in trail erosion and stream braiding. Repairs to the stream braiding and the construction of crossing structures in the trail is included in the rehabilitation work. Two structures are discussed for managing the water crossing of Cavell Meadows Trail. Either or both will be selected in the field by a PCA representative; both are discussed briefly.

Stepping stones (**Appendix C**) are suitable for use where a defined stream crosses Cavell Meadows Trail. Stepping stones provide foot placement for pedestrians, while maintaining water channel width thus reducing the erosive scour of the stream. Both sides of the water crossing should be lined with large flat stones embedded in the trail to direct water across the trail. Large flat stepping stones should be installed in the water course to provide a stepping location for recreational users. Stepping stones will be field-fit in wet areas that contain a defined stream.

Rock waterbar features (**Appendix C**) are suitable to provide drainage across Cavell Meadows Trail where a less defined stream channel is present. In areas where water crosses the trail at multiple locations, several rock waterbars may be required to achieve stabilized drainage across the trail. These features provide a hardened surface to direct a narrow band of water across the trail, and allows recreational users to easily step over the water feature, reducing the erosion caused by foot traffic. Rock waterbars will be field-fit in seasonally wet areas that facilitate drainage, but are too small to be considered streams.

4.8 SURFACE TREATMENT

A surface treatment will be applied to slopes and exposed soils that are disturbed or newly created by construction activities in the project area. Surface treatments will protect exposed soils from erosion caused by wind, precipitation, and surface water runoff, and promote naturalization of the site. Any areas of bare soil that are exposed by parking lot and road construction activities will be protected with a temporary surface treatment if permanent surface treatments will not be constructed within four weeks of exposing soils. Construction activities on the trails are not expected to result in exposed soil as rock is the primary ground cover. Temporary surface treatment options may include the installation of RECP such as jute matting over exposed soil (AT BMP 13), horizontal track packing of slopes and/or contour furrowing (AT BMP 34; **Appendix B**).

The primary surface treatment strategy will include naturalized surface treatments. Seeding may be used if deemed necessary and only following direction from PCA.

Naturalized Surface Treatment – Restoration Areas on Either Side of the Proposed Cavell Road, and Planting Areas as per the Restoration Plan

The naturalized surface treatment will be applied to all slopes east of the proposed Cavell Road, and surrounding the proposed parking lot (excluding the ditch in these areas). In these areas:

- Grade slopes to the design grade and elevation.
- Rough mound topsoil throughout the area as described in the Northern Alberta Institute of Technology – Boreal Research Institute technical note on rough mounding (**Appendix F**). Initial vegetation establishment will rely on the native seed bank contained in the topsoil.
- Install all remaining vegetation features specified in the Restoration Plan.

Seeded Surface Treatment – As Directed by the Environmental Surveillance Officer

In areas where rough mounding is not practical or cannot slow runoff in a manner that prevents soil erosion, the Environmental Surveillance Officer may direct the contractor to seed the area using the PCA approved restoration seed mix:

- Spread a 100 mm layer of salvaged topsoil over applicable areas.
- Leave the topsoil surface in a rough state to promote catchment of runoff water and seeds.
- Seed topsoil using the PCA approved restoration seed mix (**Appendix D**):
  - The seed mix will be free of weed seeds.[1]
  - The seed application rate will be as per the restoration seed mix (**Appendix D**), or as specified by the Environmental Surveillance Officer.

[1] Refer to Certification from supplier to confirm, and retain seed certification documents.

- In forest restoration areas, the Environmental Surveillance Officer may direct the contractor to include green alder (Alnus viridis) in the seed mix.
- If deemed necessary by the Environmental Surveillance Officer, fibre rolls may be installed along slope contours to promote deposition of sediments on the slope (AT BMP 38; **Appendix B**). Spacing of the fibre rolls will be determined for each slope segment, and confirmed in-field using the following formula (**Appendix E**):

$$Spacing\ (m) = \frac{height\ of\ fibre\ roll\ above\ grade\ (m)}{grade\ (\%)}$$

- Hydroseeding may be used as a method of surface treatment but is a less preferred option (AT BMP 24; **Appendix B**).
- Tackifers will only be used in hydroseeding if recommended by the hydroseed supplier or manufacturer. Tackifier bases will be limited to: guar gum, starch, or other natural types with approval of the Environmental Surveillance Officer. Petroleum based tackifiers are not to be used.

4.9 STABILIZATION OF STEEP SLOPES

Slopes steeper than 2:1 (H:V) may be present in several locations of the project area (**Appendix A**).[2] Soil bioengineering techniques will be applied to these slopes to promote soil retention and slope stability. Brush layering using live willow cuttings will be the bioengineering technique used; other techniques should be requested by the contractor for use on slopes steeper than 1:1 (although these are not expected to be encountered by project works; Polster 2015). **Appendix A** contains guideline reference details for the use and installation of brush layering; the Edith Cavell Rehabilitation Restoration Plan contains specific site details for bioengineering strategies used in restoration at the Edith Cavell site.

Brush layering is installed horizontally across a slope in successive layers and backfilled between layers. These layers are used to fill slump, depression, cut, and fill areas in a slope, and can also be used as a final surface layer installed over the desired grade. Live willow branches are cut to a desired length (1 to 3 m) and a layer is placed in the base of the area to be filled. Fill soil is backfilled over the layer in 300 mm lifts with successive brush layers installed between lifts (Polster 2015). See **Appendix A** for a reference sketch of brush layer installation.

The collection procedures for willow cuttings are provided in the Restoration Plans and will adhere to the conditions of the Basic Impact Analysis:

- Cut locally or from a similar ecosite;
- Cut during the dormant season (after leaf fall and before bud break;
- Not more than 10% of a single plant to be harvested; and
- Not more than 10% of plants in a local population to be harvested.

[2] Note that 2:1 slopes are not considered in this sub-section, only slopes steeper than 2:1 such as 1.5:1.

4.10 LOG POND SEDIMENT CONTROL STRUCTURES

Log pond sediment control structures will be installed at three locations on the cut slopes east of the proposed Cavell Road. These structures will incorporate natural materials (primarily logs) to promote ponding of water in moist areas along the slope. The design of these structures (**Appendix C**) will also include cover logs to promote the development of moist and protected microhabitats similar to those typically found throughout the region under large downed woody debris. Live staking (AT BMP 27; **Appendix B**), installed as a fence with willow stakes spaced 150 mm apart will also be used to stabilize soils, and biodegradable geotextile will be incorporated to provide additional sediment retention benefits. To maximize the benefit to soil bioengineering, each structure will be field-fit into the local topography to intercept surface drainage. The following details should be considered in the construction of the log pond sediment control structures:

- Size each log pond sediment control structure to accommodate the area available on the slope. Each structure should be 12 m to 16 m long across the slope, and 6 m to 8 m wide up the slope, maintaining an aspect ratio of 2:1, in all log length combinations.
- Install the log pond sediment control structure directly onto the subsoil at its final grade. Once complete, spread topsoil throughout the structure, mimicking the rough mounding spread in the surrounding area, but with no mounds higher than 100 mm.
- Install all four brace logs as shown in the design drawings with a minimum of 60% of each brace log installed below grade with the upslope end of the log flush with the supporting ground logs.
- Install the supporting ground logs in a trench with depth equal to 1/3 of the log's diameter.
- Install the supporting ground logs in a chevron configuration to facilitate ponding on the slope.
- About the supporting ground logs using a miter joint so that there are no gaps between the logs.
- Install a biodegradable geotextile along the upslope side of the supporting ground logs; key the mesh into a trench 300 mm deep and 200 mm wide at the base of the logs. The geotextile will be CoirMat 900 or a suitable alternative that: is biodegradable within 3 to 10 years of deployment, woven from a natural twine-like fiber, has a maximum open area not larger than 40%, does not contain straw or hay, and is approved by the Environmental Surveillance Officer.
- Install willow stakes along the downslope base of the supporting ground logs, along the length of the supporting ground logs. Specification of the willow stakes will be as per the AT BMP 27 (**Appendix B**): minimum 500 mm in length and 20 to 75 mm in diameter. Willow stakes will be installed at 150 mm spacing.
- Willow stakes will be collected as per the conditions specified in the Basic Impact Analysis
  - Cut locally or from a similar ecosite;
  - Cut during the dormant season (after leaf fall and before bud break);
  - Not more than 10% of a single plant to be harvested; and
  - Not more than 10% of plants in a local population to be harvested.

- Position all four cover logs as shown in the design drawings. The cover logs will be positioned in 100 mm deep notches cut into the supporting ground logs, and fastened by driving a 1.2 m length of 15 mm diameter rebar through a pilot hole drilled through the cover log and the supporting ground log. A short upslope segment of each cover log should be buried into the slope where they meet the upslope grade.

4.11 DE-WATERING

Dewatering may be required to remove accumulated groundwater or stormwater from within the project area. If the water does not exhibit any characteristics of contamination (e.g., visible oil sheen, discoloration, foaming, unusual smell, any other obvious forms of contamination), following Best Management Practices will be used when de-watering to minimize the entrainment and discharge of sediment-laden water:

- All de-watering locations and selected controls must be approved by the Environmental Surveillance Officer.
- Under no circumstances will water be directly discharged onto exposed soil or into any wetland or surface water body.
- De-watering will be accomplished by pumping water to a well vegetated area, through commercial filter bags or through field erected dewatering structures (such as a portable frame covered in filter fabric). Alternatively, temporary sediment control basins can be installed to stabilize outlets downstream of significant or long term de-watering areas.
- Intakes of pump hoses used to withdraw water from excavations will be elevated above the bottom of the trench/excavation to minimize pumping of sediment. Use of rock sumps or slotted buckets may also be used to minimize intake of sediment/mud.

5 Stormwater Pollution Prevention

Stormwater management involves the containment, management, and direction of storm water in a controlled manner to prevent adverse impacts to natural drainage pathways and to prevent contamination of clean stormwater with potential sources of contamination such as material stockpiles, equipment, hazardous materials and construction wastes. Reasonable measures will be implemented to prevent stormwater runoff from becoming contaminated. The following measures will be employed to prevent pollution associated with stormwater discharges:

- Fueling and minor maintenance of equipment or vehicles will be conducted only within a designated fuelling and maintenance area that is approved by the Environmental Surveillance Officer, located on a paved surface, or with spill pans positioned under machinery.
- Concrete wash out will be completely contained and removed from site.
- No fertilizers are planned for use on site but may be recommended by the landscaping plan. If final landscape planting requires the use of fertilizer onsite, the Environmental Surveillance Officer will

approve and provide advise to the contractor to prevent pollution of storm water by fertilizer products.

- Spill kits will be available on site and personnel responsible for spill response will be available to respond as needed.
- All spills will be immediately cleaned and reported to the Environmental Surveillance Officer and project Engineer.

6 Monitoring and Maintenance

6.1 INSPECTION AND REPORTING REQUIREMENTS

Installation of ESC measures and bioengineered structures will be directed and overseen by an environmental professional trained in ESC and bioengineering soil stabilization techniques.

The contractor will be responsible for completing inspections of temporary ESC measures weekly, and immediately following (but no later than 24 hours) after every precipitation event during active construction. The ESC inspection checklist (**Appendix G**) will be completed during each inspection to document the types and performance of ESC measures in place, repair and replacement requirements, and action items required to meet the guiding principles of ESC as discussed in **Section 2**. The weekly ESC inspection checklist will be maintained as a record of ESC inspections and submitted to the Site Foreman, Engineer and the Environmental Surveillance Officer by 17:00 hours on the business day following the inspection.

6.2 MAINTENANCE REQUIREMENTS

The contractor will take actions to address deficiencies that are identified in the ESC checklist within 24 hours, or the next work day, of submission of the ESC checklist to the Site Foreman. Deficiencies will be addressed to the satisfaction of the Engineer and the Environmental Surveillance Officer within 7 days of submission of the ESC inspection checklist to the Site Foreman.

The following maintenance procedures will be implemented at deficient sites:

- Immediate action will be taken to remedy such conditions that may result in a release of storm water and/or to prevent damage to offsite areas from sediment displacement.
- As appropriate to each specific phase of construction, stockpiles of crushed stone, silt fencing and other and materials will be maintained on site to deal immediately with emergency problems and conditions.
- Seeded areas that have washed away will be filled and graded as necessary, reseeded and installed with the appropriate erosion control method.
- Sediment will be removed from the silt fence sediment barriers where accumulations reach one third of the above ground height of the fence. Sediment cleaned from the silt control fence will be redistributed behind the silt fencing, graded flat and stabilized. Any silt fence that has been

undermined or over topped will be replaced with stone filter outlets immediately. Silt fence will be inspected for depth of sediment, tears in the fabric, and fabric attachment to posts. Also, fence posts shall be inspected to ensure that they are firmly set in the ground. Deteriorated silt fencing will be replaced as soon as the condition is discovered.

- Riprap will be inspected for evidence of movement or washout. Riprap experiencing movement or washout will be removed and carefully replaced in response to the observed runoff flow patterns. Larger stones will be incorporated into the structure for anchoring and support, where needed.
- Erosion channels formed on slopes, in swales, or around structures will be repaired and stabilized as soon as practicable after they are discovered.

Closure

This ESC Plan was prepared for the Parks Canada Agency Jasper National Park of Canada for the Edith Cavell Rehabilitation project. The measures, structures, and monitoring prescribed in this ESC plan are suitable to meet the guiding principles of ESC described in **Section 2** of this plan.

The services provided by Associated Environmental Consultants Inc. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
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Appendix A – Tables and Figures

Table 1a. Project schedule and environmentally sensitive time periods for 2016.

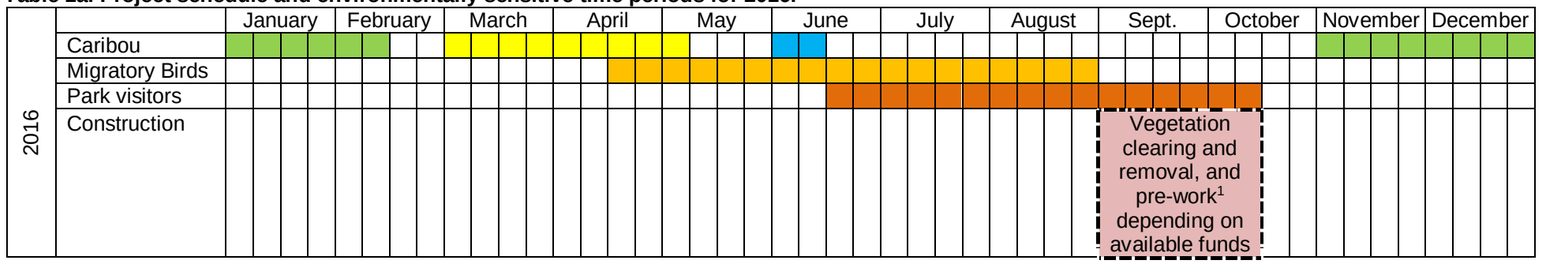


Table 1b. Project schedule and environmentally sensitive time periods for 2017.

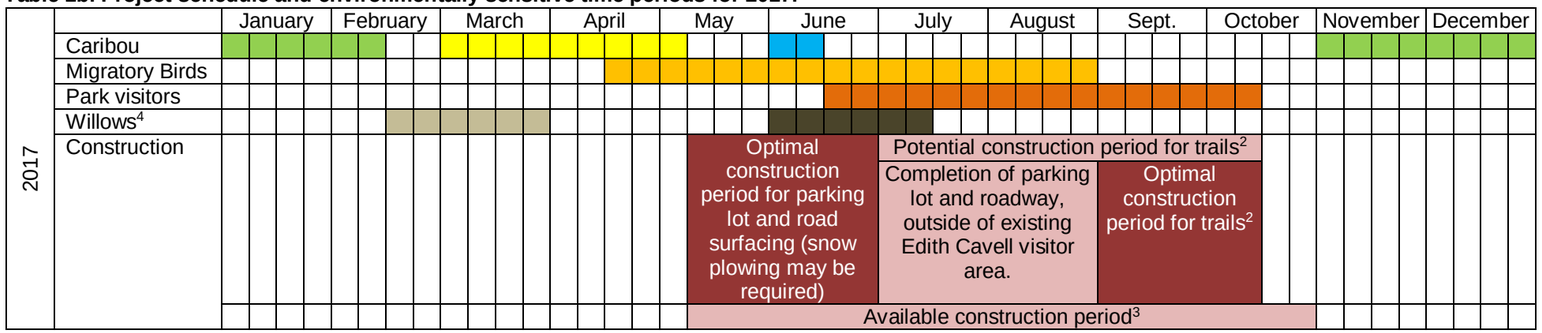
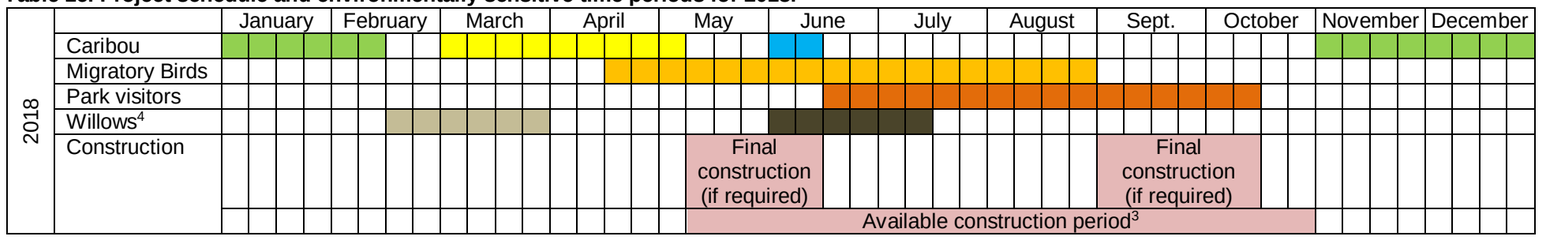


Table 1c. Project schedule and environmentally sensitive time periods for 2018.



1 Pre-work consisting of transport of material, rough grading of trails and parking lot.

2 Trail surfacing will occur in summer/ fall and will be prioritized to avoid impacts to sensitive plants over impacts to tourists (i.e. construction on trails will occur only after soil has completely thawed from winter and mitigation measures for sensitive plants can be appropriately implemented, which is during the active tourist season, given that the tourist season extends to October 15, or to the first significant snowfall).

3 It is noted that Parks Canada Highways Service Centre does not normally plow the road to Edith Cavell area before June 15 or after October 15. However, if conditions are favourable, and for the sake of extending the construction season, the project may arrange for this road to be ploughed for construction by early May and in late October.

4 Willow cuttings will be sourced from either the Edith Cavell area or a similar ecosite (ie. the icefields area); it is noted that the Edith Cavell area may not be accessible by road during the sourcing window. For late season planting, willow cuttings should be propagated into plugs in a nursery.

LEGEND

- Delayed access period to woodland caribou critical habitat (including Edith Cavell day use area)
- General woodland caribou calving in Jasper National Park (not at Edith Cavell)
- Potential for woodland caribou at Edith Cavell day use area elevation (including project area)
- Migratory birds protection period (no vegetation clearing at this time)
- Open season for tourists (no construction at existing visitation area; Jun. 15 to Oct. 15 or first significant snowfall)
- Optimal willow collection period after the Delayed Access Period and prior to bud break
- Optimal willow planting period
- Proposed construction activities
- Optimal period for proposed construction activities to avoid woodland caribou and Edith Cavell visitors

Required vegetation clearing must be completed during this period to avoid migratory birds.

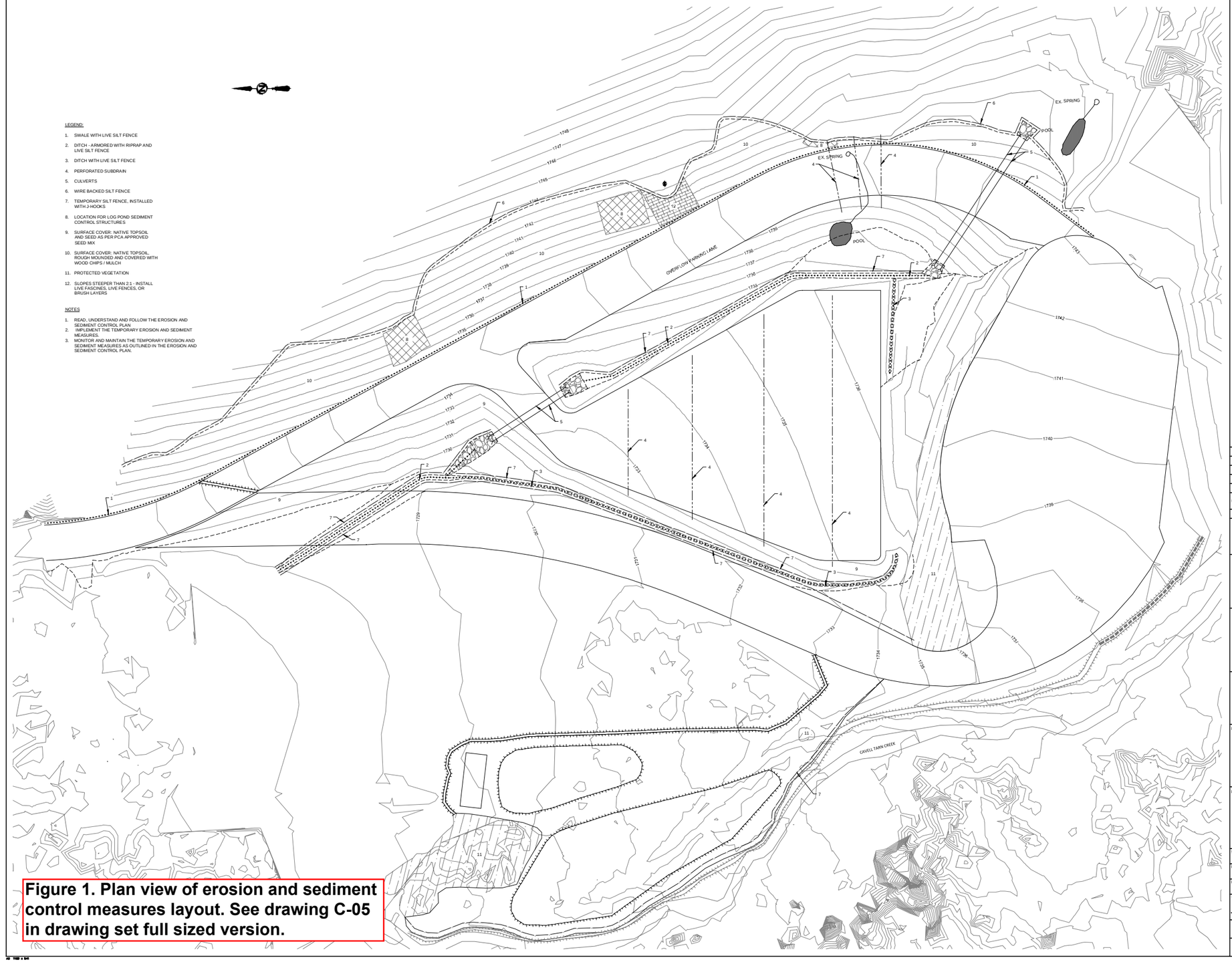


Figure 1. Plan view of erosion and sediment control measures layout. See drawing C-05 in drawing set full sized version.

No.	Date/Date	Description/Description	Drawn by / Dessiné par	Approved / Approuvé
B	2017FEB08	ISSUED FOR 60% REVIEW	M.T.	A.P.
A	2016JUN21	ISSUED FOR 60% REVIEW	M.T.	A.P.

