



ENVIRONMENTAL BEST PRACTICES

EROSION AND SEDIMENT CONTROL

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**Saskatchewan
Ministry of
Highways and
Infrastructure**

PREFACE

The purpose of this document is to provide guidance to field personnel (construction contractors, maintenance contractors and MHI maintenance field staff) on the application, construction, inspection and maintenance of erosion and sediment control measures. The techniques presented in this document are considered commonly acceptable baseline practices and are not intended to supersede a design provided by a designer and/or engineer. It is recognized that erosion and sediment control techniques are continually developing and the methods recommended in this document may be replaced with newer methods.

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1.0 EROSION AND SEDIMENT CONTROL BASICS

1.1 WHAT IS EROSION?

Soil erosion is the process by which soil is removed or lost by the action of water, ice, wind or gravity. Though it is a natural process, utilization and disturbance of land increases the rate of soil loss significantly. Soil erosion by water is dominant in areas disturbed by construction. For this reason, erosion and sediment control (ESC) strategies presented in this manual will focus on preventing and/or managing erosion caused by precipitation and run off. Wind erosion is a lesser concern, but still has implications in transportation infrastructure construction, particularly in terms of dust, visibility and traffic safety.

Soil erosion by water occurs in three stages:

1. particle detachment,
2. sediment transport, and
3. sedimentation or sediment deposition.

In the particle detachment phase, soil particles are detached by the forces exerted by falling raindrops or by the shear forces of runoff. In the second phase, sediment transport, particles are moved down slope by the splash action of falling raindrops and by the runoff itself. The third phase, sedimentation, occurs when the velocity of the runoff is reduced, causing some of the sediment to settle out of the water.

It is important to recognize that flowing water needs a certain amount of kinetic energy to detach particles and cause erosion. That being said, erosion can be prevented by limiting or controlling the flow of water.

1.2 TYPES OF WATER EROSION

Water erosion results from the removal of soil material by flowing water. A part of the process is the detachment of soil material by the impact of raindrops. The soil particles are suspended in runoff water and carried away.

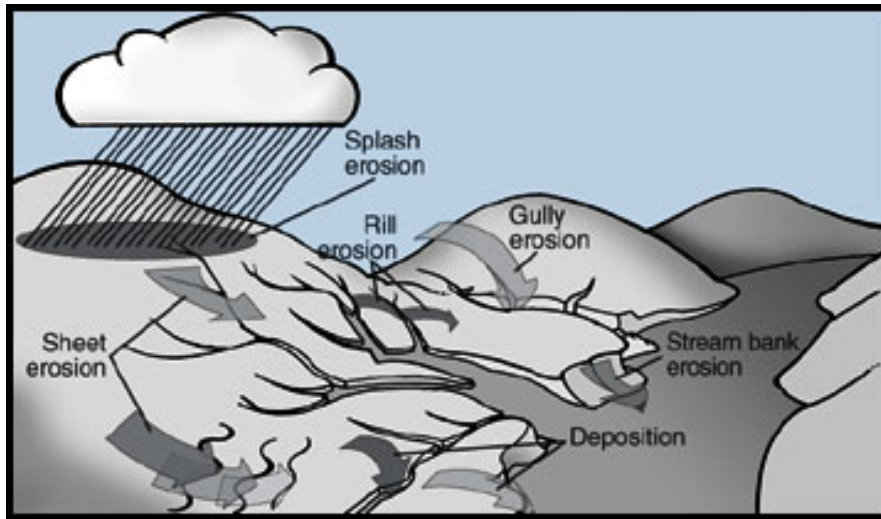


FIGURE 1.2-1 TYPES OF WATER EROSION (UNIVERSITY OF MISSOURI EXTENSION, 2010)

SPLASH EROSION: The movement of soil particles caused by the direct impact of raindrops on bare soil.

SHEET EROSION: The uniform removal of soil from an area by runoff that flows over the ground in a thin layer.

RILL EROSION: The loss of soil through small channels where runoff concentrates. The channels are shallow, usually only a few centimeters deep.

GULLY EROSION: The loss of soil from a watercourse caused by concentrated flow of runoff over unprotected, erodible soil. The channels created are larger than rills, possibly measuring into the metre range.

STREAM & CHANNEL BANK EROSION: The bank and bed erosion of an existing stream channel caused by runoff.

1.3 EROSION CONTROL VERSUS SEDIMENT CONTROL

It is advisable to recognize the difference between erosion control measures and sediment control measures when preparing an effective ESC plan. Erosion control is any measure undertaken to reduce the potential for erosion to occur. Sediment control is any measure implemented to reduce the potential for sediment to be transported and/or deposited beyond the limits of the construction site. For example, an erosion control blanket is considered erosion control, whereas a silt fence is considered sediment control. Erosion control should be viewed as a first defense when protecting downstream aquatic habitats, while sediment control should be implemented as a contingency plan. Sediment control will also be required if there is absolutely no means of preventing erosion. It is more desirable to control erosion rather than to control sedimentation, as it will cost less in the long term.

1.4 PLANNING FOR EROSION AND SEDIMENT CONTROL

Soil erosion is not a quick process, occurring naturally at a slow rate. Areas disturbed by construction activities experience soil erosion at much higher rates; unprotected construction sites can experience annual soil loss rates of 13,500 – 18,000 tonnes per hectare. The following is a list of construction activities that should be looked at for ESC problems in roadway construction and maintenance:

- Excavation and borrow areas
- Clearing and grubbing
- Embankment construction
- Ditch construction
- Channel or stream realignments
- Culvert installations or extensions
- Earthwork near/across streams and lakes
- Temporary cofferdams or other diversion works

Often it is common to find severe erosion damage in locations that, although required, never had any erosion control measures implemented, or had erosion control measures installed incorrectly. An initial site assessment should be conducted to gather information necessary for creating an erosion and sediment control plan. It is essential to determine any potential erosion sites and to address them before erosion occurs. Ensuring that ESC measures are correctly installed will decrease the chance of having to address the issue a second time.

The implementation of ESC measures to prevent soil erosion and sedimentation during the early stages of planning is important for reducing serious and costly problems in the future. If left uncontrolled, these processes may result in adverse impacts to the environment, such as degradation of surface water quality, damage to adjacent land and degradation of aquatic habitat. In addition to the costs associated with environmental damage, increased soil erosion may include the monetary costs through replacement of lost soil, re-grading, cleaning clogged channels and culverts, payments for erosion-related damages to down slope and downstream property and possible regulatory penalties.

The design of ESC measures should be viewed as a flexible process that responds to new information obtained throughout the construction phase. As such, the design of temporary and permanent ESC measures should be expected to evolve throughout construction to varying degrees based on site conditions and field performance of implemented measures.

1.5 SELECTION OF EROSION AND SEDIMENT CONTROL MEASURES

This document includes a brief inventory of ESC measures that could easily be applied to the activities listed above. The information includes details on the purpose, application, implementation, maintenance, limitations and advantages of each measure. This guide is not a comprehensive document containing all available erosion and sediment control measures. Selection of ESC measures can be

guided by factors such as topography, soil conditions, vegetation and connectivity to fish bearing waters, as well as the designer's experience and judgment. It is important to understand that a variety of measures may be required if conditions pose a significant potential impact. The selection of ESC measures will also be directly influenced by site-specific design specifications, specific construction requirements, environmental regulations and costs.

1.6 INSTALLATION SCHEDULING

Another important step in erosion and sediment control is proper scheduling. It is integral to develop an installation schedule for each project. This includes the sequencing of construction activities with the implementation of ESC measures.

The purpose of scheduling is to coordinate efforts between those involved in the project. It is generally a good idea to decide on an ESC plan during the design stage. This will allow for flexibility with ESC measure selection and timing opportunities. Knowing when and where a measure is going to be installed is important when deciding on materials and suppliers. A schedule can include details for short-term or temporary practices, as well as any long-term operations or activities that may have been planned.

Installation scheduling is only effective if followed closely and modified as required throughout the construction project. Ensure that the work is being done according to the preliminary schedule and amend the schedule when changes are warranted. Be sure to schedule inspection dates and any anticipated ESC measure removals. Chapter 4 provides information on Monitoring, Maintenance, and Removal.

2.0 REGULATORY REQUIREMENTS

Both provincial and federal legislation needs to be considered in construction projects that could result in erosion and/or sedimentation. There are a number of Acts and regulations that govern the release of deleterious substances from erosion associated with construction projects. Fisheries & Oceans Canada (DFO) operates in Saskatchewan to enforce federal legislation. The Ministry of Environment enforces provincial legislation in collaboration with DFO. When dealing with erosion and/or sedimentation it is important to maintain compliance with all applicable legislation, regulations and environmental code protocol. For more information on the Acts and their applications, contact your MHI Regional Environmental Specialist.

2.1 FEDERAL

Fish and fish habitat are protected under the provisions of the [Fisheries Act](#). All habitat protection provisions must be considered when reviewing the negative effects of a project to fish habitat. The Fisheries Act prohibits the deposit of deleterious substances and prohibits the harmful alteration, disruption or destruction of fish habitat.

2.2 PROVINCIAL

The [Environmental Management & Protection Act \(EMPA\)](#) respects the management and protection of the environment. It protects air, land and water resources of the province through regulating and controlling potentially harmful activities and substances. It is pertinent that you are familiar with EMPA and the environmental code for works in or near water.