Revision / Revision

A detail number / numéro de detail
B source drawing no. / de dessin no.
C detail on drawing no. / detail sur dessin no.

Consultant's Name / Nom de l'expert-conseil: Associated Engineering

Eng. Stamp / Sceau de l'ingénieur

Public Works and Government Services Canada / Travaux publics et Services gouvernementaux Canada

Client Services Team Southern Alberta Operations Branch / Le Client Entretient l'Équipe Alberta Méridional Branche d'Opérations

Canada

Client/client: Parks Canada Agency / L'Agence Parcs Canada

Western and Northern Region / Ouest et Nord du Canada

Project title/Titre du projet

MT. EDITH CAVELL REHABILITATION CONTRACT 2 JASPER NATIONAL PARK OF CANADA

Drawing title/Titre du dessin

CIVIL
EROSION AND SEDIMENT CONTROL

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
	M. TROMBLAY	2017Feb08
Designed by/Concept par	Reviewed by/Revisé par	Scale/Echelle
A .PODOLSKI		AS SHOWN

PWCSC Project Manager/Administrateur de Projets TPSGC: C. MARI

Client Acceptance/Acceptation du client: Approved by/Approuvé par

Parks Responsible Officer/Agent Responsable | PWCSC Project Manager/Administrateur de Projets TPSGC

Project No./No. du projet	Asset No./No. du bien	Sheet No./No. de la feuille
718		6 / 19

Drawing Reference No./No. de référence du dessin: C-05

FOR REFERENCE ONLY – SEE EDITH CAVELL REHABILITATION: RESTORATION PLAN

LIVE SILT FENCING (WITH WILLOW STAKES)

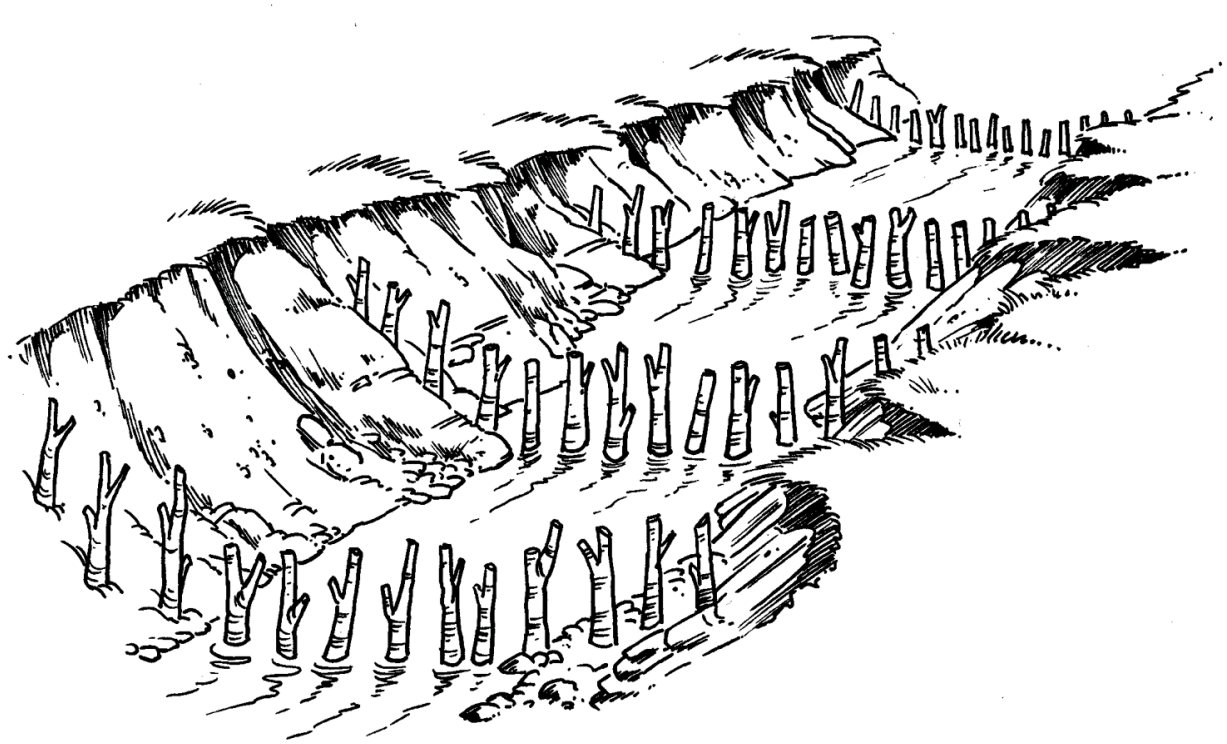


Figure 1. Live silt fence installed in a ditch or small stream

NOTES:

1. WILLOW STAKE DIMENSION AND INSTALLATION AS PER ALBERTA TRANSPORTATION BEST MANAGEMENT PRACTICE No. 27a UNLESS INSTALLED IN COMBINATION WITH RIPRAP.
    a. 50 TO 100 mm IN LENGTH
    b. 20 TO 75 mm IN DIAMETER
    c. 80% OF WILLOW STAKE LENGTH PLANTED IN GROUND
    d. PLANTED BUTT-END IN GROUND
2. WILLOW STAKES INSTALLED IN COMBINATION WITH RIPRAP MUST BE CUT LONG ENOUGH TO ENSURE AT LEAST 400 mm IS INSTALLED IN SOIL, AND TOP OF EACH WILLOW STAKE EXTENDS AT LEAST 100 mm ABOVE THE TOP SURFACE OF THE RIPRAP.
    a. 100 mm IN LENGTH PLUS THICKNESS OF RIPRAP (IF RIPRAP 50 mm THICK, WILLOW STAKES TO BE 150 MM IN LENGTH
3. SPACING BETWEEN WILLOW STAKES TO BE 100 mm.
4. SPACING BETWEEN LIVE SILT FENCES TO BE 1.0 TO 2.0 m. ROWS TO DECREASE AS GRADE INCREASES (I.E., LIVE SILT FENCES CLOSER TOGETHER IN STEEPER DITCHES).

Adapted from: Polster, David F. 2015. Natural Processes: Restoration of Dramatically Disturbed Sites. Polster Environmental Services Ltd. Duncan (BC).

FOR REFERENCE ONLY - FIELD-FIT AS PER ENGINEER AND/OR ENVIRONMENTAL SURVEILLANCE OFFICER'S DIRECTION

BRUSH LAYERING (WITH WILLOW MATERIAL)

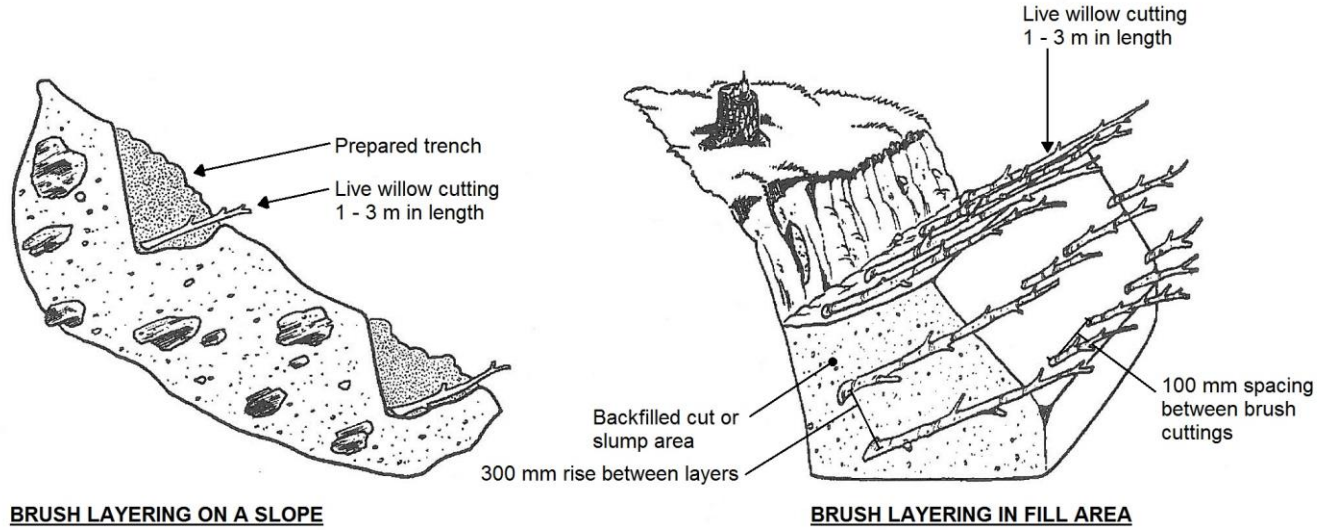


Figure 1. Brush layering shown installed in prepared trenches and in fill slope

NOTES:

1. FOR USE ON SLOPES STEEPER THAN 2:1.
2. CONSTRUCTED FROM LIVE WILLOW BRANCHES 1 m TO 3 m LONG, SOAKED AND PREPARED IN SAME FASHION AS WILLOW STAKE CUTTINGS.
3. SPACING BETWEEN LIVE WILLOW BRANCHES TO BE 100 mm.
4. RISE BETWEEN LAYERS TO BE 300 mm FOR FILL AREAS.
5. RISE BETWEEN LAYERS IN PREPARED TRENCHES NOT TO EXCEED 1 m.

Adapted from: Polster, David F. 2015. Natural Processes: Restoration of Dramatically Disturbed Sites. Polster Environmental Services Ltd. Duncan (BC).

Appendix B – Alberta Transportation Best Management Practices

Silt Fence Sediment Control	B.M.P. #1

Description and Purpose

- Permeable fabric barriers installed vertically on support posts along contours to collect sediment laden sheet flow runoff
- Causes water to pond allowing sediment to settle out as water filters through fabric
- Entraps and minimizes coarse sediment from sheet flow or overland flow from entering waterbodies
- Perimeter control for sediment transport and deposition

Applications

- Temporary measure
- Used at bottom of cut or fill slopes to collect sediment laden runoff
- Used along streams (or channels) banks
- Used around stockpiles
- Midslope grade-break (using "J-hook" or "smile" pattern to effect ponding, filtering and sedimentation)

Advantages

- Low permeability silt fences have high filtering capabilities for fine sand to coarse silt
- Filter fence more effective than straw bales at filtering out sediment

Limitations

- Applicable for sheet flow, cannot handle concentrated channel flow volumes
- May fail under high runoff events
- Limit to locations suitable for temporary ponding of sediment laden runoff
- Low permeability silt fences may not be strong enough to support weight of water retained behind it and may require reinforcement (i.e., wire mesh and stronger support)
- Sediment build up needs to be removed on a regular basis
- Damage to fence may occur during sediment removal
- Useable life of approximately one year dependent on regular maintenance

Silt Fence Sediment Control	B.M.P. #1

Construction

- Two methods of installation are commonly used
  - Trench method
  - Mechanical (slicing) installation method (e.g. Tommy Silt Fence Machine or equivalent)
- Trench Method
  - Select location of silt fence (usually along contours)
  - Drive support posts a minimum of 0.3 m into ground, spaced a maximum of 2 m apart
  - Excavate trench approximately 0.15 m deep by 0.15 m wide for entire length of fence along upstream side of posts
  - Attach the wire mesh or snow fencing, if used as reinforcement, to upstream side of posts with staples
  - Extend filter fabric to base of trench and attach over wire mesh or snow fence, if used, on upstream side of posts
  - Backfill and compact soil in trench, being careful not to damage fence
- Mechanical Installation Method
  - Select location of silt fence (usually along contours)
  - Use mechanical installation machine to embed the fabric a minimum of 0.15 m into the ground. One mechanical installation method is by slicing (with special equipment) the geotextile fabric embeds into the ground without excavation and backfill. There is only minor disturbance of the ground. Tamping of ground is required for compaction.
  - Drive support posts a minimum of 0.3 m into ground, spaced a maximum of 2 m apart
  - Attach the wire mesh or snow fencing, if used as reinforcement to silt fence fabric, to upstream side of posts with staples
  - Extend filter fabric to base of trench and attach over wire mesh or snow fence, if used, on upstream side of posts

Construction Considerations

- Site Selection

  - Size of drainage area should be no greater than 0.1 ha per 30 m length of silt fence
  - Maximum flow path length above silt fence should be no greater than 30 m
  - Maximum slope gradient above the silt fence should be no greater than 2H:1V
- Fence should be placed on contour to produce proper ponding
- Fence should be placed far enough away from toe of slope to provide adequate ponding area (minimum of 1.8 m away from toe of slope is recommended)
- Ends of fence should be angled upslope to collect runoff
- Fence should not extend more than 0.6 m above grade
- Posts can be wood or metal material dependent on design and ground conditions
- Posts should be placed on downstream side of fence
- Posts should not be spaced greater than 2 m apart
- Wire mesh or standard snow fencing may be placed between the posts and fabric barrier to provide additional strength and support reinforcement
- Geotextile should be cut from a continuous roll to avoid joints (if joints are necessary, the wrapping of fabric around the fence post and a minimum overlap of 0.2 m with staples should be used to attach the fabric to the post)
- Fence (and wire mesh or snow fence, if used) should be attached to posts with heavy duty staples, tie wires, or hog rings
- Fence (and wire mesh or snow fence, if used) should be dug into a trench at least 0.15 m deep to prevent undercutting of fence by runoff
- Trench backfill should be compacted
- Long runs of silt fence are more prone to failure than short runs
  - Maximum length of each section of silt fence should be 40 m
  - Silt fence should be installed in 'J' hook or 'smile' configuration, with maximum length of 40 m, along contours allowing an escape path for ponded water (minimizes overtopping of silt fence structure)

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Repair undercut fences and repair or replace split, torn, slumping or weathered fabric immediately

Silt Fence Sediment Control	B.M.P. #1

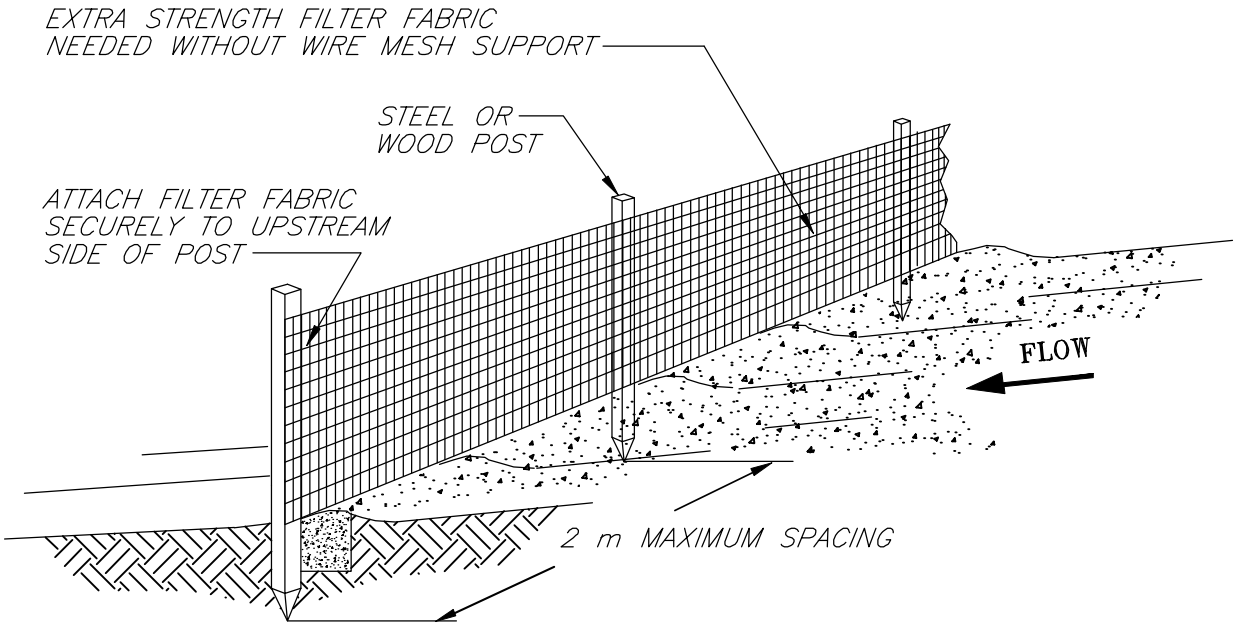
- Sediment build up should be removed once it accumulates to a depth of 0.2 m
- Remove fence after vegetation is established
- Deactivate fabric by cutting-off top portion of fabric above ground; bottom trenched-in portion of fence fabric can be left in-ground thus minimizing ground disturbance

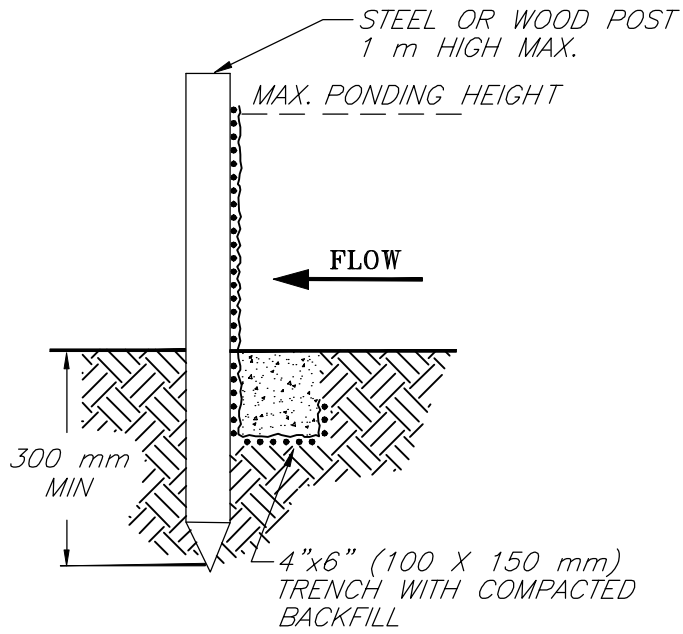
Similar Measures

- Straw Bales
- Rock Barrier
- Permeable/Synthetic Barriers

Design Considerations

- For a silt fence system to work as a system, the following factors should be considered:
  a) quantity – adequate number and frequency of fence for efficient ponding and sedimentation
  b) installation – workmanship
  c) compaction – backfill and trenching of fabric
  d) support – posts adequately embedded, appropriate selection of post material and spacing
  e) attachment – secure fabric to post
- Install silt fences in a 'J' hook or 'smile' configuration





TRENCH METHOD DETAIL

NOTES:

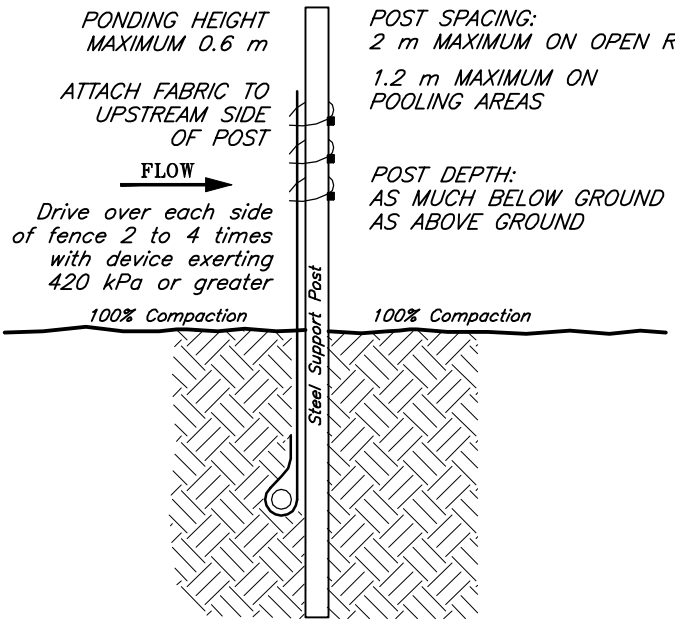
1. SILT FENCE SHALL BE PLACED ON SLOPE CONTOURS TO MAXIMIZE PONDING EFFICIENCY.
2. INSPECT AND REPAIR FENCE DAILY AND AFTER EACH STORM EVENT AND REMOVE SEDIMENT WHEN ACCUMULATED SILT REACHES 200 mm.
3. REMOVED SEDIMENT SHALL BE DEPOSITED TO AN AREA WILL NOT CONTRIBUTE SEDIMENT OFF-SITE.
4. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

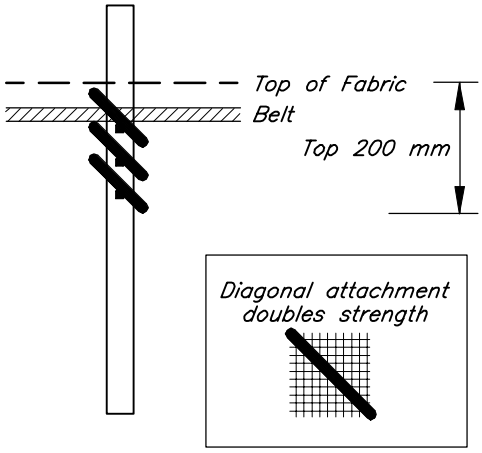
SILT FENCE

(TRENCH METHOD)

FILE: SILTFENC



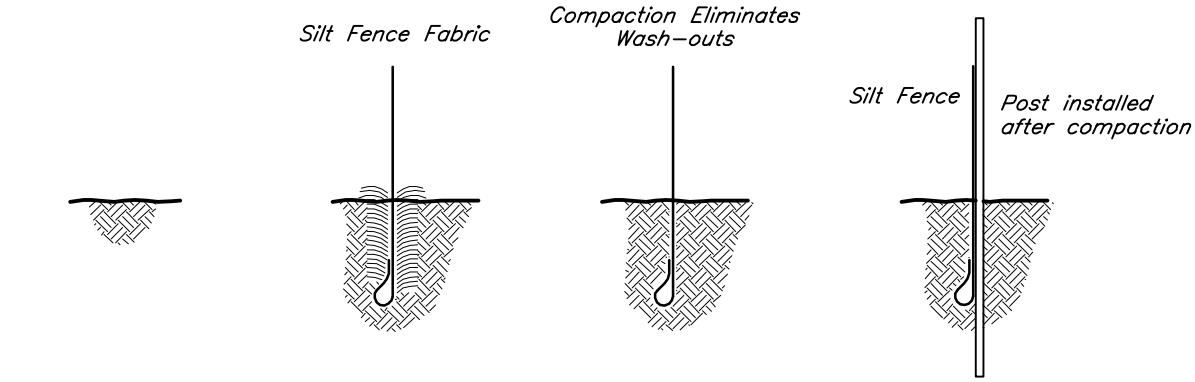
NO MORE THAN 0.6 m OF A 0.9 m FABRIC
IS ALLOWED ABOVE GROUND



ATTACHMENT DETAILS:

- Gather fabric at posts, if needed.
- Utilize three ties per post, all within top 200 mm of fabric.
- Position each tie diagonally, puncturing holes vertically a minimum of 25 mm apart.
- Hang each tie on a post nipple and tighten securely.
- Use cable ties (50 lbs) or soft wire.

MECHANICAL (SLICING) METHOD



a) Before Installation

b) During fabric insertion. Disrupted soil.

c) After Compaction. Greater stability.

d) Completed Installation

MECHANICAL (SLICING) METHOD INSTALLATION SEQUENCE

NOTES:

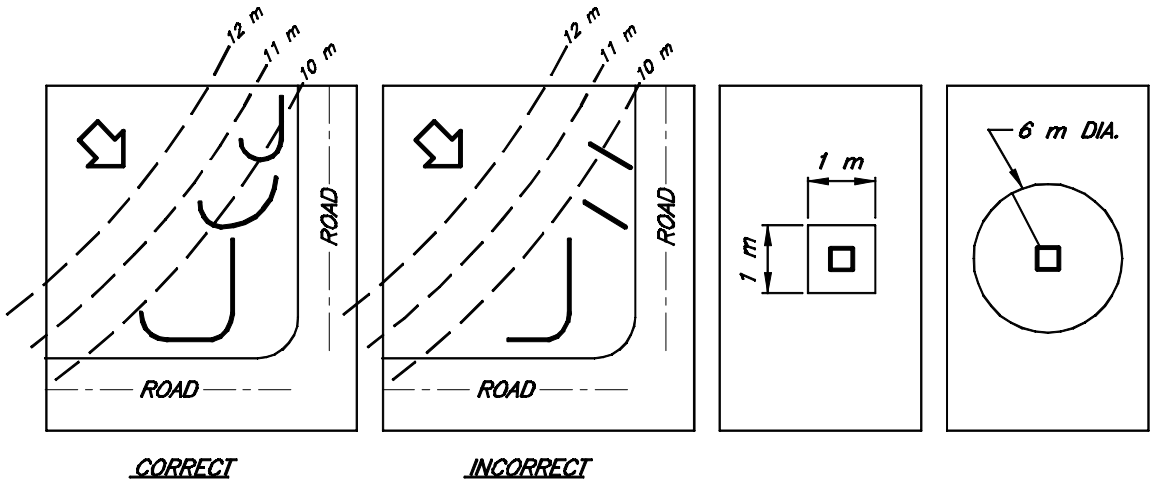
1. INSTALLATION MACHINE MUST ALLOW CONTINUOUS SLICING AND EMBEDMENT OF GEOTEXTILE INTO GROUND WITH MINOR GROUND DISTURBANCE.
2. INSTALLATION MACHINE TYPES WILL VARY WITH MANUFACTURER.
3. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

SILT FENCE

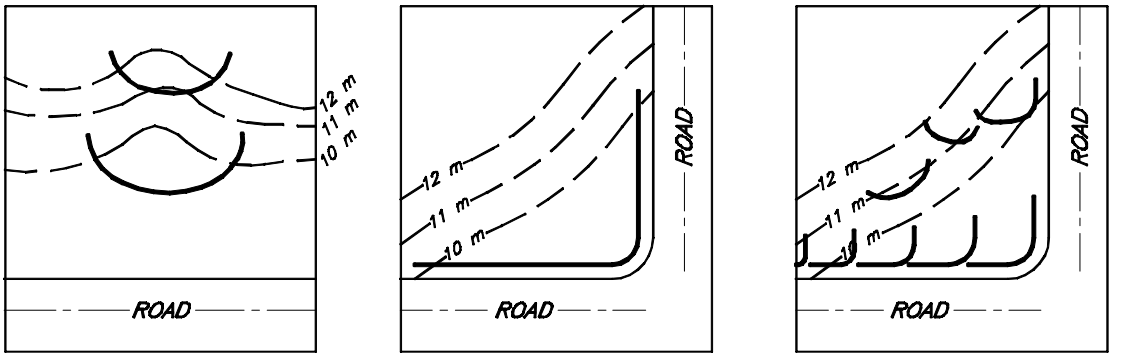
(MECHANICAL METHOD)

SOURCE: CARPENTER T. 2000



"J" CONFIGURATION

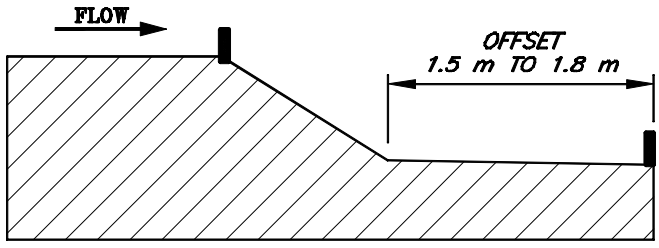
SILT FENCE BARRIER AT STORM INLET



"SMILE" CONFIGURATION

AVOID LONG INSTALLATION

COMBINATION OF "SMILE" AND "J" CONFIGURATIONS



LOCATION AT TOP AND BOTTOM OF SLOPE

NOT TO SCALE

NOTE:

1. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

SOURCE: CARPENTER T. 2000

SILT FENCE
(CONFIGURATION PLAN)

Continuous Perimeter Control Structures Sediment Control	B.M.P. #4

Description and Purpose

- Constructed of sand or gravel-filled geotextile, or formed structures comprised of compost, shredded wood mulch, and natural fibres
- Used to divert and intercept sheet or overland flow
- May be used to form ponds and allow sediment to settle out
- Compost should possess no objectionable odours or substances toxic to plants
- Compost contains plant nutrients but is typically not characterized as a fertilizer

Applications

- Temporary measure
- May be used in place of silt fences or straw bale barriers to retain sediment on construction sites
- Compost used on AT projects must meet Canadian Council of Ministers of the Environment (CCME) Guidelines for Compost Quality (trace elements, maturity/stability, pathogens), which are adopted by Alberta Transportation and found on AT Products List (www.transportation.alberta.ca).
- May be used in place of silt fences or straw bale barriers to retain sediment on construction sites

Advantages

- Trenching may not be required as weight and flexibility of structure typically allows continuous contact with ground surface

Limitations

- Sand or gravel filled geotextile requires Continuous Structure Machine (CBM) for construction
- Requires specialized blower truck, hose and attachments for berm installation

Construction

- Install structure a minimum of 2 m away from toe of slope to provide adequate ponding area on upstream side of structure
- Follow operating procedures for CBM
- Use of woven geotextile is preferred due to higher tensile strength and small deformation

- If required, PVC drainage pipes (e.g., 50 mm) may be inserted in downstream side of structure, spaced 100 to 150 mm apart, to facilitate drainage
- If required and appropriate, slits may be cut in upstream side of structure to facilitate filtering and drainage

Compost filter berm installation:

- Parallel to the base of the slope, or around the perimeter of affected areas, construct a trapezoidal berm at the following dimensions:

Annual Rainfall/Flow Rate	Total Precipitation	Berm Dimensions (height x width)
Low	25 mm – 635 mm	30 cm x 60 cm – 45 cm x 90 cm
Average	635 mm – 1270 mm	30 cm x 60 cm – 45 cm x 90 cm
High	>1270 mm	45 cm x 90 cm – 60 cm x 120 cm

- Base of berm is twice the height
- Compost shall be uniformly applied using an approved spreader unit - including pneumatic blowers, specialized berm machines, etc
- Seeding the berm may be done in conjunction with pneumatic blowing
- Compost can be blown into a netted sock to be used as a berm

Construction Considerations

- Structure constructed of sand, aggregate, or other pervious soil encased in geotextile fabric
- Maximum structure height is approximately 0.4 m
- Higher permeability fill materials should be used in ‘drainage chambers’ in low areas
- Compost filter berm dimensions and blanket application rates vary with soil characteristics, existing vegetation and climatic conditions
- Use larger berm application rate in high rates of precipitation and rainfall intensity, and snow melt
- Use larger berms in severe grade and long slope lengths
- Berms may be placed at the top and the base of a slope
- A series of berms may be used down a slope (5 to 8 m apart)
- Berms may be used in conjunction with a compost blanket, especially in regions with spring melt, and sites with severe grades and long slopes

- Use smaller berm application rate in lower precipitation rates and rainfall intensity regions
- Use larger berms where they are required to be in place or function for more than one year

Inspection and Maintenance

- Inspection frequency should be in accordance with PESC and TESC Plans.
- Inspect for sediment accumulation and remove sediment when depths reach approximately one-third the structure height
- Inspect for toe undermining, weathered/deteriorated geotextile, and end runs and erosion of the filter and repair immediately
  - Damaged sections may be repaired by restapling or placing another section of continuous structure upstream of the damaged section to provide seal
- If the structure is encased in a geotextile fabric, removal of structure is accomplished by splitting the structure, spilling fill material and removing fabric
- Removal of berm is accomplished by splitting the berm and sock, spilling fill material and removing sock

Similar Measures

- Structures/Barriers
- Sand/Gravel Bag Barriers
- Silt Fence
- Compost Berm

Rock Check Dam Erosion Control and Sediment Control	B.M.P. #7

Description and Purpose

- Small dam constructed of rock placed across steep channel
- Decrease flow velocities to reduce erosion caused by storm runoff
- Sediment laden runoff is detained allowing sediment to settle out

Applications

- Temporary or permanent measure
- Reduces long steep grade to intervals of gentle grades between successive structures
- Reduces flow velocities and kinetic energy to decrease erosion potential caused by runoff
- Sediment laden runoff is retained behind structure allowing sediment to settle out
- May be used in channels that drain 4 ha (10 ac) or less
- May be used in steep channels where storm water runoff velocity is less than 1.5 m/s (5 fps)

Advantages

- Cheaper than using riprap armouring or gabion structures in a ditch
- Easy to construct

Limitations

- Not appropriate for high flow velocity >1.5 m/sec; (use gabion structures for flow velocity >1.5 m/sec)
- Not appropriate for channels draining areas larger than 4 ha (10 ac)
- Not to be placed in grass lined channels unless erosion is anticipated
- Susceptible to failure if water undermines or outflanks structure

Construction

- Excavate a trench key a minimum of 0.15 m in depth at the rock check structure location
- Place non-woven geotextile fabric over footprint area of rock check
- Construct structure by machine or hand
- Structure should extend from one side of the ditch or channel to the other

- Structure should be constructed so that centre of the crest is depressed to form a centre flow width which is a minimum of 0.30 m lower than the outer edges
- Height of structures should be less than 0.8 m in height to avoid impounding large volumes of runoff
- Downstream slope of the check dam should be 5H:1V (minimum)
- Upstream slope of the check dam should be 4H:1V (minimum)

Construction Considerations

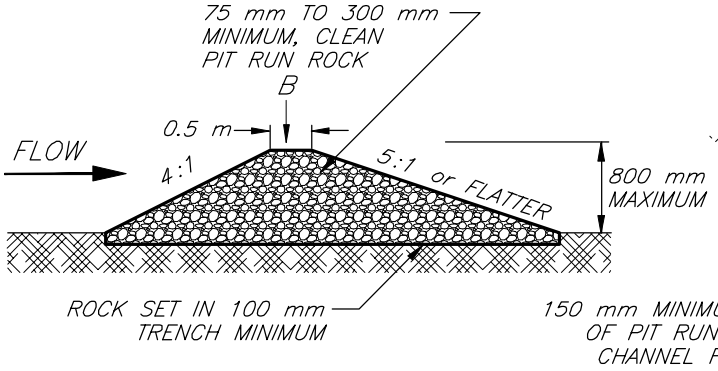
- Should be designed with roadside design clear zone requirements in mind.
- Height and spacing between structures should be designed to reduce steep channel slope to intervals of flatter gradient
- Rock check structures should be constructed of free draining aggregate
- Aggregate used should have a mean diameter (D_{50}) of between 75 mm and 150 mm and must be large enough to remain in place during high velocity flow situations. Maximum rock diameter should not exceed 150 mm if the structure is to be used as a sediment trap.
- If rock check structures are to be placed in channels with significant high flows, they must be properly designed for stone size and structure spacings

Inspection and Maintenance

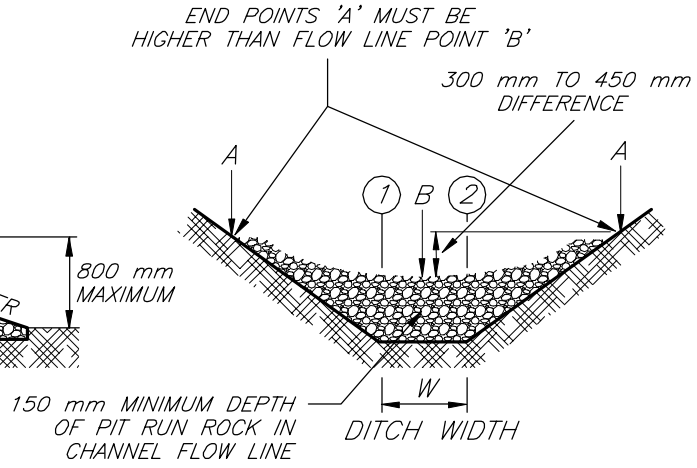
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Remove sediment build up before it reaches one half the check structure height
- Erosion repairs should be made immediately to prevent failure of the structure
- Replace dislodged aggregate immediately with heavier aggregate or gabion structures

Similar Measures

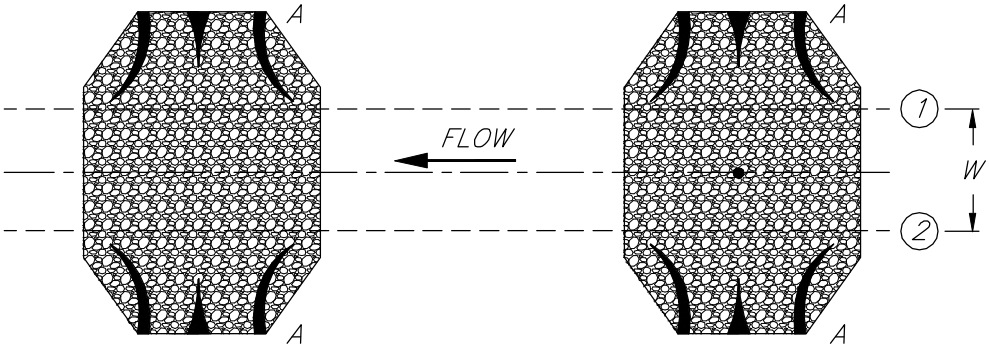
- Synthetic Permeable (Ditch) Barriers

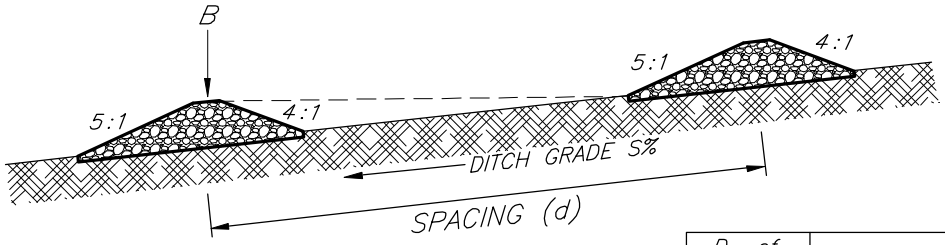


SIDE VIEW



FRONT VIEW





D_{50} of ROCK (mm)	MAXIMUM FLOW DEPTH OVER ROCK (mm)
75	50
150	100

SUGGESTED ROCK DIAMETER AND OVERFLOW DEPTHS

NOTES:

1. SUITABLE FOR FLOW VELOCITY ≤ 1.5 m/s.
2. SUITABLE FOR DRAINAGE AREA ≤ 4 ha.
3. SUITABLE FOR GRADES FROM 5% TO 8%.
4. SPACING (d) AND ROCK SIZE (D_{50}) TO BE DETERMINED BY ENGINEER BASED ON HYDRAULIC CONDITIONS.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

ROCK CHECK DAM

Synthetic Permeable Barrier Erosion Control and Sediment Control	B.M.P. #10

Description and Purpose

- Double panel, low profile, uni-body porous synthetic barriers used to dissipate flow energy and reduce velocity
- Barriers of patented design constructed of lightweight and durable synthetic materials
- May be used to create a grade break to reduce flow energy and velocities allowing some sediment to settle out at the upstream barrier panel of the barrier structure
- Can be used to dissipate flow energy and trap sediment during the period of revegetation; should be removed at successful re-establishment of vegetation

Applications

- Temporary structure
- May be placed across trapezoidal ditch to dissipate flow energy and reduce flow velocities
- Can be used to supplement as grade breaks along ditch interval between permanent drop structures along steep ditch grades
- May be used as midslope grade breaks along contours of midslope or at toe of disturbed slopes
- Usually used as grade breaks along ditch (3 to 7% grade) in conjunction with erosion control matting or non-woven geotextile as soil covering mattings; usually used in conjunction with permanent gabion structure (i.e., gabion) at steep grade (+6%) areas
- Designed to be reusable

Advantages

- Prefabricated
- Reusable/moveable
- More appropriate for installing at transition areas of changing grades of channels so that hydraulic jumps (or change of flow regime from supercritical to subcritical) may be simulated to dissipate flow energy, thus minimizing erosion potential
- Provide portable drainage control for construction sites, ditches, channels, roads, slopes
- The double panel porous barrier may allow significant energy loss as the flow of water undergoes from supercritical flow to sub-critical flow from the upstream panel

to the downstream panel with a more laminar flow evolving downstream and roughly parallel to the stream bed. Less turbulence and erosion energy may be created when compared with cascading, over-topping and tumbling flow from drop structures (i.e., gabions, check structures, straw bales)

- Barriers constructed of UV resistant material may be left in place for final channel stabilization as UV degradation is low
- Biodegradable synthetic option available
- Observed to enhance aggregation of silt material and to function as a sediment barrier with the formation of an earth block at behind the upstream barrier panel area; the downstream flow exiting at the downstream barrier panel may be of laminar nature and less erosive

Limitations

- More appropriate for use as a grade break and may be installed between permanent drop structures
- Partially effective in retaining some sediment and reducing flow velocities
- Less sturdy as drop structures in resisting high flow impact
- Not to be designed as drop structures
- Must be hand installed
- Become brittle in winter and may be easily damaged by highway maintenance activities or by public
- At the time of deactivation of the structure after vegetation establishment, metallic anchor pins, if not biodegradable, may require removal at time of completed revegetation
- Stick-up of metallic anchor pin above ground may be a nuisance and may be a human hazard and cause damage to maintenance equipment
- The use of biodegradable anchor pins is advisable

Construction

- Install as per manufacturers recommended installation instructions
- Normally installed in conjunction with erosion control matting in ditches and channels
- Prepare soil surface
- Install basal layer of erosion mat or geotextile fabric; key-in basal mat/fabric at upstream end

- Place and anchor barrier panels with adequate pin anchors to basal soils

Construction Considerations

- Maintain intimate contact between base of barrier and soil with laying of basal matting/fabric intimate to ground surface
- Ensure side panel of barrier is extended to outer edges of channel to sufficient height to provide freeboard of channel flow

Inspection and Maintenance

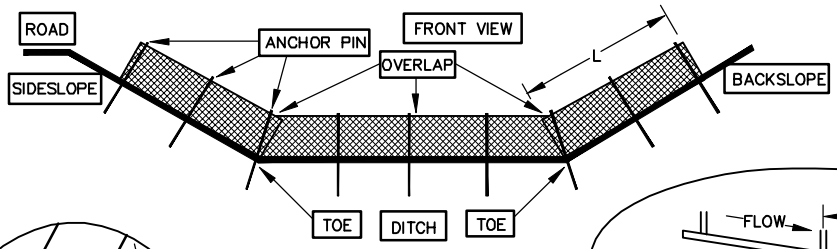
- Inspection frequency should be in accordance with the PESC and TESC Plans
- Remove sediment build-up before it reaches one-half the check structure height
- Do not damage barrier panel during removal of sediment
- Partial or non-removal of sediment build-up will create a non-permeable barrier and low level earth mini-drop structure which will force water flow over-topping the barrier. The option of non-removal of sediments may be open to converting the sediment build-up into a "vegetated earth mini-drop structure" along the ditch with the non-removal of synthetic permeable barrier in-place. This will require topsoil and seeding (or intensive mulch seeding) to promote vegetation growth
- If erosion is noted at the toe or upslope edges of the structure, hand regrading or suitable repairs should be made immediately to prevent failure of the structure
- Remove and deactivate at 1 year after vegetation is established

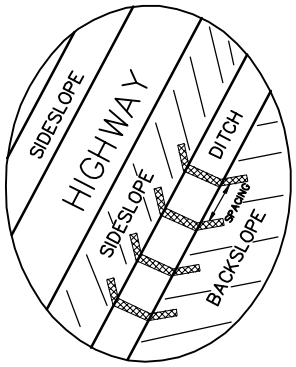
Similar Measures

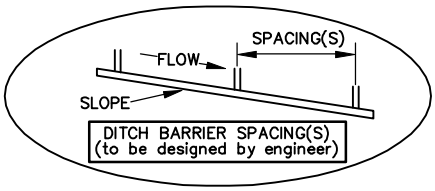
- Silt fences or straw bales partially equivalent in retaining sediment

Design Considerations

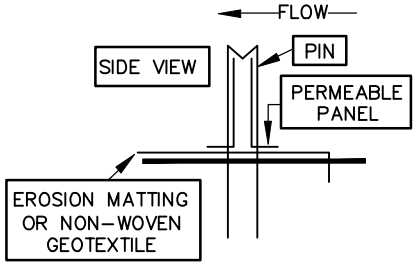
- Install synthetic permeable barrier along ditch interval between permanent drop structures (i.e., gabion); can be economic alternative and supplemental to (i) total hard armouring of complete channel length, or (ii) high frequency of gabion installation required for high flow applications in steep ditch grade



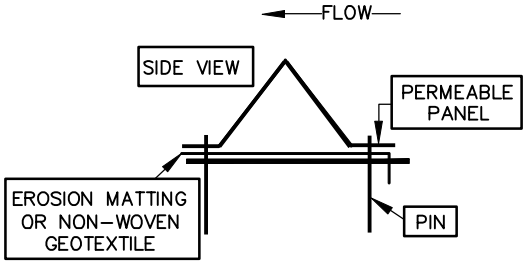




MINIMUM INSTALLATION LENGTH UP SLOPES	
SLOPE	LENGTH: L (m)
2:1	0.55
2.5:1	1.1
3:1	1.1
3.5:1	1.1
4:1	1.1
5:1	1.3
6:1	1.5



1) DOUBLE PANEL



2) TRIANGLE PANEL

SYNTHETIC PERMEABLE DITCH BARRIER

N.T.S.