3.0 ESC MEASURES FOR THE CONSTRUCTION SITE

The following table includes the ESC measures described in this document:

SECTION	NAME	PRIMARY PURPOSE
3.1	Vegetated Buffer	Prevents soil erosion and catches sediment
3.2	Topsoil	Helps to encourage vegetation growth
3.3	Seeding	Provides soil protection through vegetation growth
3.4	Hydro-seeding	Stabilizes soil and enhances vegetation growth
3.5	Erosion Control Blanket	Prevents erosion and allows plant growth to develop
3.6	Straw Mulch	Protects disturbed soil by limiting soil detachment
3.7	Slope Texturing	Reduces runoff velocity and traps sediment
3.8	Silt Fence	Slows and filters runoff to retain sediment
3.9	Check Dams	Provide retention of sediment from flows
3.10	Wattles	Reduce flow velocity and catch sediment
3.11	Straw Bale Barriers	Intercept runoff and remove sediment
3.12	Rip Rap	Provides stable erosion resistant cover
3.13	Turf Reinforcement Matting	Prevents erosion scour and allows plant growth to develop
3.14	Soil Bioengineering	Prevents erosion by using living plant material to provide structural support to soils
3.15	Dust Control Measures	Prevent wind erosion

In selecting the appropriate ESC treatment for any project, it is essential to consider both temporary and permanent measures. ESC measure considerations are dependent on site slopes, drainage patterns, existing vegetation and other site-specific conditions. It is important to remember that ESC plans will change from project to project. When planning for erosion and sediment control remember that multiple measures can be used in conjunction with each other. For example, a slope could be protected by using both erosion control blankets and wattles.

The purpose of this document is to provide basic guidelines and standard procedures for ensuring that construction activities are proactive in preventing soil erosion and reducing sedimentation. The practices outlined in this document are simple, low cost and applicable to Ministry construction sites.

In selecting the appropriate ESC measure for any construction project, the procedures outlined in this manual will produce satisfactory results. The fifteen ESC measures are relatively easy to implement in the projects undertaken by our Ministry.

Remember that this document is not a complete list of every available ESC measure and that there may be more suitable methods available. Also, with any ESC product, be aware that the manufacturer's installation specifications should always be considered more accurate than information given in this document.

3.1 VEGETATED BUFFER

DESCRIPTION & PURPOSE

Vegetation is the key to long-term stability. Trees, shrubs and ground cover control erosion, help stabilize critical areas, reduce runoff and enhance the aesthetics and wildlife habitat. Existing vegetation should be retained as much as possible, as it is a durable and effective erosion control measure.

Buffer strips of existing vegetation should be left along stream channels, graded/cleared areas and steep slopes for protection against water and wind erosion. Vegetated buffers should always be considered when water resources are adjacent to or near disturbed areas. Because of the effectiveness of vegetative cover, it is usually the primary choice for long-term soil erosion control.

If disturbance is necessary, it should be limited to the construction site. When the buffer is inadequate, extra planting/seeding may be required, or if the area were completely unvegetated, seeding grass or planting trees would be an inexpensive alternative. When choosing which species to plant, it is important to consider soil tolerances, winter hardiness and overall suitability.

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3.2 TOPSOIL

DESCRIPTION & PURPOSE

Topsoil from the construction site should be preserved and used to enhance the final site stabilization with vegetative cover. This practice does not combat erosion on its own, but rather helps to encourage vegetation. Topsoil removed from the right-of-way and the borrow areas should then be stockpiled in designated areas where it will not erode, block drainage or interfere with work on the site. Once the grading is completed, the topsoil is reapplied to the finished surface.

It is important to retain the topsoil during construction due to its high organic content. If re-vegetation methods follow, the seed will germinate much quicker due to the existing nutrients in the topsoil. Topsoil placement should be in accordance with the Topsoil Management section of the MHI Construction Manual.



FIGURE 3.2-1 EXAMPLE OF TOP SOIL RECLAMATION (MHI, 2007)

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3.3 SEEDING

DESCRIPTION & PURPOSE

Seeding is generally used to provide permanent stabilization to disturbed areas. The establishment of plant cover on interrupted soils will prevent further soil disruption by raindrop impact and overland flow. Slopes and channels will be reinforced as a shallow root matrix will increase the subsurface soil strength.

APPLICATION

Two types of seeds are used: temporary and permanent. Temporary seeds (also called cover crops) are annual grasses that are mixed with permanent seeds before application. Annual grass seeds, such as winter wheat or fall rye, establish quick grass cover over bare soil and are expected to die at the end of the first growing season. Permanent seeds include herbs or grasses. They take longer to germinate, but will provide excellent erosion control. Aside from the erosion control benefits provided by vegetation, roadside aesthetics and biological habitat are also enhanced. All disturbed areas in the right of way should be seeded as soon as possible.