NOTES:

1. *FOR USE MAINLY AS A GRADE BREAK STRUCTURE FUNCTIONING AS A FLOW ENERGY DISSIPATOR AND VELOCITY RETARDER.*
2. *FOR SECONDARY USE AS SEDIMENT BARRIER.*
3. *REQUIRES NON-WOVEN GEOTEXTILE FABRIC OR BIODEGRADABLE (COCONUT FIBRE PREFERABLE) EROSION BLANKET MAT AT BASE AND KEY-IN TO SOIL AT UPSTREAM END.*
4. *MAY BE INSTALLED AS GRADE BREAK AT GRADE TRANSITION AREAS TO CREATE DISSIPATION OF FLOW ENERGY AND A MORE LAMINAR FLOW REGIME DOWNSTREAM OF STRUCTURE.*
5. *THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.*

SYNTHETIC PERMEABLE BARRIERS

Rolled Erosion Control Products (RECP)

a) Channel Installation
b) Slope Installation
c) Straw Rolls

Erosion Control

B.M.P. #13

Description and Purpose

- Biodegradable or synthetic soil coverings used for temporary or permanent protection of disturbed soils at slopes and channels
- Categories of Rolled erosion control products (RECP) can be:
  - Erosion control blankets (ECB) (generally biodegradable and temporary)
  - Turf reinforcement mats (TRM)
  - Composite turf reinforcement mats (C-TRM)
- RECP may be manufactured of organic material, synthetic material, or as a composite of organic and synthetic materials
- Protect disturbed soils from raindrop impact and surface runoff erosion, increase water infiltration into soil, retains soil moisture and decreases evaporation loss
- Protect seeds from raindrop impact, runoff, and predators
- Stabilizes soil temperature to promote seed germination and enhance vegetation growth

Applications

- Temporary or permanent measure
- May be used to protect disturbed, exposed soils for cut or fill slopes at gradients of 2.5H:1V or steeper
- May be used on slopes where erosion potential is high
  - Silts and sands have higher erosion potential than high plastic clays
- May be used on slopes where vegetation is likely to be slow to develop
- May be used to protect disturbed exposed soils in ditches and channels (with high flow velocities) by providing additional tractive resistance cover in conjunction with a successful high density vegetative growth established

Advantages

- Degree of erosion protection is higher, more uniform, and longer lasting than for sprayed-on products (e.g., mulches)
- Wide range of commercially available temporary (biodegradable) or permanent products

Rolled Erosion Control Products (RECP) a) Channel Installation b) Slope Installation c) Straw Rolls Erosion Control	B.M.P. #13

Limitations

- Non-performance of RECP may result from the following:
  - Low density vegetation growth (beneath RECP) due to non-favourable weather and growth conditions (i.e., soil type, moisture, storm events at critical times). It is noted that values of tractive resistance of RECP products for vegetative growth may be generally tested in laboratory after a growth period (e.g., 3 months) under greenhouse growth conditions. The effectiveness of RECP, especially along channels, is very dependent on success of vegetation growth on site. It is important that the designer should assess the effectiveness of RECP in accordance with site, soil, terrain and vegetation growth conditions
  - Hydraulic uplift of RECP and erosion of underlying soils can occur under rapid snow melt conditions when dammed up melt water generates a hydraulic head and high flow velocity generated in constricted snow melt channel. This situation can occur along steep channels interlaced with drop structures and with RECP lining installed in-between the drop structures. Ponding of melt water and non-anchored RECP joint areas allow flow entry beneath the RECP and generate hydraulic heads to uplift the RECP. This can occur along un-anchored edges of RECP at upper edges of ditch when snow melt occurs at tops of ditch and flow beneath the RECP. This is especially critical when underlying soil is easily erodible. (e.g., fine grained non-cohesive silty soils). It is important to trench-in and anchor the edges of the RECP installations and installed anchor pin (staples) at sufficient dense intervals
  - Ice build-up from groundwater seepage source can uplift and dislocate the RECP and causing flow beneath the RECP to erode the substrate soils. Winter ice accumulation may be related to groundwater regime and investigative design on subsurface drainage by a geotechnical engineer is required
- Can be labour intensive to install
- Must be installed on unfrozen ground
- Temporary blankets may require removal before implementation of permanent measures
- Rolled erosion control products (RECP) are not suitable for rocky sites
- Proper surface preparation is required to ensure intimate contact between blanket and soil
- Plastic sheeting can be used at sensitive slopes with precautions:
  - Plastic sheeting RECP product can be easily torn, ripped, non-biodegradable, and should be disposed of in a landfill

- Plastic sheeting product, if used, results in 100% runoff, thus increasing erosion potential in downslope areas receiving the increased flow volumes
- Plastic sheeting should be limited to temporary covering of sensitive soil stockpiles or temporary covering of small critical unstable slope areas

Construction (Slopes)

- RECP should be installed in accordance with manufacturer's directions

The following is a general installation method:

- Prepare surface and place topsoil and seed
- Surface should be smooth and free of large rocks, debris, or other deleterious materials
- Blanket should be anchored at top of slope in a minimum 0.15 m by 0.15 m trench for the entire width of the blanket
- The blanket should be rolled out downslope
  - (1) Where the blanket roll is not long enough to cover the entire length of the slope, a minimum 0.15 m by 0.15 m check slot should be excavated at the location of the lap, and the downslope segment of blanket anchored in the check slot, similar to the method used for the top of the slope, or (2) when blankets must be spliced down the slope, place blanket end over end (shingle style with approximately 0.10 m overlap. Staple through overlapped area at 0.3 m intervals.
  - The upslope portion of blanket should overlap the downslope portion of blanket, shingle style, at least 0.15 m with staple anchors placed a maximum 0.3 m apart
  - Adjacent rolls of blanket should overlap a minimum 0.1 m
  - Anchors should be placed along central portion of blanket spaced at $4/m^2$ minimum (0.5 m spacing) for slopes steeper than 2H:1V and $1/m^2$ (1 m spacing) for slopes flatter than 2H:1V
  - Anchors along splices between adjacent rolls should be placed 0.9 m apart

Construction (Channels)

- **A Blanket should be installed in accordance with manufacturers directions**

The following is a general installation method

- Prepare surface and place topsoil and seed

- Surface should be smooth and free of large rocks, debris, or other deleterious materials

– Begin by excavating a minimum 0.15 m deep and 0.15 m wide trench at the upstream end of channel and place end of RECP into trench
  - Use a double row of staggered anchors approximately 0.1 m apart (i.e., 0.2 m linear spacing) to secure RECP to soil in base of trench
  - Backfill and compact soil over RECP in trench
– Roll centre RECP in direction of water flow on base of channel
– Place RECP end over end (shingle style) with a minimum 0.15 m overlap downgrade
  - Use a double row of staggered anchors approximately 0.1 m apart to secure RECP to soil
– Full length edge of RECP at top of sideslopes must be anchored in a minimum 0.15 m deep and 0.15 m wide trench
  - Use a double row of staggered staple anchors a maximum of 0.1 m apart (i.e., 0.2 m linear spacing) to secure RECP to soil in base of trench
  - Backfill and compact soil over RECP in trench
– Overlap RECP on sideslopes (shingle style down channel) a minimum of 0.1 m over the centre RECP and secure RECP to soil with anchors spaced a maximum of 0.2 m apart
– In high flow channels, a check slot across the width of the channel is recommended at a maximum spacing of 10 m to anchor the ends of the RECP to the underlying soil
  - Use a double row of staggered staple anchors a maximum of 0.1 m apart (0.2 m linear spacing) to secure RECP to soil in base of check slot
  - Backfill and compact soil over RECP in check slot
– Anchor terminal ends of RECP in a minimum 0.15 m deep and 0.15 m wide trench
  - Use a double row of staggered anchors a maximum of 0.1 m apart (i.e., 0.2 m linear spacing) to secure RECP to soil in base of trench
  - Backfill and compact soil over RECP in trench

Rolled Erosion Control Products (RECP) a) Channel Installation b) Slope Installation c) Straw Rolls Erosion Control	B.M.P. #13

Construction Considerations

- Slopes should be topsoiled and seeded prior to placing RECP
- Ensure blanket is in intimate contact with the soil by properly grading soil, removing rocks or deleterious materials, prior to placing blanket
- In channels, blankets should extend to above the anticipated flow height, with a minimum 0.5 m of free board
- For turf reinforcement mat (TRM), blanket should be placed immediately after topsoiling
- Blanket should be anchored by using wire staples, metal geotextile stake pins, or triangular wooden stakes
  - All anchors should be a minimum of 0.15 to 0.2 m in length
  - For loose soils, use longer anchors
- Blankets should be placed longitudinal to direction of flow, with fabric not stretched but maintaining contact with underlying soil
- It is essential to understand product specifications and follow manufacturers instructions on installation methods

Product Quality Assurance/Quality Control (QA/QC) Certification

RECPs should be certified by the supplier/manufacturer to ensure product performance and compliance with specified property requirements. A certificate for QA/QC testing of manufactured products is required. The performance and QA/QC testing should be carried out by reputable laboratories (e.g., TxDoT – Hydraulic and Erosion Control Laboratory OR equivalent laboratory) to ensure a commonly acceptable QA/QC standard. Dependent on product type and intended performance, the product information certificate should be provided by the product supplier/manufacturer to include the following:

- Manufacturer's Certificate on
- Performance specification
  - Permissible Tractive Resistance (include testing methods and vegetative growth conditions)
  - Permissible Flow Velocity (if available)
  - Longevity (for biodegradable or non-biodegradable products)

- Minimum Average Roll Values (MARVs) along with specified testing methods for
  - Physical properties
    - Mass per unit area
    - Thickness
    - Tensile strength
    - UV Resistance
  - Other physical properties (for non-woven below Erosion Mat (if specified)
    - Grab tensile strength
    - Grab elongation
    - Puncture strength
    - Trapezoidal tear
    - UV Resistance

Inspection and Maintenance

- Areas covered with blankets should be inspected/remediated regularly or in accordance with the PESC and TESC Plans, especially after periods of severe rainfall or storm events, to check for blanket separation or breakage
- Any damaged or poorly performing areas should be repaired/remediated immediately. Regrading of the slope by hand methods may be required in the event of rill or gully erosion.
- Inspection and maintenance should continue until dense vegetation is established
- Areas with low vegetation density should be reseeded
- After approximately one year, a top dressing of fertilizer may be applied to improve vegetation cover and assist degradation of temporary blankets

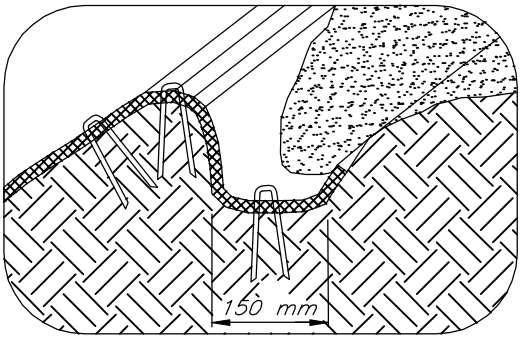
Similar Measures

- Mulching (for slopes only)
- Riprap (primarily in channels)
- Gabion mattresses (primarily in channels)

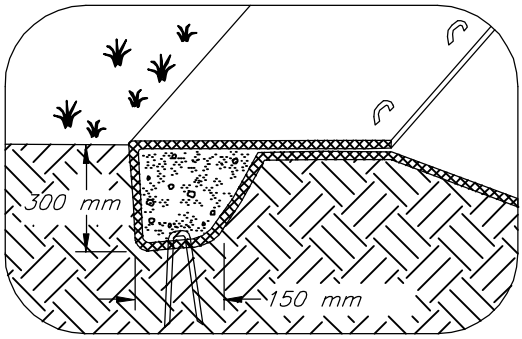
Rolled Erosion Control Products (RECP) a) Channel Installation b) Slope Installation c) Straw Rolls Erosion Control	B.M.P. #13

Design Considerations

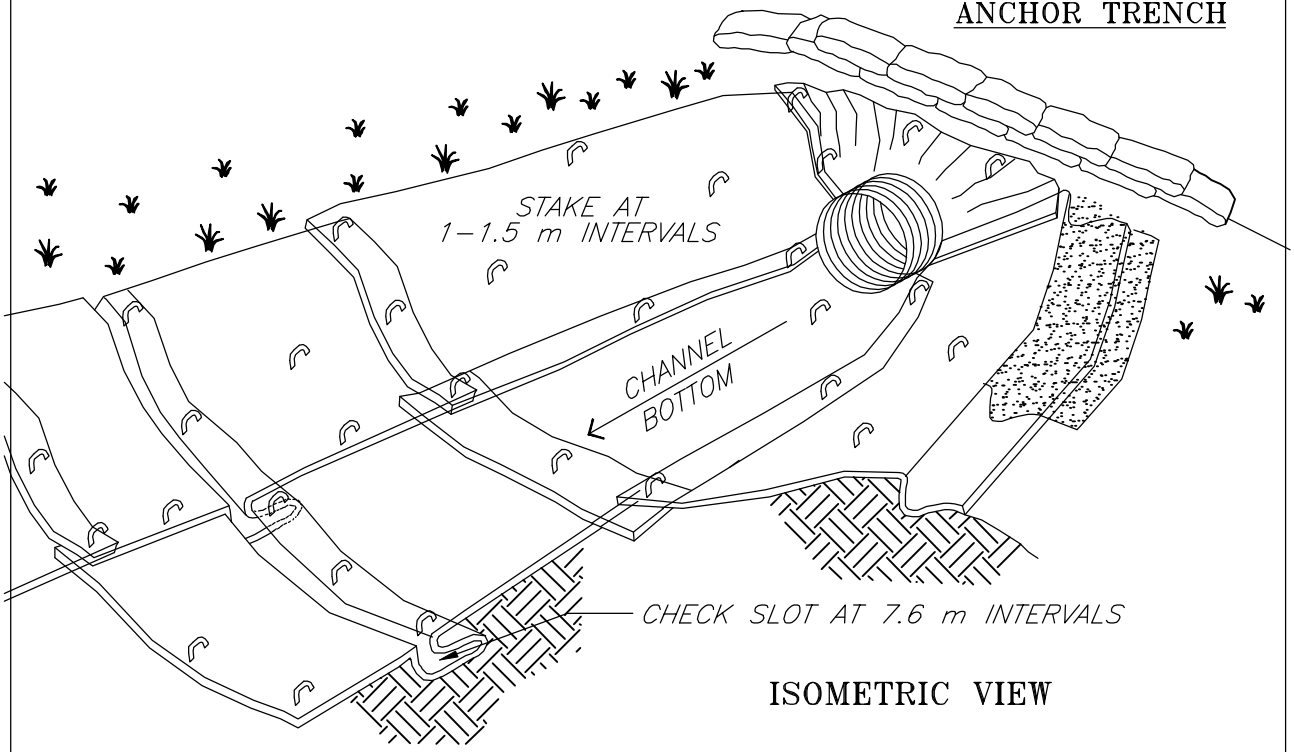
- Assess hydraulic flow conditions and tractive stress on channel
- Assess local soil, weather and growth conditions (favourable/non-favourable) for revegetation (within 3 to 12 months) to allow a determination on use or non-use of RECP as a protective measure. If the revegetation conditions are assessed favourable, the use of RECP can be considered
- Assess suitability of a RECP product using tractive resistance data tested for (i) bare soil, and (ii) vegetated (a specified duration of growth period) condition
- It is noted that tractive resistance data are adopted as selection criteria of RECP and permissible velocity data can be provided for reference.



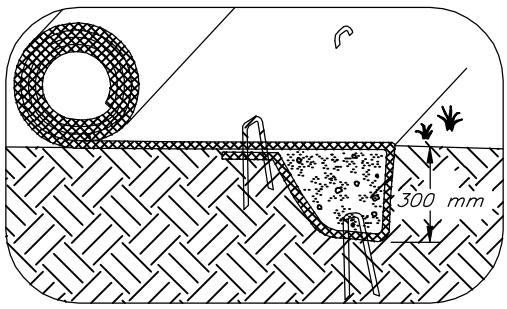
LONGITUDINAL ANCHOR TRENCH



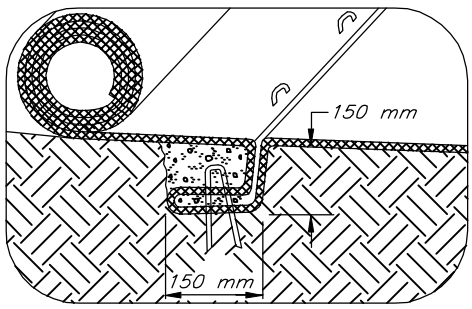
TERMINAL SLOPE AND CHANNEL ANCHOR TRENCH



ISOMETRIC VIEW



INITIAL CHANNEL ANCHOR TRENCH



INTERMITTENT CHECK SLOT

NOTES:

1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURERS SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURERS SPECIFICATIONS.
3. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

ROLLED EROSION CONTROL PRODUCTS (RECP)

CHANNEL INSTALLATION

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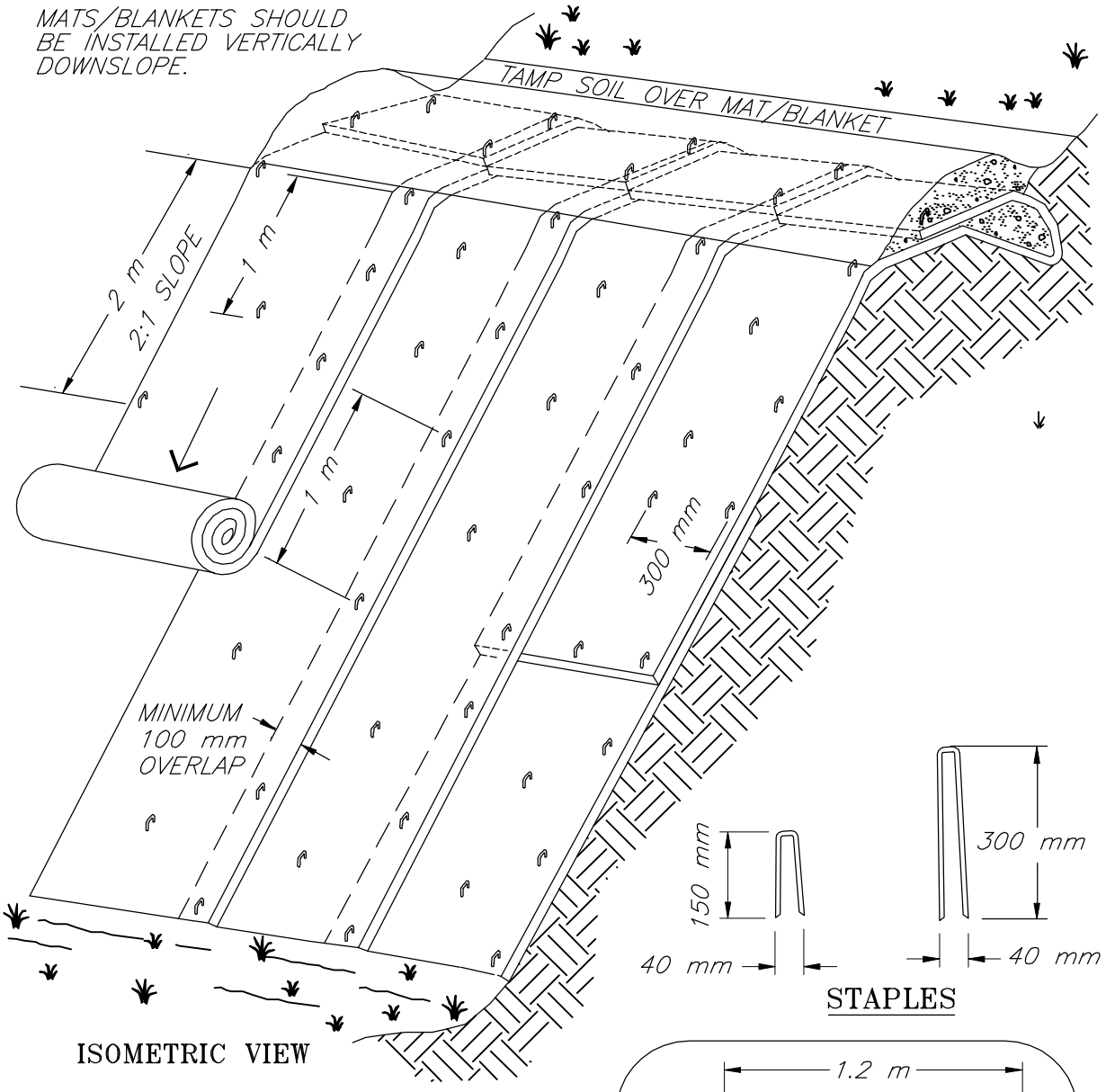
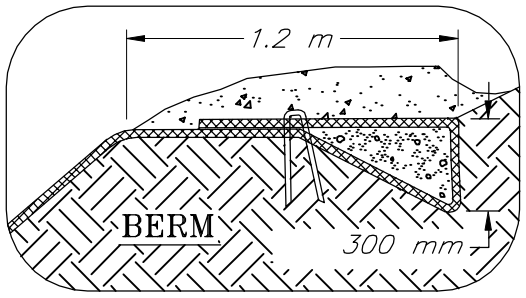
B.M.P. #13a
Typical Section





NOT TO SCALE

TYPICAL SLOPE SOIL STABLIZATION

NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/ BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.
4. CHECK SLOTS, STAKING, STAPLING AND OTHER CONSTRUCTION DETAILS PER MANUFACTURES SPECIFICATIONS.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

ROLLED EROSION CONTROL PRODUCTS (RECP) SLOPE INSTALLATION

Riprap Armouring a) Slope Protection b) Channel Protection Erosion Control	B.M.P. #14 (a & b)

Description and Purpose

- Large, loosely placed cobbles or boulders placed along channel banks or slopes to protect underlying soil from erosion due to flowing water
- Can protect slopes and channel banks against erosion

Applications

- Permanent measure
- May be used on channel banks and slopes with flow velocities ranging from 2 m/s to 5 m/s (dependent on rock size and thickness); appropriate for slopes that do not exceed 2H:1V
- Riprap only needs to be placed at lower portion of channel section to the anticipated flow height (mean annual peak flow) plus freeboard
  - Other form of soft armouring (RECP blankets, seeding) can be used to promote vegetation to protect soil at upper portion of channel slopes, above riprap
- Must be used in conjunction with a non-woven geotextile underlay acting as a filtration separator with basal soil
- For fluctuating high flow channel, the riprap should be underlain by a layer of granular filter material for cyclic drawdown long-term performance with/without an extra layer of non-woven geotextile as underlay

Advantages

- Easy to install and easy to repair
- Very durable, long lasting, and virtually maintenance free
- Flexible

Limitations

- Expensive form of channel lining and stabilization
- Requires heavy equipment and transport of rock to site
- May not be feasible in areas where suitable rock is not available
- Riprap may have to be placed by hand
- Normally 2 to 3 times riprap thickness is required in comparison with gabion mattress thickness for equivalent protection performance under identical hydraulic conditions

- Use of gabion is preferred at flow greater than 3 m/s due to larger nominal size of riprap and thickness required for erosion protection during flow velocities of this magnitude
- Can be classified as uniform or graded. Uniform riprap would contain stones which would contain a mixture of stones ranging from small to large. Graded riprap forms a flexible self healing cover

Construction

- Grade the slope or channel to final design grade
- Place filter (underlay) layer on prepared slope
  - Filter layer can consist of non-woven geotextile underlay and/or well graded granular material dependent on hydraulic conditions
- Place riprap layer
- Riprap should consist of a graded mixture of sound, durable stone with at least 50% of the riprap material being larger than 200 mm in diameter
- Riprap should be sized according to the following gradation and mass:

		Riprap Class			
		1M	**1**	**2**	**3**
Nominal Mass **Nominal Diameter**	**kg** **mm**	**7** **175**	**40** **300**	**200** **500**	**700** **800**
None heavier than:	kg or mm	40 300	130 450	700 800	1800 1100
No less than 20% or more than 50% heavier than:	kg or mm	10 200	70 350	300 600	1100 900
No less than 50% or more than 80% heavier than:	kg or mm	7 175	40 300	200 500	700 800
100% heavier than:	kg or mm	3 125	10 200	40 300	200 500

Percentage quoted are by mass.
Sizes quoted are equivalent spherical diameters, and are for guidance only.

Source: AT Bridge Spec. 2010

- Non-woven geotextile fabric underlay below riprap should meet the following specifications and physical properties:

Non-Woven Geotextile Filter Fabric
Specifications and Physical Properties

	Class 1M, 1 and 2	Class 3
Grab Strength	650 N	875 N
Elongation (Failure)	50%	50%
Puncture Strength	275 N	550 N
Burst Strength	2.1 MPa	2.7 MPa
Trapezoidal Tear	250 N	350 N
Minimum Fabric Overlap to be 300 mm		

Source: AT Bridge Spec. 2010

Construction Considerations

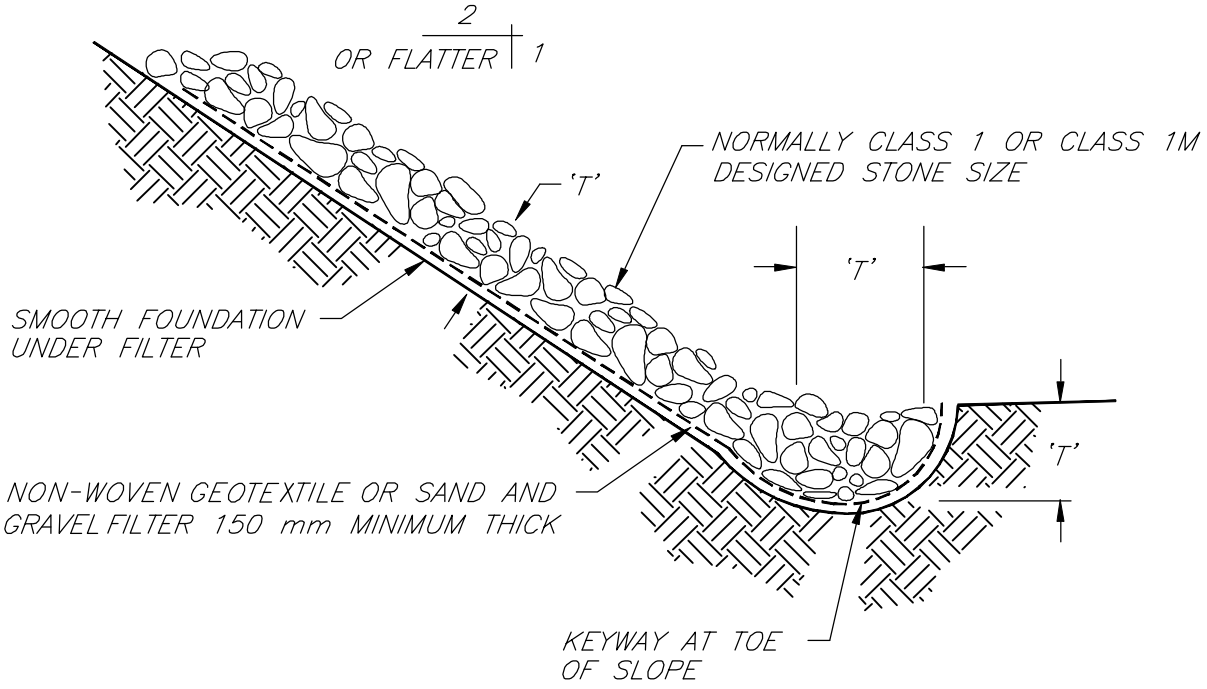
- Riprap should be placed in a uniform thickness across the channel so as not to constrict channel width
- Blasted rock is preferred (if available)
- Riprap layer should be 1.5 to 2 times the thickness of the largest rocks used, 1.5 to 3 times the thickness of the D_{50} material, and not less than 300 mm in thickness

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Periodic inspections to check for erosion of protected material or movement of riprap

Similar Measures

- Rolled erosion control products (RECP) well vegetated; not for use at severe flow and high velocity areas
- Gabion mattresses



TYPICAL SECTION

NOTE:

1. 'T' = THICKNESS: THICKNESS SHALL BE DETERMINED BY THE ENGINEER.
   MINIMUM THICKNESS = 300 mm. (i.e. 1.5x D_{50}) FOR D_{50} = 200 mm.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

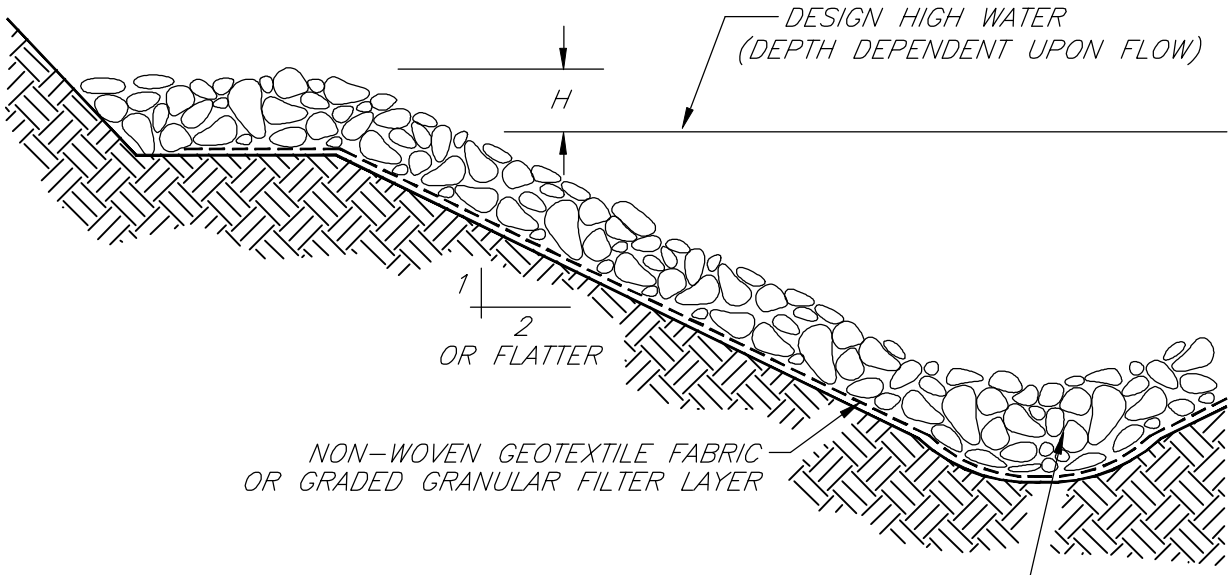
RIPRAP ARMOURING FOR SLOPE

FILE: RIPRAP

Government of Alberta ■
Transportation

B.M.P. #14a
Typical Section

DESIGN HEIGHT (H), WIDTH AND STONE SIZE SHALL
BE DETERMINED BY THE ENGINEER



MINIMUM 300 mm THICK LAYER OF 50 mm MINIMUM DIAMETER DRAIN ROCK. D_{50} =200 mm. LARGER STONE SHALL BE USED DEPENDENT UPON GRADIENT, SOIL TYPE, AND DESIGN FLOW.

TYPICAL SECTION

NOTES:

1. RIPRAP GRADATION AND THICKNESS SHALL BE DETERMINED BY THE ENGINEER IN ACCORDANCE WITH HYDRAULIC CONDITIONS.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

RIPRAP ARMOURING FOR CHANNEL

FILE: RCKCHNEL

Government of Alberta ■
Transportation

B.M.P. #14b
Typical Section

Hydroseeding Sediment Control and Erosion Control	B.M.P. #24a

Description and Purpose

- The spraying-on of a slurry to a slope or channel surface to provide a layer of seed and growth bedding medium
- The slurry consists of seed, fertilizer, mulch, tackifiers, and water which are mixed together in a tank
- Enables quick re-vegetation of very steep or rocky/gravelly slopes where re-vegetation by any other method would be very difficult or unsafe; frequent re-seeding and special mix design may be required
- When sprayed on the soil, the slurry forms a continuous blanket with seeds and protects the soil from wind and water erosion and raindrop impact by aggregating (or adhering) them in place
- The slurry conserves moisture, reduces soil moisture evaporation, and decreases soil surface crusting due to evaporation or drying of soil

Applications

- Temporary measure
- Slurry is held in suspension through consistent agitation and is sprayed onto disturbed areas using high pressure pumps
- Can be used for spray-on seeding covering large areas efficiently after placement of topsoil
- Can be used to provide temporary and permanent erosion control prior to establishment of vegetation
- May be used to provide soil stabilization for seeding disturbed soil areas
- Can also be used with higher efficiency and large area coverage with advantages over conventional methods (broadcast seeders, drill seeders)
- Can be used in areas where little topsoil is available

Limitations

- Site must be accessible to hydroseeding equipment
  - Usually mounted on trucks
  - Maximum hose range of approximately 150 m
- May require subsequent spraying to reseed bare spots or areas with low growth

Hydroseeding Sediment Control and Erosion Control	B.M.P. #24a

Construction

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil if available
- Spray on hydroseed-hydromulch as per supplier's recommendations

Construction Considerations

- Seed
  - Seed selection should be made in accordance with Alberta Transportation approved seed mixes
  - Alberta Transportation has adopted seed mixes used on Alberta Highway and Bridge Projects depending on site location (see BMP #22 Seeding)
  - The various areas of the province used in selecting the seed mix are presented in the Seed Mix Zones map (see BMP #22 Seeding)
  - Seed mixes have been developed based on historic performance results throughout Alberta

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by runoff may need to be repaired and/or protected from further erosion
- Small bare spots may need to be reseeded

Similar Measures

- Seeding
- Mulching
- Rolled erosion control products (RECP)

Hydromulching Sediment Control and Erosion Control	B.M.P. #24b

Description and Purpose

- The spraying-on of a slurry to a slope or channel surface to provide a layer of growth bedding medium
- The slurry consists of seed, fertilizer, mulch, tackifiers, and water which are mixed together in a tank
- The slurry conserves moisture, reduces soil moisture evaporation, and decreases soil surface crusting due to evaporation or drying of soil

Applications

- Temporary measure
- Can be used in areas where little topsoil is available

Advantages

- Relatively cheap and efficient spraying method of promoting plant growth as well as erosion protection
- Allows spray-on re-vegetation of steep slopes where conventional re-vegetation methods are very difficult
- Minimizes effort required to re-vegetate disturbed areas as hydromulching usually only requires one spray-on operation in comparison with planting and farrow method
- Relatively efficient operation with high coverage rates
- Provides dust control and protection from wind erosion

Limitations

- Site must be accessible to hydromulching equipment
  - Usually mounted on trucks
  - Maximum hose range of approximately 150 m

Hydromulching Sediment Control and Erosion Control	B.M.P. #24b

Construction

- Prepare soil surface by removing large rocks or other deleterious materials
- Apply topsoil if available
- Spray on hydromulch as per supplier's recommendations

Construction Considerations

- Hydraulic Mulches
  - Cellulose
    - Comprised of recycled paper from newspapers, magazines, or other paper sources
    - Rapid method for applying seed, fertilizer, mulch, and water in almost any disturbed areas
    - Usually installed without tackifier in slurry
    - Short fibre lengths and lack of tackifier limits erosion control effectiveness and does little to moderate moisture content and temperature within the soil
    - Residual inks within the recycled paper may leach into soil, potential problem on environmentally sensitive areas
    - Longevity significantly shorter than for wood fibre mulches or bonded fibre matrices (BFM)
    - Cheaper than wood fibre mulches and bonded fibre matrices (BFM)
  - Wood Fibre
    - Comprised of whole wood chips
    - Industry standard, provides quick and uniform method and medium for re-vegetating large areas quickly and economically
    - Longer fibre lengths than for cellulose mulches
    - Longer lasting and has better wet-dry characteristics than cellulose mulches
    - Provides limited erosion control even when sprayed on with tackifiers
    - Provides limited moderation of soil moisture content and temperature when applied at higher rates
    - Cheaper than BFM, however, less effective than BFM
    - More expensive than cellulose mulches, however, more effective than cellulose mulches

- Bonded Fibre Matrices (BFM)
  - Slurry comprised of either cellulose mulch, wood fibre mulch, or a combination of the two
  - Mulches are bound together using chemical bond, mechanical bond, or a combination of the two
  - All fibres and binding agents are premixed by manufacturer, ensuring uniformity and consistency throughout the application
  - Well suited for sites with existing desirable vegetation and where worker safety and minimal ground disturbance are desired
  - Degree of protection similar to that obtained from rolled erosion control products (RECP)
  - Quicker installation/application than for RECP
  - Chemically bonded BFM may require a 'set-up' or curing/drying period
    - Application must be limited to periods where there is no threat of rain during curing period
    - Mechanically bonded BFM have no curing time and are effective immediately after application
  - Application on dry soils is not recommended
  - More expensive than cellulose and wood fibre mulches
  - More effective than cellulose or wood fibre mulches
- Tackifiers
  - May include vinyl compounds, asphalt, rubber, or other substances mixed with water

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Areas damaged by runoff may need to be repaired and/or protected from further erosion.

Similar Measures

- Seeding
- Mulching
- Rolled erosion control products (RECP)

Live Staking Streambank Stabilization Technique	B.M.P. #27a

Description and Purpose

- Consists of installing woody plantings (trees and shrubs) to develop a root matrix within the soil, increasing subsurface soil strength and stabilizing slopes with deeper root systems than grasses
- Reduces erosion potential of slopes and channel banks

Applications

- Temporary or permanent measure
- May be used on slopes stable enough to support vegetation; however, there is a low success rate for steep slopes and channel banks with gradients greater than 1H:1V
- May be used on slopes and channel banks with adequate sunlight, moisture, and wind protection to support vegetation
- May be used as bio-engineering stabilization in cases where there have been historical shallow slope instability, soil movements on eroded slopes and gullies
- May be used along channels to provide higher channel roughness to reduce flow velocity and in sedimentation ponds to provide higher sedimentation duration of runoff impoundment

Advantages

- Promotes development of organic mat
- Dense leaves and large diameter plant stalks increases channel roughness and reduces flow velocities in channel thus decreasing erosion potential
- Traps sediment laden runoff and stabilizes soil
- Aesthetically pleasing once developed
- Grows stronger with time as root structure develops
- Usually has deeper root penetration than grass with greater depth of stabilization
- Manual planting may be attempted on steep slopes that are sensitive to machinery disturbance or represent an area of high erosion potential

Live Staking Streambank Stabilization Technique	B.M.P. #27a

Limitations

- Can be labour intensive to install
- Some level of uncertainty as success of plant growth is dependent on various unknown site parameters (i.e., moisture, soil, terrain, weather, seeding conditions, etc.)
- Re-vegetated areas are susceptible to erosion until vegetation develops; and should be used in conjunction with hydroseeding and/or mulching
- Plants may be damaged by wildlife
- Potential for low success rate
- Few precedents as this measure is generally not used on AT construction projects

Construction

- Used on cut or fill slopes or in ditches/channels
- Comprised of willow or poplar stakes inserted into the ground; other indigenous plants may be acceptable
- Individual dormant willow or poplar stakes should be cut to a minimum length of 0.5 m using pruning shears
  - Cuts should be made at a 45° angle a minimum of 0.05 m (5 cm) below a leaf bud
  - All side shutes should be trimmed to within 0.05 m of the main stem
- Install live stakes in a 1 m by 1 m grid
- Make a pilot hole a minimum of 0.3 m in depth to insert live stake into
  - Use iron bar, broom handle or other tool to make pilot hole
- Insert live stake into pilot hole and lightly tamp soil around live stake
- A minimum of two leaf buds should remain above grade

Construction Considerations

- Successful installation requires the use of freshly cut branches or stakes
  - Storage time of cut branches/stakes on-site prior to installation should be kept to as short a time period as possible
- Successful growth dependant on soil moisture and rainfall conditions
- Consultation with agrologist, greenhouse growers, local expertise can be beneficial in selecting and procuring appropriate species for planting

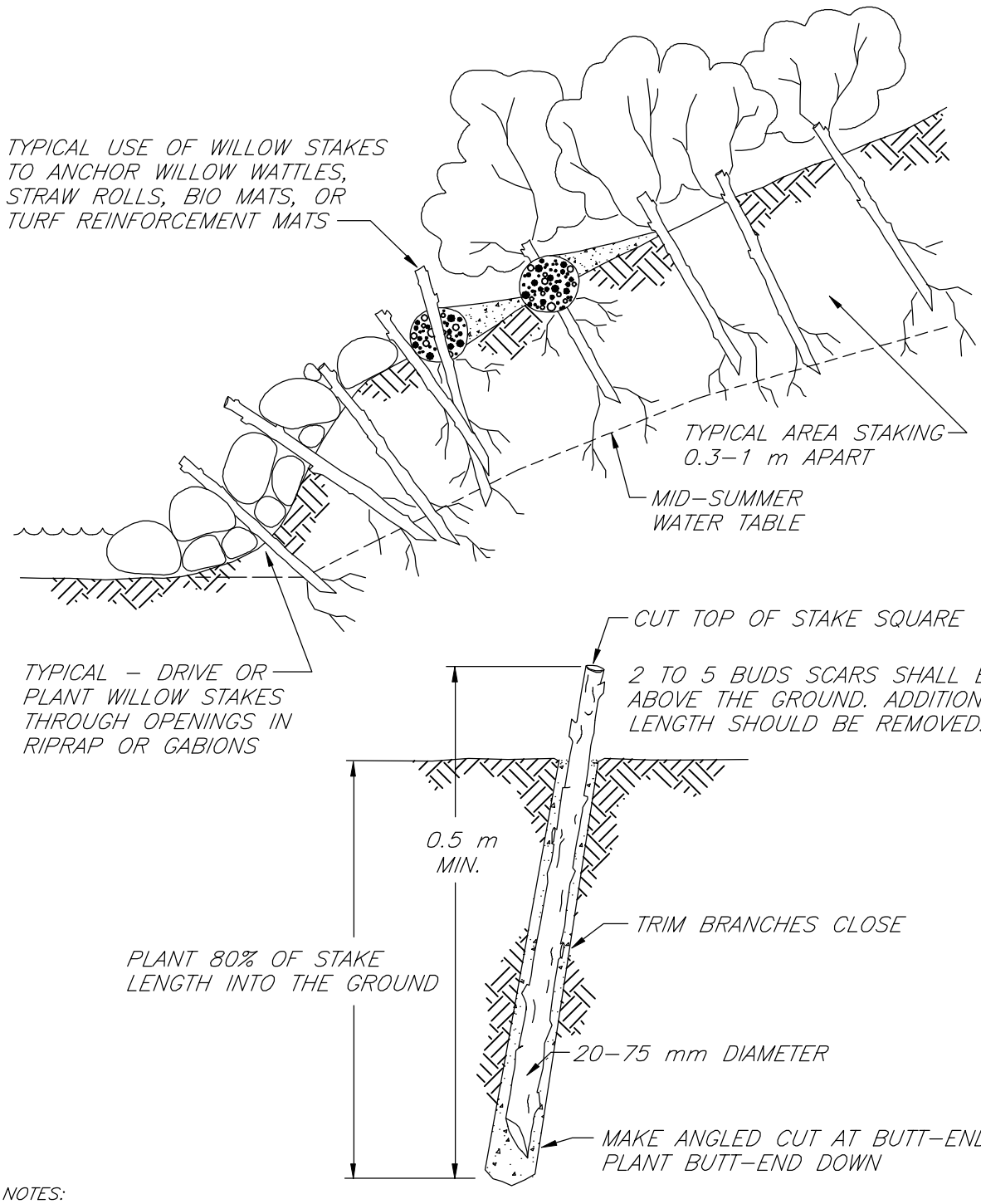
Live Staking Streambank Stabilization Technique	B.M.P. #27a

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
  - Areas damaged by washout or erosion rilling should be replanted immediately
- Additional stormwater control measures should be considered for severe rilling areas damaged by runoff
- Watering plants is required for first one to two months after planting

Similar Measures

- Seeding
- Mulching
- Hydroseeding
- Hydromulching
- Rolled erosion control products (RECP)
- Brush layering



NOTES:
1. HARVEST AND PLANT STAKES DURING THE DORMANT SEASON.
2. USE HEALTHY, STRAIGHT AND LIVE WOOD AT LEAST 1 YEAR OLD.
3. MAKE CLEAN CUTS AND DO NOT DAMAGE STAKES OR SPLIT ENDS DURING INSTALLATION, USE A PILOT BAR IN FIRM SOILS.
4. SOAK CUTTINGS FOR 24 HOURS (MIN.) PRIOR TO INSTALLATION.
5. TAMP THE SOIL AROUND THE STAKE.
6. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

NOT TO SCALE

LIVE STAKING

FILE: LIVESTK

Stabilized Worksite Entrances Sediment Control and Erosion Control	B.M.P. #33

Description and Purpose

- Comprised of a gravel pad located at site access points (entrances) that are used to reduce the amount of sediment carried off construction sites by vehicles
- Collect sediment from vehicle washing and retains sediment on construction site
- Should include water supply to wash off excess soil from vehicles prior to exiting the constructions site

Applications

- Temporary measure
- For use anywhere vehicles enter or exit a construction site

Advantages

- Retains sediment on construction site, where it belongs
- Reduces deposition of sediments on public roads which may be carried by runoff into natural watercourses or drains

Limitations

- Sediment control measures should be installed to collect sediment laden runoff from gravel pad
- Installation of gravel pads may be limited by space constraints

Implementation

- Install gravel pad at planned entrances to worksite
  - Gravel pad (minimum of 15 m in length) should be of sufficient length to accommodate longest anticipated vehicle entering or exiting the site
  - Width of pad should be sufficient to accommodate the widest anticipated vehicle entering or exiting the site (minimum of 3.6 m in width)
  - Thickness of gravel pad should be a minimum of 0.30 m thick (0.3 m thickness is preferred for highway projects) and should comprise 50 to 150 mm diameter coarse aggregate placed on top of woven geotextile filter fabric
- Install temporary sediment control measures (such as straw bale barriers or silt fences) to collect washed off sediment from gravel pad

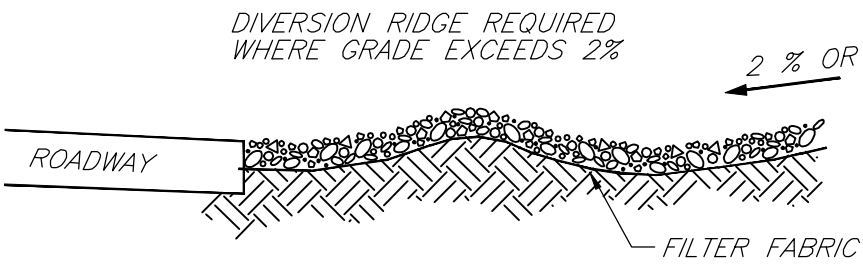
Stabilized Worksite Entrances Sediment Control and Erosion Control	B.M.P. #33

Construction Considerations

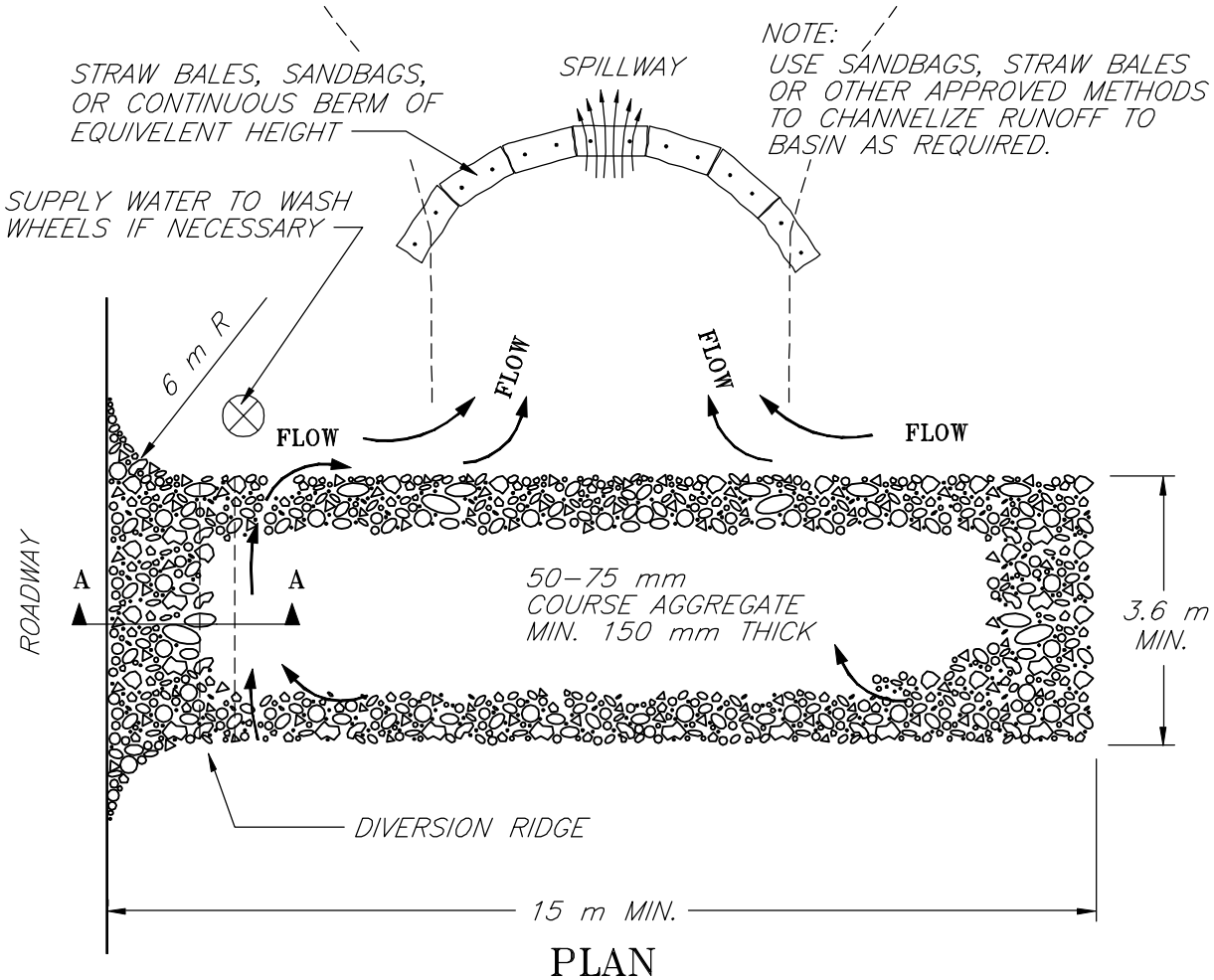
- Should be constructed at all access points to construction sites
  - If impractical to construct at all access points, limit vehicle access traffic to stabilized worksite entrances only
- Entrances located with steep grades or at curves on public roads should be avoided
- Woven geotextile filter fabric should be used as underlay below gravel pad as strength requirement
- Install an elevated ridge adjacent to roadway if gradient of the gravel pad is steeper than 2%, sloped towards the roadway

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Granular material should be regraded when required
  - Material may need to be added to fill large voids to maintain a minimum pad thickness of 0.30 m
- Inspect and clean out downstream sediment control measures at least once per week and after periods of significant rainfall
- Material accidentally deposited onto public roads should be cleaned as soon as possible



SECTION A – A



PLAN

NOTES:

1. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION THAT WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC RIGHT–OF–WAYS. THIS MAY REQUIRE TOP DRESSING, REPAIR AND/OR CLEANOUT OF ANY MEASURES USED TO TRAP SEDIMENT.
2. WHEN NECESSARY, WHEELS SHALL BE CLEANED PRIOR TO ENTRANCE ONTO PUBLIC RIGHT–OF–WAY.
3. WHEN WASHING IS REQUIRED, IT SHALL BE DONE ON AN AREA STABLIZED WITH CRUSHED STONE THAT DRAINS INTO AN APPROVED SEDIMENT TRAP OR SEDIMENT BASIN.
4. FOR HIGHWAY CONSTRUCTION, 300mm THICKNESS OF GRAVEL IS PREFERRED.
5. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT

FILE: ENTRANCE

Slope Texturing (a-c) Sediment Control	B.M.P. #34 (a - c)

Description and Purpose

- Texturing of slopes, either by roughening the surface, tracking the surface, or installing grooves or benches
- Texturing reduces the runoff velocity, traps sediment, and increases the infiltration of water into the soil

a) Surfacing Roughening

b) Grooved or Serrated Slope

c) Benched Slope

Applications

- Temporary measure
- May be used to roughen the exposed soils on the slope surface in the direction of water flow to minimize erosion and to entrap some sediments
- May be used on fresh cut or fill slopes (8 m length or longer; practical travel reach of a dozer) with gradients of generally 3H:1V or steeper (2H:1V as general steepness limit) constructed in cohesive soils
- May be used on slope subgrade that will not be immediately topsoiled, vegetated or otherwise stabilized
- May be applied to topsoiled slope to provide track serration to further reduce erosion potential
- May be used in graded areas with smooth and hard surfaces
- As part of slope design, benching may be used to effect a reduction of erosion hazard where a long slope length needs to be shortened into smaller sectional lengths with mid-benches; normally a 3 m wide bench can be appropriate
  - Benching is usually a permanent slope design feature and should only be designed by a qualified geotechnical engineer
  - Benching of a long slope section to divide into short sections can reduce erosion hazard in the range of 30 to 50% (e.g., sediment yield for 15 m high 3H:1V slope with mid-bench)

Slope Texturing (a-c) Erosion Control	B.M.P. #34 (a - c)

Advantages

- Reduces erosion potential of a slope
- Texturing will create protrusions to increase surface roughness to reduce overland flow velocities and erosion energy
- Texturing will create minor spaces to entrap a portion of the coarse sediment and reduces amount of sediment transported downslope
- Texturing of slopes will benefit development of vegetation
- Texturing of slopes aids in performance of mulches and hydroseeding
- Texturing with track-walking up/downstream may effect a 50% reduction of sediment yield compared with untracked slope

Limitations

- Surface roughening and tracking may increase grading costs
- Surface roughening and tracking may cause sloughing in certain soil types (i.e., sandy silt) and seepage areas; geotechnical advice is recommended
- Texturing provides limited sediment and erosion control and should be used as a temporary measure prior to topsoiling
  - Should be used in conjunction with other erosion and sediment control measures (i.e., offtake ditches) to limit the sheet flow downslope

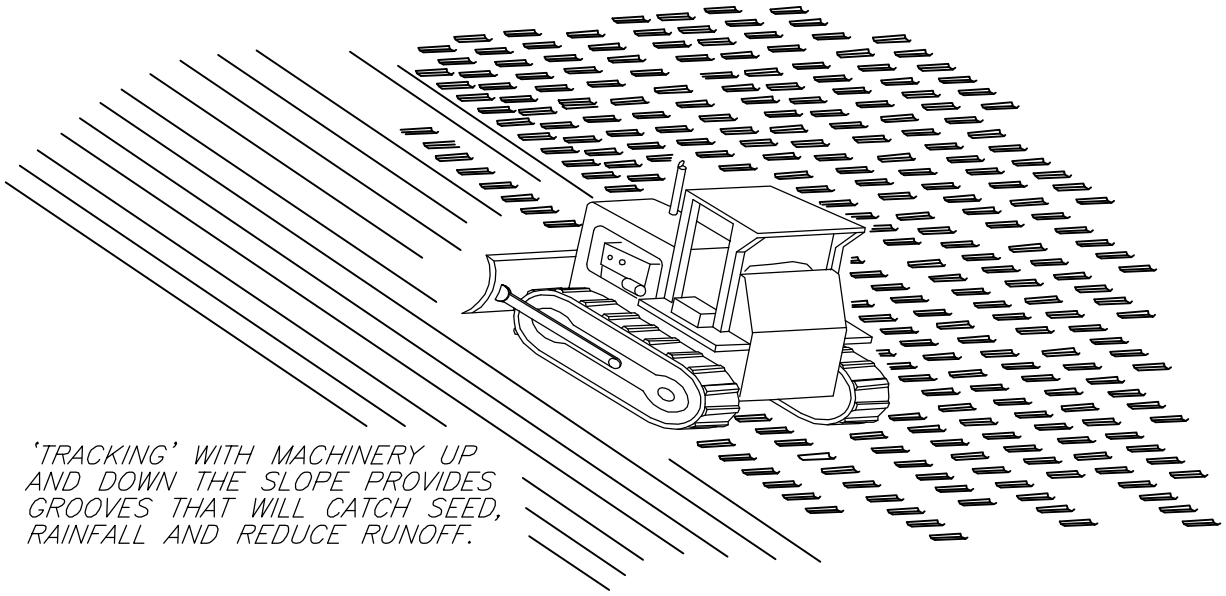
Construction

- Surface Roughening
  - Leave soil in rough grade condition, do not smooth grade soil
  - Large lumps of soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Surface Tracking
  - Using tracked construction equipment to move up and down the slope, leaving depressions perpendicular to the slope direction; limit passes to prevent overcompaction of the surface
  - Depressions in the soil will aid in decreasing runoff velocities, trap sediment, and increase infiltration of water
- Grooving
  - Excavating shallow furrows across the width of the slope, perpendicular to the direction of the slope

  - If used, contour grooves should be approximately 0.1 to 0.2 m in depth
- Grooves can be made by using equipment or hand
- Benching
  - Construction of narrow, flatter sections of soil on the slope, perpendicular to the direction of the slope
  - Benches should be designed by qualified geotechnical engineer

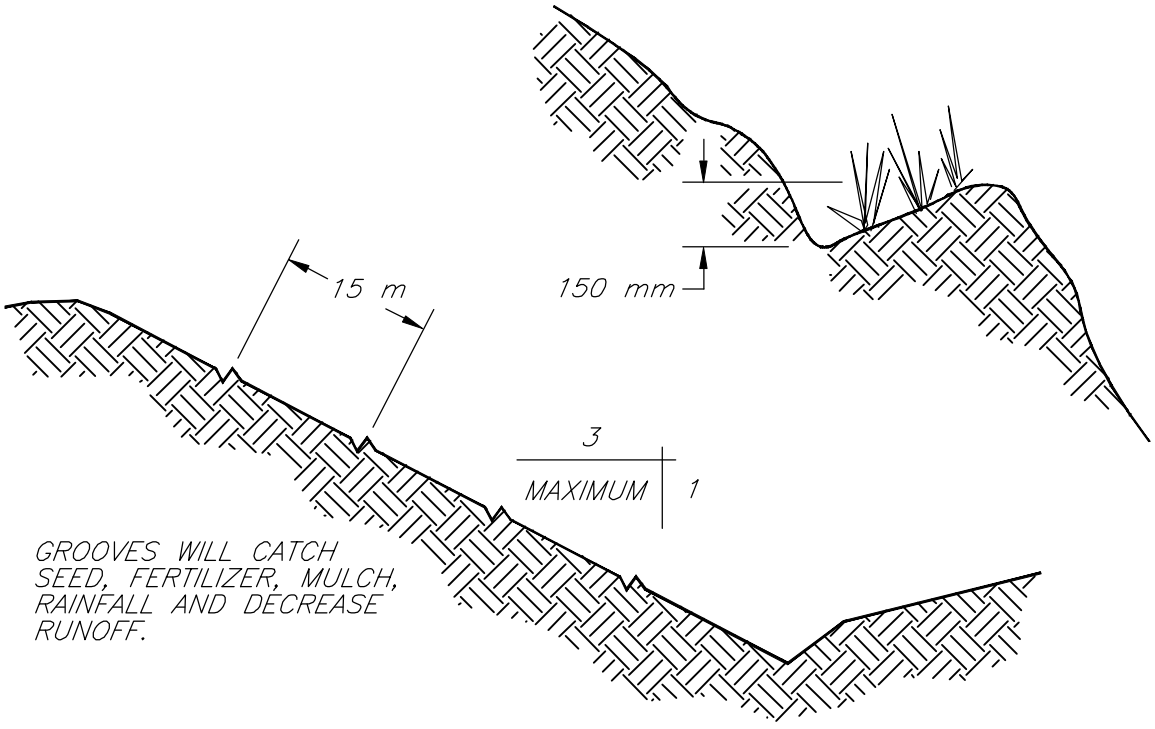
Construction Considerations

- During tracking operations, care must be taken to minimize disturbance to the soil where the equipment turns or changes direction
- Minimize the number of tracking passes to 1 or 2 times to avoid overcompaction, which can negatively impact the vegetation growth
- It is practical to track roughen a slope length of greater than 8 m for practical up/down slope operation of a small bulldozer. It is important to minimize the loosening of soil caused by turning movement of the bulldozer at the end of each pass. As the erosion potential is lower for slope of low vertical height (<3 m height and 3H:1V slope), the tracking of low height slope is not required and not practical for bulldozer tracking operation.



'TRACKING' WITH MACHINERY UP AND DOWN THE SLOPE PROVIDES GROOVES THAT WILL CATCH SEED, RAINFALL AND REDUCE RUNOFF.

TRACKING



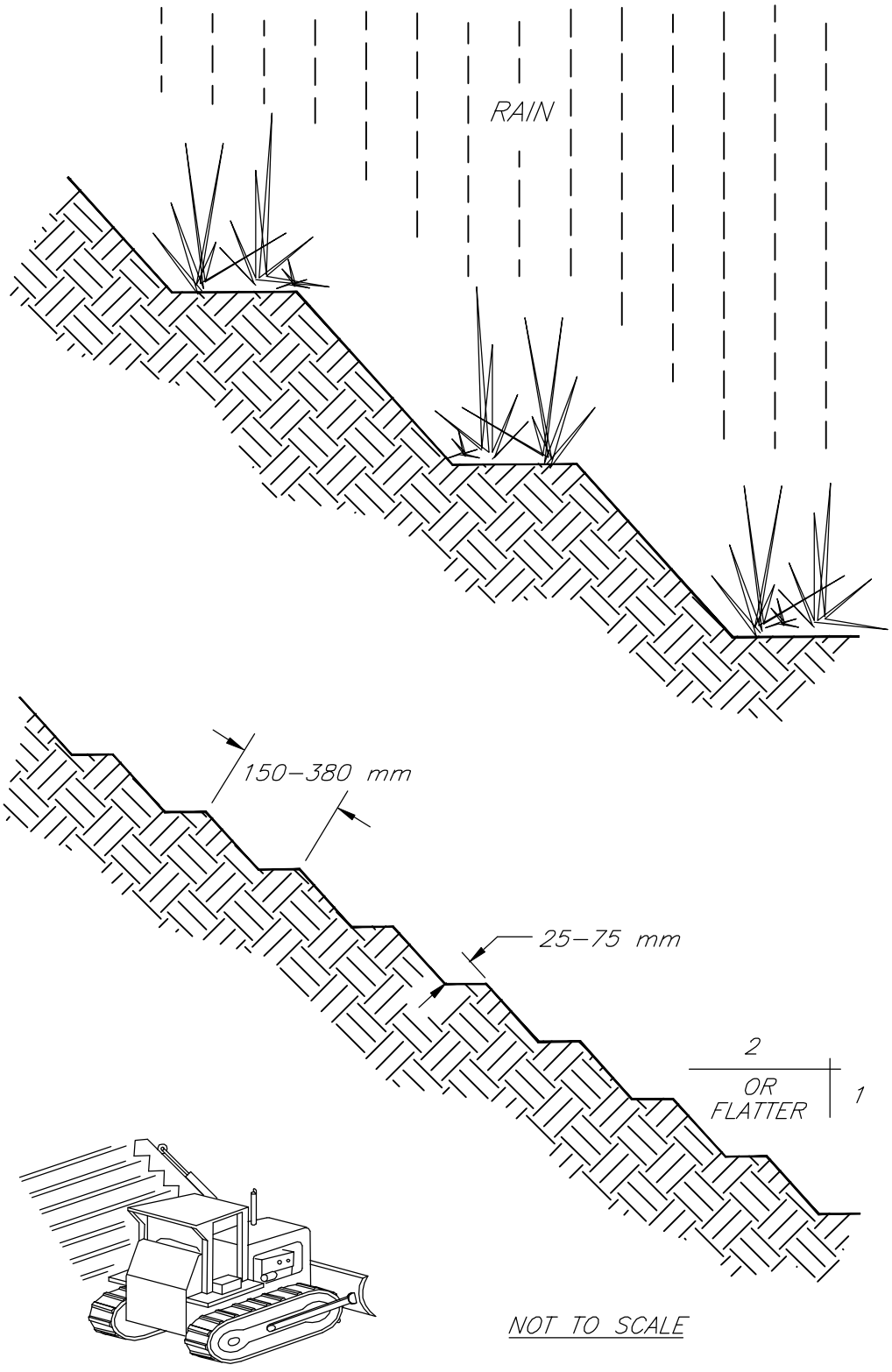
CONTOUR FURROWS

SURFACE ROUGHENING

FILE: SRFROUGH

Government of Alberta ■
Transportation

B.M.P. #34a
Typical Section



NOT TO SCALE

NOTE:

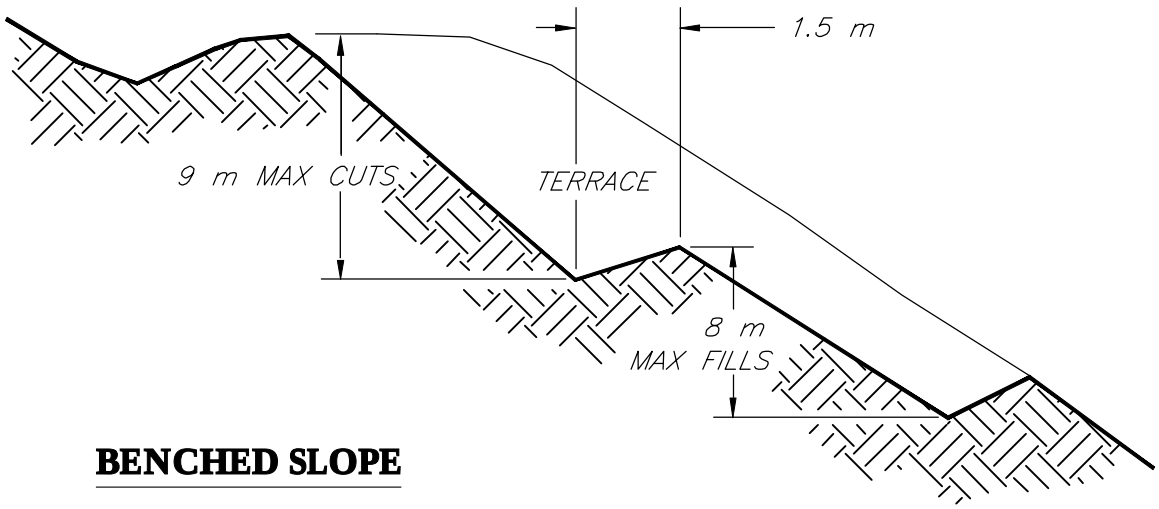
GROOVE BY CUTTING SERRATIONS ALONG THE CONTOUR. IRREGULARITIES IN THE SOIL SURFACE CATCH RAINWATER, SEED, MULCH AND FERTILIZER.

GROOVED OR SERRATED SLOPE

FILE: SERSLOPE

Government of Alberta ■
Transportation

B.M.P. #34b
Typical Section



BENCHED SLOPE

NOT TO SCALE

BENCHED SLOPE

FILE: STPSLOPE

Government of Alberta ■
Transportation

B.M.P. #34c
Typical Section

Rolls
a) Coir Roll
b) Fibre Roll
Streambank Stabilization Techniques and Erosion Control

B.M.P. #38

Description and Purpose

- Coir Rolls are long cylindrical tubes that are composed of interwoven coconut fibres which are bound together with durable coir netting. Coir rolls are particularly applicable for wetland, streambank, and shoreline projects. Coir rolls are most commonly available in 300mm diameters and 6m lengths. These rolls can be linked together to form longer tubes, and are often used in combination with other biotechnical techniques, such as brush layering or live siltation. Coir logs encourage siltation and wetland/floodplain creation
- Fibre rolls are installed across slope contours as a grade break to reduce erosion potential by reducing overland flow velocities
- Straw roll consists of bundled straw (or natural fibre) wrapped in photo-degradable open-weave plastic netting staked into the soil along slope contours as a grade break to reduce erosion potential
- Normally live staking can be installed to anchor the Fibre Rolls to provide deep root vegetation with potential favourable moisture retention provided by fibre roll
- Fibre Rolls also capture sediment, organic matter, and seeds carried by runoff

Applications

- The tough, long-lasting coconut fibres make coir rolls appropriate for wetland, streambank, and shoreline applications. Coir rolls work well when immediate erosion control is needed. Brushlayers work well with coir roll applications, adding further stabilization with a live root system, while also providing excellent habitat features. The coir roll provides a base for the brushlayer cuttings to be laid upon at an appropriate angle which benefits the growth of cuttings. The cuttings provide further protection from breaking waves and high flows
- Fibre Rolls may be used on slopes stable enough to support vegetation (steep, confined, slopes and channel banks with gradients greater than 1H:1V may have low success potential)
- Fibre Rolls may be used along long slopes as a grade break to shorten slope length between line of fibre rolls at different contour elevations
- Fibre Rolls may be used as grade breaks, where slopes transition from flatter to steep gradients

Advantages

- The coir material is natural and long lasting (5 to 7 years), and has high tensile strength

- The fibre rolls and mats accumulate sediment while the plants grow and the plant roots develop. Eventually the coir material biodegrades and the cohesive strength of the root systems and flexible nature of the plants become the primary stabilizing element
- The coir roll/brushlayering combination provides immediate shoreline and streambank protection, with additional benefits of riparian enhancement when the cuttings become established
- Coir Rolls address ecological concerns by encouraging vegetation and wildlife habitat, and are an alternative to stone revetments or other structural measures
- The high tensile strength coconut fibres, fibre netting and the wooden stakes used to anchor the material make up the initial structural components of the system, while plant root and top growth increase the strength and baffle effects of the structure
- Fibre Rolls can be used on slopes too steep for silt fences or straw bales sediment barriers
- In time, plastic netting will degrade due to the sunlight and straw will degrade and be incorporated into the soil
- Fibre Rolls primary purpose is erosion control, however fibre rolls do provide some sediment control

Limitations

- This technique should be implemented during the dormancy period of the cuttings used for brushlayering and staking
- Coir Rolls are relatively expensive
- Fibre Rolls are designed for low sheet flow velocities
- Fibre Rolls are designed for short slopes with a maximum gradient of 1H:1V
- Fibre Rolls may be labour intensive to install
- Straw rolls have short life span due to natural degradation
  - Usually only functional for two seasons
- Susceptible to undermining and failure if not properly keyed into the soil
- Labour intensive maintenance may be required to ensure rolls are in continuous contact with the soil, especially when used on steep slopes or sandy soils

Construction

- Determine annual water elevation
- Mark the annual water level on a stake driven into the substrate, 0.3 or 0.6 m offshore. Installing the materials and plants at the correct elevation is the most important aspect to assure success of the installation. Determine, on site, where the installation will begin and end
- Determine soil level by laying a straight cutting on the coir roll with approximately 20% of the cutting sticking out past the roll, and with the basal ends dipping down into the soil
- Begin installation at the downstream end (if using in a streambank project)
- Prepare the site for installation of coir roll and coir mats by removing any large rocks, obstructions or material that may prevent the coir from making direct and firm contact with the soil. Coir rolls must be level, installed along a horizontal contour. Place coir rolls parallel to the stream bank or shoreline. It is very important to key the ends of the coir rolls firmly into the shoreline or stream bank, so waves and flows will not scour behind the rolls and compromise the integrity of the structure
- Install the coir roll such that 50 mm of the roll extends above the annual water elevation
- Adjacent rolls shall be laced together, end-to-end, tightly and securely
- If using brushlayer cuttings prepare soil bed behind installed coir rolls for laying. It is important that the bud ends of the live cuttings angle up to some degree from the basal ends. Lay cuttings in this fashion, slightly crisscrossed for additional strength
- Next, backfill over cuttings with soil, covering the lower 80% of the branches. At this time, soil can be levelled and prepared for a soil wrap for additional height and soil stability
- If simply covering the cuttings with soil, compact slightly and grade slope to appropriate angle. Use water to wash soil in between branch layers
- If using plant materials, such as container-grown, pre-rooted plant plugs or willow stakes, they should be planted into the coir rolls and through the coir mats and netting
- To install plant plugs and willow stakes into the coir roll, use a planting iron or pilot bar into the roll and wedge it back and forth to create a hole for the plant. It is extremely important that the root system of the plant be placed below the water

level for certain species. All plants shall be checked to ensure that they have been firmly installed in the fibre material

- Mulch and seed exposed areas with native species
- Prepare slope face and remove large rocks or other deleterious materials
- Excavate small trenches a minimum of 0.15 m deep and 0.15 m wide across the width of the slope, perpendicular to slope direction, starting at the toe of the slope and working upwards towards crest of slope
- Space trenches a maximum of 3 to 8 m apart along the slope incline, with steeper slopes having trenches spaced closer together
- Place fibre rolls into trench ensuring continuous contact between fibre roll and soil surface
- Butt-joint adjacent fibre roll segments tightly against one another
- Use a metal bar to make pilot hole through middle of the fibre roll a minimum depth of 0.3 m into underlying soil
- Pilot holes should be spaced a maximum of 1 m apart
- Secure fibre roll to soil using wooden stake or other appropriate anchor; live stake may be used as alternate anchor
- Place soil excavated from trench on upslope side of fibre roll and compact to minimize undermining of fibre roll by runoff
- Seed the soil along the upslope and downslope sides of the fibre roll to promote vegetation growth

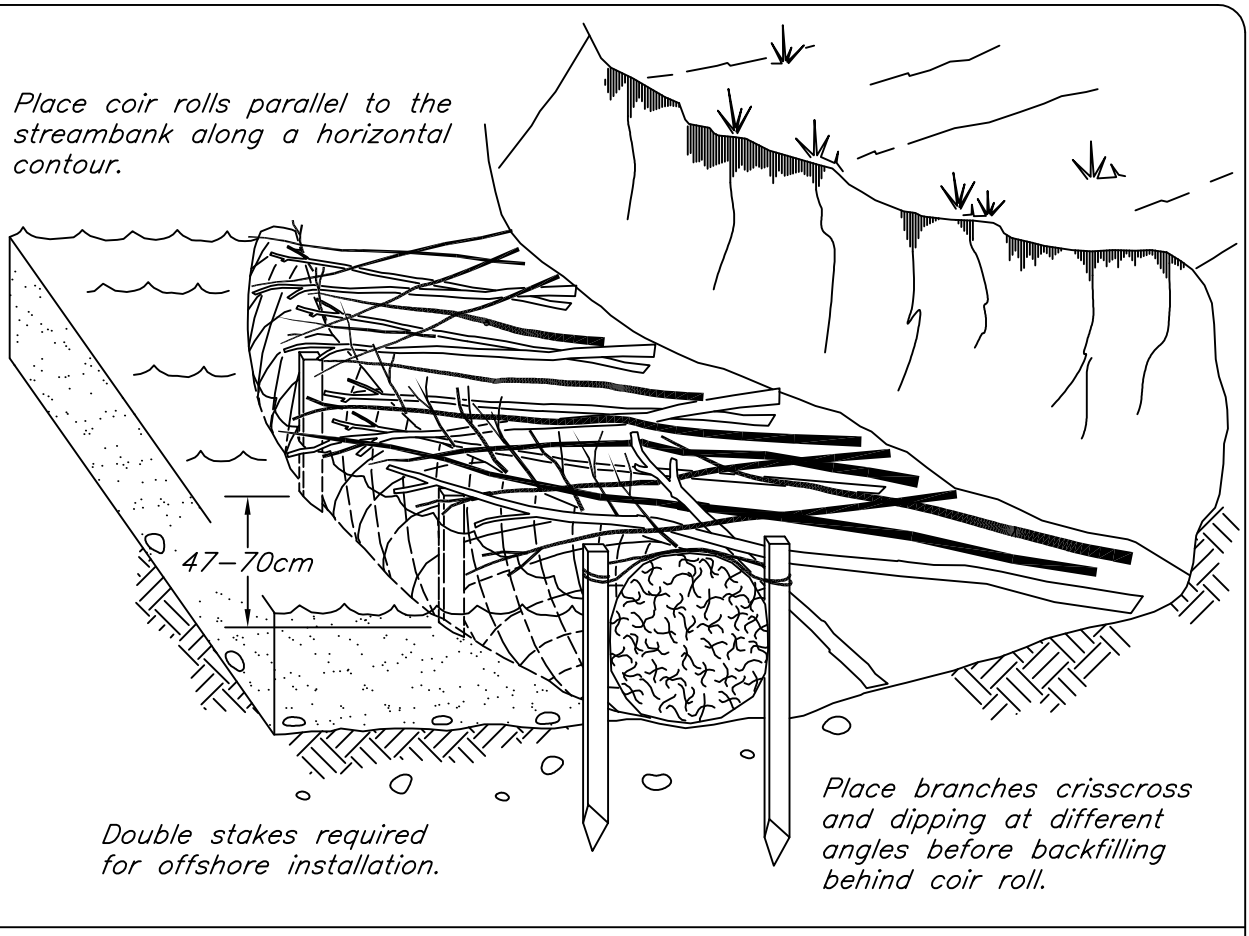
Construction Considerations

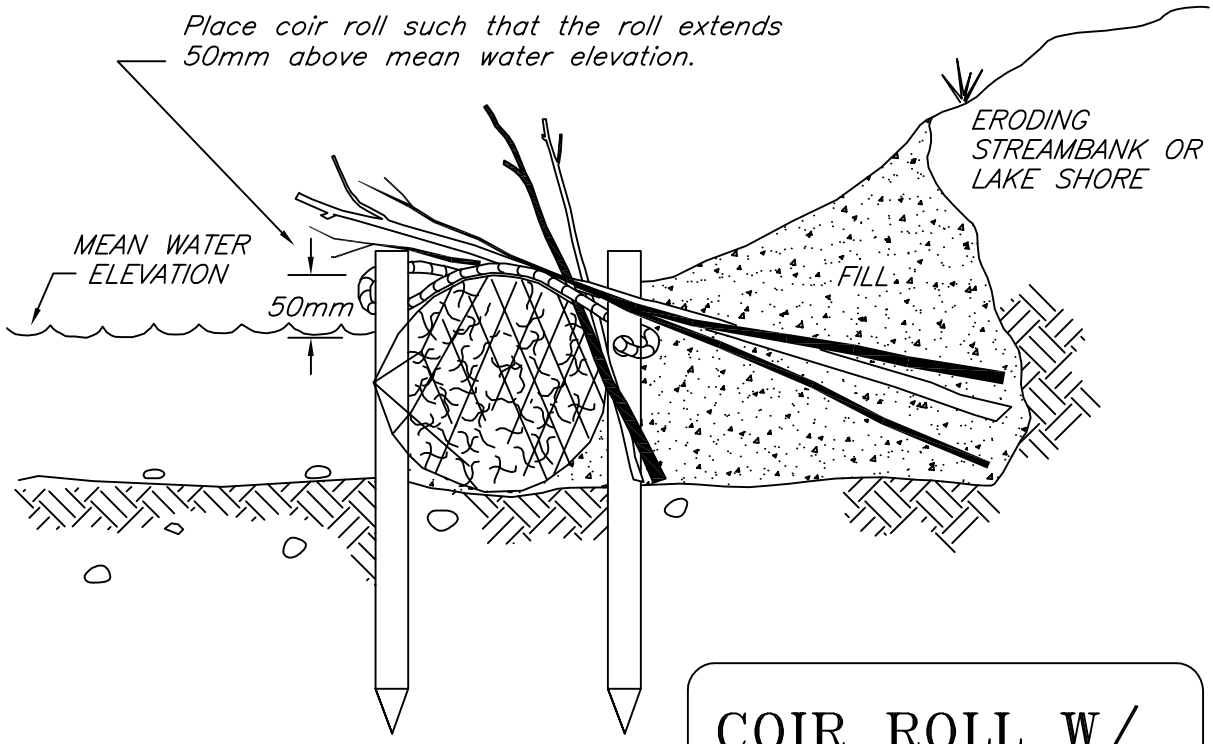
- All work site disturbance should be minimized. Protect any existing plant, when possible, and avoid additional disturbance that can lead to erosion and sedimentation
- Install additional erosion and sediment control measures such as temporary diversion dikes, silt fences and continuous berms, as needed, before beginning work
- Coir rolls can be used in the stream as a sediment barrier, silt curtain, and/or coffer dam to control sediment while work is being done in the water
- Topsoil should be saved, if possible, and replaced once the subsoil has been removed or regraded. Soil shall be stored away from the water's edge and it shall be moved to its final location and stabilized as quickly as possible

- For typical applications at the water's edge, coir rolls are held in place with a single row of stakes, 300 mm on center. Stakes may be driven through the netting on the outer edge of the roll. It is very difficult to drive stakes through the high-density rolls, however, a stake can be driven with the help of a pilot hole through the low density coir rolls
- Lacing among the stakes is recommended for coir mats exposed to extreme conditions such as ice, waves, or flooding
- Coir rolls shall be placed along streambanks or shorelines at a height sufficient to protect the bank from flows or waves. Additional coir rolls may be placed above the lower rolls, in a tile-like fashion, to protect the upper shore or stream bank
- Use live stakes in place of wooden stakes
- If the slope soil is loose and uncompacted, excavate trench to a minimum depth of 2/3 of the diameter of the fibre roll
- For steep slopes, additional anchors placed on the downslope side of the fibre roll may be required

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Check plants to ensure that they have been firmly installed in the fibre material
- Water plants, if necessary, during the establishment phase
- Check all materials periodically or after storms to ensure they remain properly secured. Make necessary repairs promptly
- All temporary and permanent erosion control practices shall be maintained and repaired as needed to ensure continued performance of their intended use
- Areas damaged by washout or rutting should be repaired immediately
- Additional stormwater control measures should be considered for rilling areas damaged by runoff



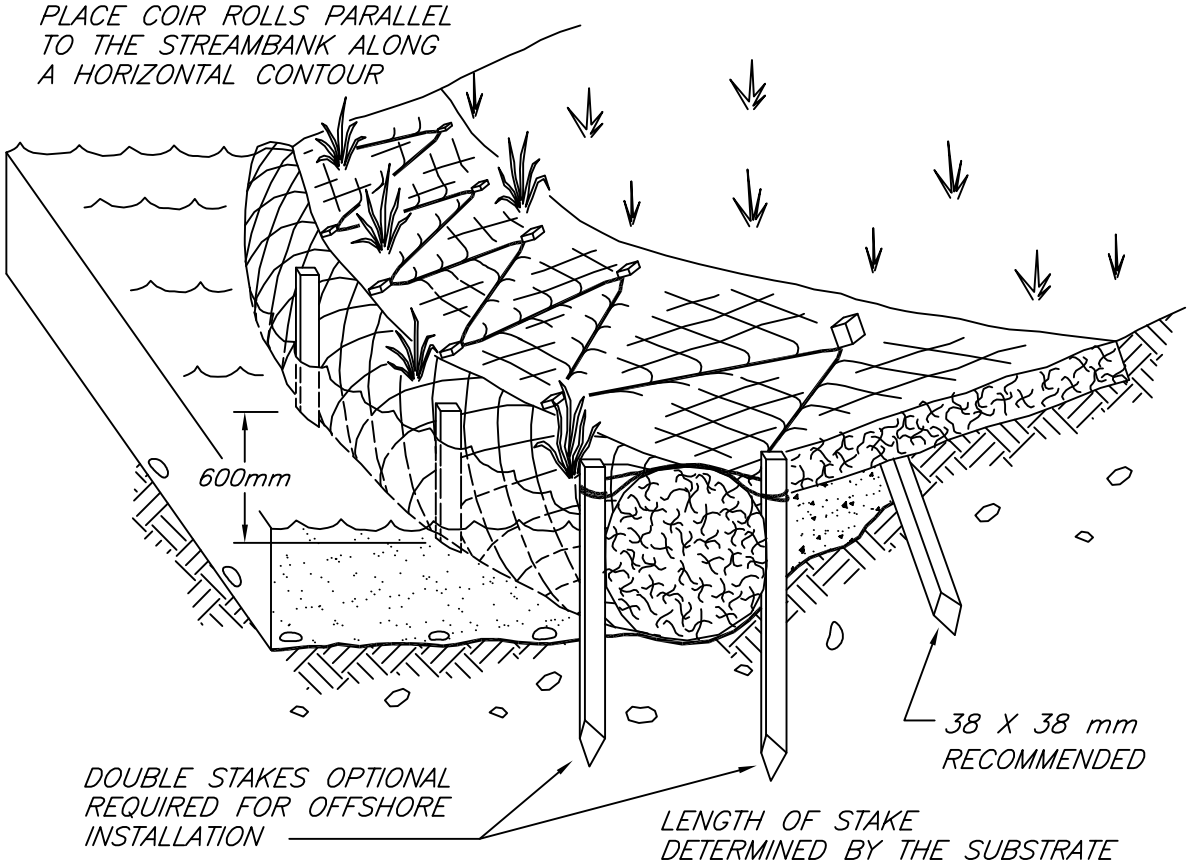


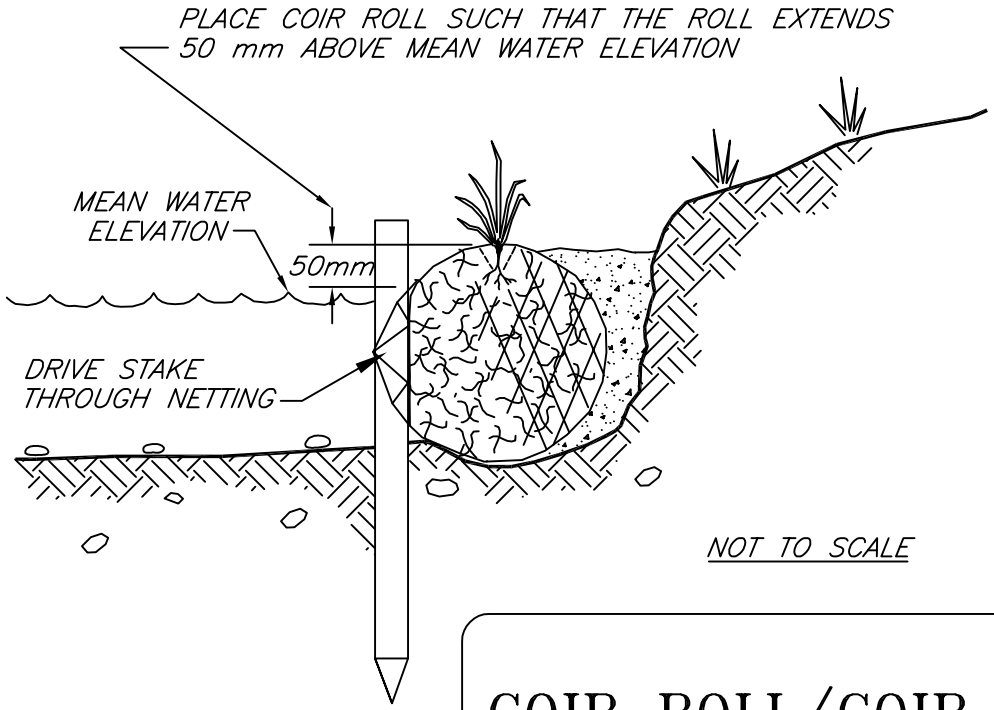
COIR ROLL W/ BRUSHLAYERING

FILE: COIRBRLY

Government of Alberta ■ Transportation

B.M.P. #38a
Typical Section





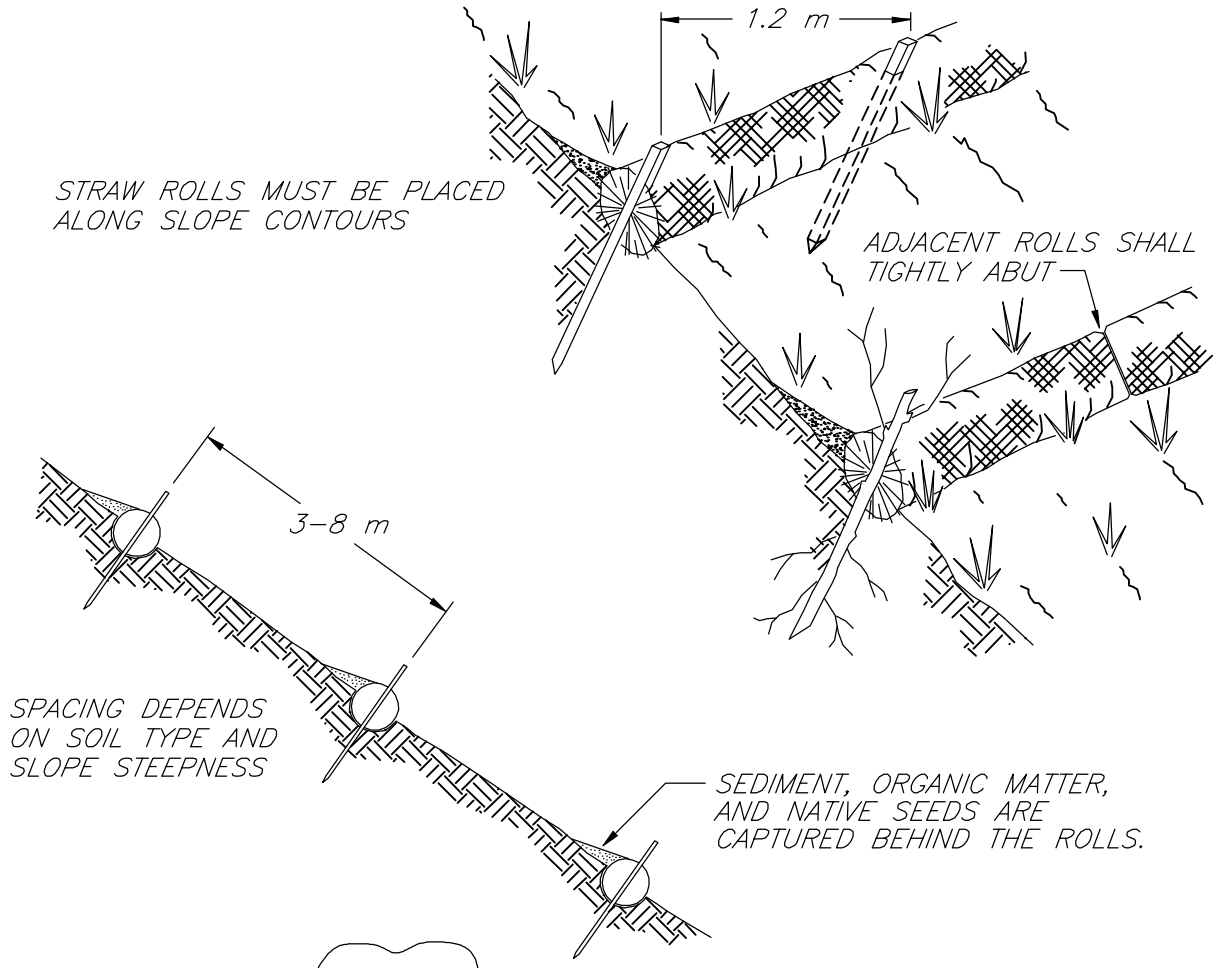
NOT TO SCALE

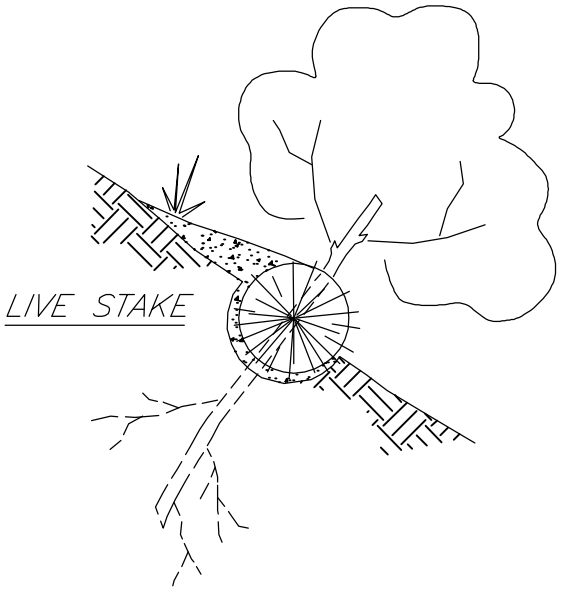
COIR ROLL/COIR MATS

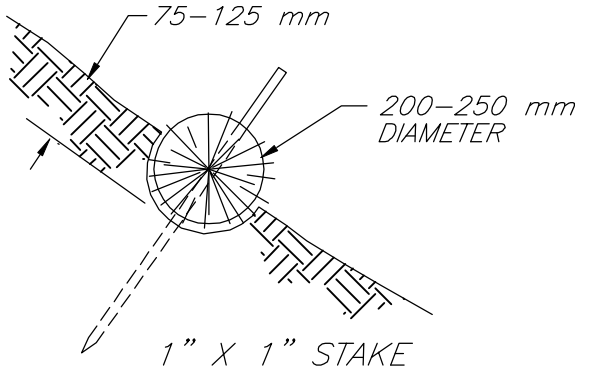
FILE: COIRRM

Government of Alberta ■ Transportation

B.M.P. #38b
Typical Section







NOT TO SCALE

NOTE:

1. STRAW ROLL INSTALLATION REQUIRES THE PLACEMENT AND SECURE STAKING OF THE ROLL IN A TRENCH, 75–125 mm DEEP, DUG ON CONTOUR. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND ROLL.
2. THIS FIGURE IS PROVIDED FOR GUIDANCE ONLY AND DOES NOT CONSTITUTE A DESIGN. A SITE SPECIFIC DESIGN IS REQUIRED FROM DESIGNER/ENGINEER.

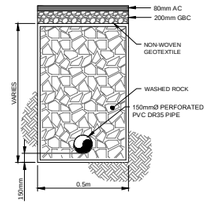
STRAW ROLLS

FILE: STRWROLL

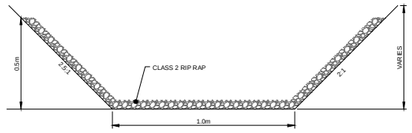
Government of Alberta ■
Transportation

B.M.P. #38c
Typical Section

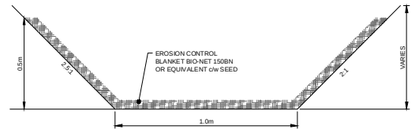
Appendix C – Applicable Design Drawings



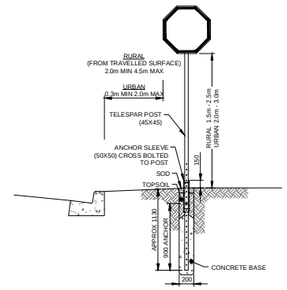
1 DETAIL
SUB-DRAIN TRENCH



2 DETAIL
TYPICAL PARKING LOT EAST DITCH

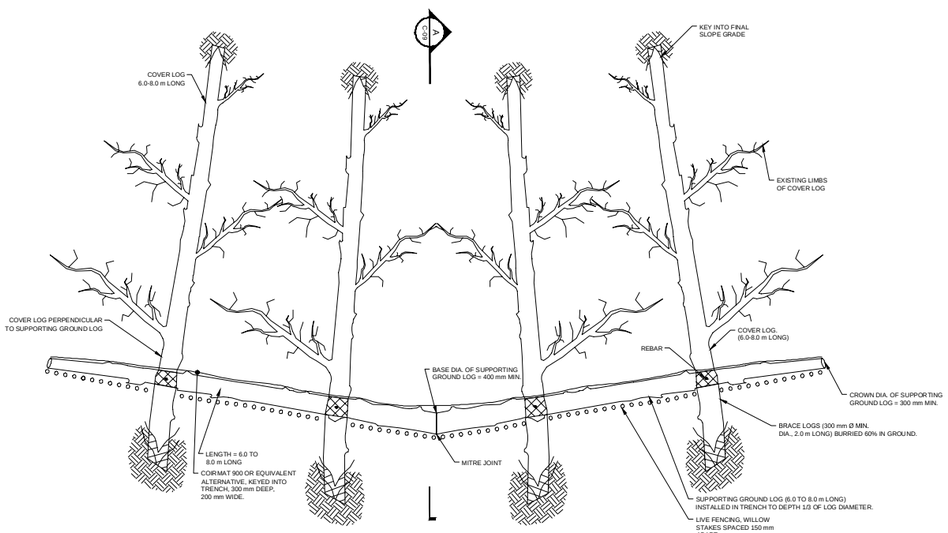


3 DETAIL
TYPICAL PARKING LOT WEST DITCH



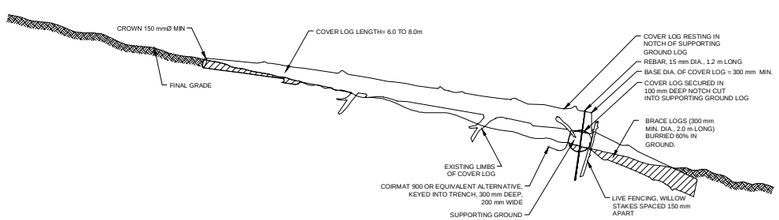
NOTES:
1. REFER TO THE "MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES FOR CANADA" (MUTCDC), LATEST EDITION, FOR FURTHER DETAILS.
2. ALL DIMENSIONS SHOWN IN MILLIMETRES UNLESS NOTED OTHERWISE.

4 DETAIL
TYPICAL SIGN INSTALLATION



NOTES:
1. COVER LOG TO REST IN NOTCH OF SUPPORTING GROUND LOG.
2. FILTER FABRIC TO BE BIODEGRADABLE, KEYED IN ON UP SLOPE FACE OF SUPPORTING GROUND LOG.
3. INSTALL THE LOG POND SEDIMENT CONTROL STRUCTURE DIRECTLY ONTO SUBSOIL AT FINAL GRADE.
4. WILLOW STAKES MIN LENGTH = 500 mm, MIN DIA. = 40 mm.
5.COVER LOG TO BE SECURED TO SUPPORTING GROUND LOG USING 1.2 M LONG REBAR (15 mm DIA.) AT EACH JOIN, DRIVEN THROUGH PILOT HOLE.
6. TOPSOIL THROUGHOUT THE LOG POND SEDIMENT CONTROL STRUCTURE TO BE 100 mm THICK.

PLAN
LOG POND SEDIMENT CONTROL STRUCTURE



A C-09 SECTION

See engineering drawing set for full size plan sheet.

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
A	2018AUG23	ISSUED FOR 90% REVIEW	K.C	J.G
A	2018JUN21	ISSUED FOR 60% REVIEW	M.T.	A.P

Revision / Revision

A detail number
numéro de detail
B source drawing no.
de dessin no.
C detail on drawing no.
detail sur dessin no.

Consultant's Name / Nom de l'expert-conseil
Associated Engineering

Eng. Stamp
Sceau de l'Ingénieur

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

Client Services Team Southern Alberta Operations Branch
Le Client Entretient l'Équipe Alberta Méridional Branche d'Opérations

Canada

Client/client
Parks Canada Agency / L'Agence Parcs Canada
Western and Northern Region / Ouest et Nord du Canada

Project title/Titre du projet
MT. EDITH CAVELL REHABILITATION CONTRACT 1
JASPER NATIONAL PARK OF CANADA

Drawing title/Titre du dessin
CIVIL DETAILS

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
	M. TREMBLAY	2015Aug11
Designed by/Concept par	Reviewed by/Revisé par	Scale/Échelle
A. PODOLSKI		N.T.S.

PWGSC Project Manager/Administrateur de Projets TPSGC
C. MAKI

Client Acceptance/Acceptation du client
Port Responsible Office/Agent Responsable

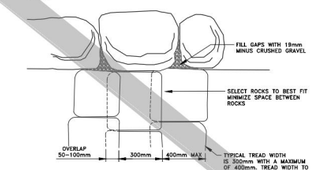
Approved by/Approuvé par
PWGSC Project Manager/Administrateur de Projets TPSGC

Project No./No. du projet	Asset No./No. du bien	Sheet No./ No. de la feuille
718		10 11

Drawing Reference No./No. de référence du dessin
C-09

NOTE:
- WHERE STAIRS GO DIRECTLY UP A SLOPE, CROWN OR SLOPE TO ONE SIDE TO DRAIN AWAY FROM CENTER OF STAIRS.

PLAN



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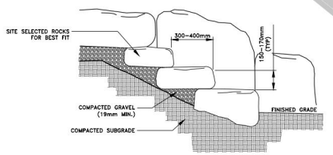
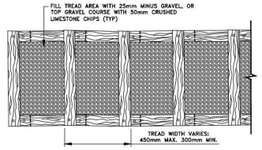


1 DETAIL NTS
STONE STAIRS

NOTE:
- TREATMENT TO BE APPLIED TO AREAS WITH GENTLE SLOPES
- TREAD TO BE SLOPED DOWNHILL AT 2%
- RISE AND RUN TO BE CONSISTENT FOR ENTIRE STAIRWAY
- REGULAR MAINTENANCE REQUIRED

PLAN



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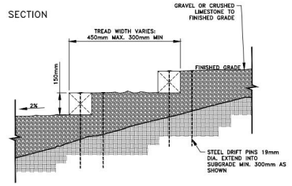
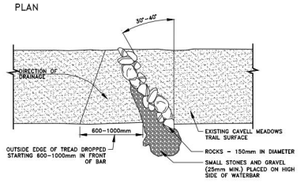


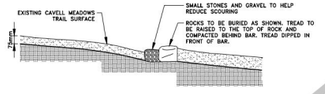
2 DETAIL NTS
TIMBER STEPS WITH GRAVEL FILL

NOTE:
- TO BE USED IN AREAS OF HEAVY RAINFALL OR AREAS WITH STEEP GRADES
- MOST EFFECTIVE IN AREAS WHICH HAVE WATER RUNNING DOWN THE SURFACE OF THE TRAIL WITH THE GRADE BEING 5% OR LESS

PLAN

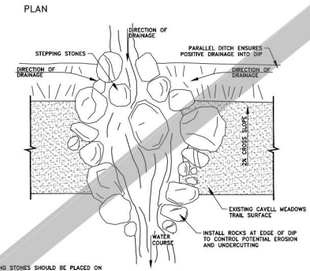


SECTION



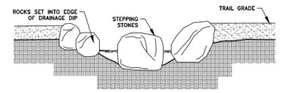
3 DETAIL NTS
ROCK WATERBAR

PLAN



NOTE:
- STEPPING STONES SHOULD BE PLACED ON UPHILL SIDE OF TRAIL
- SIZE OF STEPPING STONES WILL VARY BASED ON LOCAL AVAILABILITY
- LARGER STONES WITH A RELATIVELY FLAT SURFACE ARE MOST DESIRABLE
- STEPPING STONES SHOULD BE AS STABLE AS POSSIBLE AND SHOULD NOT PROTRUDE HIGH ABOVE THE TREAD SURFACE.

SECTION



4 DETAIL NTS
STEPPING STONES

NOTE:
- REMOVE ALL LARGE ROCKS AND LOGS FROM THE TOP OF THE SLOPE WHICH COULD POTENTIALLY ROLL ONTO THE TREAD SURFACE

SECTION

5 DETAIL NTS
GRAVEL TRAIL CONSTRUCTION ON MODERATE SLOPE

NOTE:
- TRAILS ARE TO BE CONSTRUCTED ON RELATIVELY STABLE RUBBLE AND TALUS SLOPES ONLY.

SECTIONS

6 DETAIL NTS
GRAVEL TRAIL CONSTRUCTION ON RUBBLE/TALUS SLOPES

PLAN

SECTION

NOTE:
- ALL VOID SPACES TO BE FILLED WITH CRUSH AND CONSOLIDATED TO PREVENT MIGRATION OF MATERIALS
- ALL BOULDERS TO BE STRUCTURALLY SOUND, FREE OF ANY SPOILING,CRACKS, CREVICES OR SPLINTERS
- ALL BOULDERS TO BE BURIED 1 DEPTH INTO GRADE, PLACE TO FACILITATE SLOPE STABILITY
- ENSURE ALL VOID SPACES ARE FILLED WITH CLEAN GRANULAR MATERIAL

7 DETAIL NTS
REST NODE CONSTRUCTION W/ BOULDER RETAINING WALL

No.	Date/Date	Description/Description	Drawn by Dessiné par	Approved Approuvé
A	2015APR28	ISSUED FOR REPORT	D.S.	D.S.

Revision / Revision

A detail number
numéro de detail
B source drawing no.
de dessin no.
C detail on drawing no.
detail sur dessin no.

Consultant's Name / nom de l'expert-conseil
Associated Engineering

Eng. Stamp / Sceau de l'ingénieur

Public Works and Government Services Canada
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Client Services Team Southern Alberta Operations Branch
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Canada

client/client
Parks Canada Agency / L'Agence Parcs Canada
Western and Northern Region / Ouest et Nord du Canada

Project title/Titre du projet
PARKS CANADA
MT. EDITH CAVELL
REHABILITATION
JASPER NATIONAL PARK

Drawing title/Titre du dessin
LANDSCAPE
DETAILS

Surveyed by/Arpenté par	Drawn by/Dessiné par	Date/Date
	D.SCHREINER	2015Aug11
Designed by/Concept par	Reviewed by/Revisé par	Scale/Échelle
D.SCHREINER	J.BENNETT	AS SHOWN

PWGSC Project Manager/Administrateur de Projets TPSGC
C. MARI

Client Acceptance/Acceptation du client
Approved by/Approuvé par
Park Responsible Officer/Agent Responsable
PWGSC Project Manager/Administrateur de Projets TPSGC

Project No./No. du projet	Asset No./No. du-bien	Sheet No./ No. de la feuille
		8 / 11

Drawing Reference No./No. de référence du dessin
L-04

A1 1150 x 841

Appendix D – Seed Mix

Associated Environmental

Date:	January 12, 2016	**File:**	2015-3V08
To:	Landon Shepherd, Jasper National Park		
From:	Joël Gervais, B.Sc., CISEC		
Project:	Edith Cavell Rehabilitation		
Subject:	Seed Mix Options		

MEMO

Edith Cavell – Acceptable native species for seed mix

Establishing plants from seed may be difficult due to the high elevation and soil conditions at Edith Cavell. This seed mix list is intended to supplement the reclamation suggestions provided in the mitigation section of the Basic Impact Analysis. Additional measures such as greenhouse establishment of plant material prior to planting, or watering of seeded areas may be necessary. The seed mix should contain *Elymus trachycaulus* (number 1) and a minimum of 3 additional species from the following list (number 2 to 7);

1. The manufacturer's recommended seed ratio should be reviewed and approved by the PCA Vegetation Specialist;
2. Drill seeding not to exceed 15 kg/ha, broadcast seeding not to exceed 30 kg/ha;
3. Seeded areas should be fenced to protect from foot traffic;
4. Stockpile and re-use existing topsoil as it contains an existing seedbank; and
5. It is highly recommended that forbs be included in the seed mix (number 8 to 13).

Recommended: mandatory grasses:

1

Name: ***Elymus trachycaulus / Agropyron trachycaulum***
Status: Native, Secure
Habitat: high elevations
Forage: upland game birds and small mammals

Name(s), common:
Slender wheatgrass
Slender wild rye

Recommended: any three of the following grasses:

2

Name: ***Calamagrostis purpurascens***
Status: Native, Secure
Habitat: Dry mountainous zones
Forage: big horn sheep

Name(s), common:
Purple reedgrass
Purple pinegrass
Alpine reedgrass

3

Name: ***Danthonia parryi***
Status: Native, Secure
Habitat: high elevations
Forage:

Name(s), common:
Parry's oatgrass
Parry's danthonia

4

Name: ***Festuca campestris***
Status: Native, Secure
Habitat: dry to moist grasslands and open forests
Forage: ungulates

Name(s), common:
Foothills rough fescue
Mountain rough fescue
Buffalo bunchgrass

5	**Name:** ***Koeleria macrantha*** **Status:** Native, Secure **Habitat:** **Forage:** ungulates, deer	**Name(s), common:** Prairie Junegrass Crested hair grass
6	**Name:** ***Poa alpine*** **Status:** Native, Secure **Habitat:** dry, cold, boreal and mountainous areas **Forage:** ungulates, deer	**Name(s), common:** Alpine bluegrass Alpine meadowgrass
7	**Name:** ***Stipa richardsonii / Achnatherum richardsonii*** **Status:** Native **Habitat:** grasslands and pine forests **Forage:** elk, big horn sheep	**Name(s), common:** Richardson's needlegrass Spreading needlegrass Canada mountain-ricegrass

Recommended: include three or more of the following forbs in the seed mix

	Scientific Name	**Common name**
8	***Aquilegia*** **species**	Columbine
9	***Aster ciliolatus***	Lindley's aster
10	***Lupinus sericeus***	Silky lupine
11	***Fragaria virginiana***	Strawberry
12	***Achillea millefolium***	Yarrow
13	***Lathyrus ochroleucus***	Yellow peavine

Compiled by:

Submitted digitally

Joël Gervais, B.Sc., CISEC
Associated Environmental Consultants Inc.

Submitted digitally

Melanie Piorecky, B.Sc., P.Ag.
Associated Environmental Consultants Inc.

Sources:

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Appendix E – Sediment Control Spacing Formula

Associated Engineering | GLOBAL PERSPECTIVE. LOCAL FOCUS.

USING THE SEDIMENT CONTROL SPACING FORMULA

$$Spacing\ (m) = \frac{height\ of\ fibre\ roll\ above\ grade\ (m)}{grade\ (\%)}$$

Example:

An ESC practitioner has selected to install fiber rolls along the contours of an 10% slope (10:1, H:V). Once installed, the fiber rolls have a height above grade of 0.2 m. To determine the appropriate spacing of the fiber rolls, the ESC practitioner applies the known information to the spacing formula as follows:

1. **Known variables:**
   Height of fiber roll above grade (installed): 0.2 m
   Grade of slope (10%) expressed in decimal form: 0.10
   Spacing: ?

2. **Application of the spacing formula:**

$$Spacing\ (m) = \frac{height\ of\ fibre\ roll\ above\ grade\ (m)}{grade\ (\%)}$$

$$Spacing\ (m) = \frac{0.2\ m}{0.10}$$

$$Spacing\ (m) = 2.0\ m$$

3. **Solution:**
   The ESC practitioner will space the fiber rolls 2.0 m apart, measuring horizontally from the last installed fiber roll.

Appendix F – Technical Note on Soil Rough Mounding

BOREAL RESEARCH INSTITUTE

BOREAL RECLAMATION PROGRAM



Technical Note, June 2013

Making Sites Rough and Loose: A Soil Adjustment Technique

DAVID POLSTER

Rough and loose surface treatments (Polster 2009) provide an effective way to control erosion and create conditions that promote the revegetation of the site. By creating topographic heterogeneity (Larkin et al. 2008) the rough and loose surface configurations provides increased diversity of habitats therefore improves ecological resilience (Holling 1973). This brief document shows how sites can be made rough and loose to gain these ecosystem benefits and initiate natural successional processes (Polster 1989).

Rough and loose surface configurations (Photographs 1 and 2) can be achieved by using an excavator to open holes on the slope, dumping the material that is generated from the holes in mounds between the holes. The excavator, using a digging bucket (not clean-up), takes a large bucket full of soil and places it to the left of the hole that was just opened, half a bucket width from the hole so it is half in and half out of the hole. A second hole is then excavated half a bucket width to the right of the first hole. Material from this hole is then placed between the first and second holes. A third hole is now opened half a bucket width to the right of the second hole, with the excavated soil placed between the second and third holes. Care should be taken when excavating the holes to shatter the material between the holes as the hole is dug. The process of making holes and dumping soil is continued until the reasonable operating swing of the excavator is reached. The excavator then backs up the width of a hole and repeats this process, being sure to line up the holes in the new row with the space between the holes (mounds) on the previous row.

Photograph 1 (left) and 2 (right). Rough and loose surface configurations can be made using an excavator on slopes up to 2:1 or 26°. Large areas can be treated for a cost of about $700/ha.

Rough and loose surface treatments can be used in confined areas as well as in large open areas (Photograph 3). These treatments are ideal for recovering hydrologic integrity on resource access roads and where unauthorized access by motor vehicles ("quads" and "dirt bikes") is causing ecological degradation. The rough and loose treatments can be used on coarse textured substrates and can be applied in areas where potentially droughty conditions dictates that planting be conducted on north facing slopes (Photograph 4).

Photograph 3 (left) and 4 (right). Forest access roads and other small areas can be treated using the rough and loose technique (left) as well as areas with coarse substrates (right) such as this old dam site with alluvial boulders, cobbles and gravels.

The rough and loose treatment provides ideal conditions for live staking (Polster 2006) as the soils are loose so the stakes can be planted deeply and roots can grow unencumbered by compaction (Photographs 5 and 6). Live staking can be used to establish pioneering species such as Balsam Poplar and Willow. Two meter long cuttings inserted one meter into the substrate allows substantial root systems to develop and fosters successful establishment of these species.

Photograph 5 (left) and 6 (right). Live staking in the rough and loose soils of this tailings pond is easy and allows the cuttings to grow rapidly (right, start of 2nd year growth for cuttings)

The rough and loose surface treatments provide ideal microsites for seeds to lodge in and for seedlings to grow (Photograph 7, 8 and 9). Where local conditions provide ample seed, a diversity of native species will naturally establish. In general, these species will be appropriate for the sites where they establish so that moisture loving species will establish in the bottoms of the holes while species that favour dry sites will be found on the tops of the mounds. This species diversity enhances ecosystem resilience.

Photograph 7 (left), 8 (centre) and 9 (right). A variety of local forest species have established within a year of treatment on a rough and loose forest road on Salt Spring Island.

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Appendix G – Erosion and Sediment Control Inspection Checklist

Erosion and Sediment Control Checklist

Date:	**Location(s) of inspection:**
Inspection start time:	**Name of Inspector:**
Inspection end time:	**Affiliation:**
Inspection Type (i.e. weekly or post-rainfall):	**Notes:**

This checklist must be signed by an environmental monitor and the site foreman. Fill in applicable sections of ESC controls.

	ESC Measures	State	Action Taken by Contractor	Notes/ Comments
	A. Erosion Controls			
1	**Seeding of bare ground**	**Y / N**		
a	All applicable areas have been seeded.	Y / N		
b	Soil stockpiles requiring seeding are seeded.	Y / N		
c	NO Maintenance required.	Y / N		
2	**Rolled Erosion Control Products**	**Y / N**		
a	All stripped areas requiring cover have been covered.	Y / N		
b	Blankets are oriented in the correct up/down hill direction.	Y / N		
c	Blankets are staked into the ground as per the manufacturer's instructions.	Y / N		
d	Soil stockpiles requiring covering are covered (as well as proper placement).	Y / N		
e	RECPs are in good condition (i.e. no rips or fraying).	Y / N		
f	RECPs are properly keyed in.	Y / N		
g	NO Maintenance required.	Y / N		
3	**Rip rap on site**	**Y / N**		
a	Rip rap is properly installed (ie clean condition prior to installation and proper placement).	Y / N		
b	Excessive sediment accumulation has been removed.	Y / N		
c	NO Maintenance required.	Y / N		
	B. Sediment Controls			
4	**Storm drain inlet barriers (ie socks, straw bales or sand bags) on site**	**Y / N**		
a	Inlet barriers are properly installed at all storm drain inlets (ie proper placement).	Y / N		
b	Socks are properly functioning (ie. Impeding direct flow).	Y / N		
c	Excessive sediment accumulation has been removed.	Y / N		
d	NO Maintenance required.	Y / N		
5	**Silt fencing on site**	**Y / N**		
a	Fences are properly installed (ie proper position).	Y / N		
b	Fences are buried 200mm below the ground and keyed in using a J-hook.	Y / N		
c	Posts are installed at maximum 2 m spacing.	Y / N		
d	Posts face downslope.	Y / N		

e	Joins in silt fence are rolled.	Y / N		
f	Fencing is in good condition (ie not torn or freyed).	Y / N		
g	Excessive sediment accumulation has been removed.	Y / N		
h	NO Maintenance required.	Y / N		
6	**Check dams or synthetic permeable ditch barriers on site**	**Y / N**		
a	Check dams are the correct height and spacing (no gullies around).	Y / N		
b	Ditch barriers are staked into the ground.	Y / N		
c	Water passes over the dams, or through the ditch barriers and not around them.	Y / N		
d	Check dams or ditch barriers are appropriately spaced.	Y / N		
e	Excessive sediment accumulation has been removed.	Y / N		
f	NO Maintenance required.	Y / N		
7	**Sediment traps/catchment basins on site**	**Y / N**		
a	Sediment traps are properly installed.	Y / N		
b	Excessive sediment accumulation has been removed.	Y / N		
c	Sediment trap does not cause a safety, traffic or local flood hazard.	Y / N		
d	NO Maintenance required.	Y / N		
8	**Slope texturing/track packing, contour furrowing, straw crimping on steep slopes**	**Y / N**		
a	Properly textured for site conditions and placement.	Y / N		
b	Track packing / contour furrows are perpendicular to slope.	Y / N		
c	Crimped straw in place, tackifier used if necessary.	Y / N		
d	NO Maintenance required.	Y / N		
9	**Straw wattles on site**	**Y / N**		
a	Wattles are buried 2 inches below the surface.	Y / N		
b	Wattles are staked in place according to the manufacturer's specifications.	Y / N		
c	Wattles are installed in "C" configuration.	Y / N		
d	NO Maintenance required.	Y / N		

Remedial actions:	
Environmental Monitor	**Site Foreman**
Print:	**Print:**
Signature:	**Signature:**
Date:	**Date:**