Seeding will not provide immediate plant cover as bare soil will persist until plants have developed. Therefore, this erosion control method is most effective in its primary stage when used in combination with other control methods. For example, permanent seeding may be applied to sloped and grass-lined channels in conjunction with erosion control blankets.

IMPLEMENTATION

- Vegetation selection should depend on climate, soil type and existing local species. When seeding in areas adjacent to agricultural land use agronomic seed blends comprised of tame grass varieties and if seeding is to occur next to native habitats the use of native seed mixes is encouraged. The Native Plant Society of Saskatchewan has produced Guidelines for Use of Native Plants in Roadside Revegetation. The guidelines include: [Roadside Revegetation Reference Manual](#) and a [Roadside Revegetation Field Guide](#).
- The site should be roughened by harrowing, tracking or grooving. The seedbed should be approximately 7-15 cm deep, with at least the top 7-8 cm of stone-free topsoil.
- Seed should be applied immediately after seedbed preparation. Fertilizer, mulch and/or an erosion control blanket may then be applied.
- Hydro-seeding can be used for sites that are steeper than 3:1, or where seedbed preparation is not possible. This procedure sprays a mixture of seed and mulch onto the slope.

MAINTENANCE

- Inspect site for die out or erosion.
- Repair damaged or bare areas by reseeding.

SEEDING (CONT.)

LIMITATIONS

- Replanting may be required.
- Project scheduling and weather may not always cooperate with seeding.

ADVANTAGES

- Reduces rate of flow.
- Traps sediment and stabilizes soil.
- Stronger root structures develop over time, supporting the soil.

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3.4 HYDRO-SEEDING

DESCRIPTION & PURPOSE

Hydro-seeding is the method of spraying a seed slurry mixture onto a surface. The seed, fertilizer, mulch and tackifier can be mixed together in the tank of the hydro-seed equipment. The tackifier is an adhesive that provides a bond between the seed and the surface, thereby enhancing germination through the increase in soil moisture. When sprayed on the soil, the slurry mixture forms a seed blanket and protects the soil from wind/water erosion and raindrop impact. In highly disturbed areas, where re-vegetation is slow, hydro-seeding can be carried out through multiple applications.



FIGURE 3.4-1 HYDRO-SEEDING

APPLICATION

Hydro-seeding is an effective and efficient method of revegetation. Spray-on seeding can be used on large or small areas, on surfaces with minimal topsoil, and in places conventional seed equipment cannot maneuver. This practice can be used to provide both temporary and permanent erosion control and soil stabilization for disturbed soil areas.

IMPLEMENTATION

- Remove any large rocks or deleterious materials.
- Apply topsoil if available.
- Spray on the slurry mixture as per the supplier's recommendations.

MAINTENANCE

- Inspect the seeded areas at least once a year after the initial application or after heavy rainfall.
- Virtually maintenance-free.

HYDRO-SEEDING (CONT.)

LIMITATIONS

- Site must be accessible to the hydro-seed equipment.
- Bare areas may require reseeding.
- Areas damaged by runoff may have to be repaired.

ADVANTAGES

- Cost effective and efficient method of seeding.
- Promotes plant growth as well as erosion protection.
- High coverage rates of the seed application.
- Provides dust control.

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3.5 EROSION CONTROL BLANKET

DESCRIPTION & PURPOSE

The basic objective of an erosion control blanket or straw matting is to provide a stable seedbed for one or more growing seasons, then to biodegrade as the vegetation builds up to produce a healthy cover crop. The blanket prevents the direct impact of rain onto fragile seeded areas, while protecting the area throughout the germination process. Erosion control blankets are made from natural or synthetic materials and their durability varies from six months to three years or longer.



FIGURE 3.5-1 EROSION CONTROL BLANKETS (MHI, 2007)

APPLICATION

Erosion control blankets are generally applied to slopes that contain disturbed soils, have a high erosion potential, or are upstream of sensitive wetland/stream areas. When used in combination with mulch materials, blankets act as an anchor binding the mulch material and preventing disruption by wind.

IMPLEMENTATION

- Prepare soil before installing blankets, including any necessary application of fertilizer and seed. Soil should be well graded and free of any rocks.
- Begin at the top of the slope by anchoring the blanket in a 15cm x 15cm wide trench with ~30cm of blanket extended past the up-slope portion of the trench.
- Anchor the blanket with a row of staples/stakes approximately 30cm apart in the bottom of the trench. After stapling, backfill and compact the trench.
- Fold the remaining 30cm portion of blanket back over compacted soil. Secure the blanket over compacted soil with a row of staples/stakes spaced approximately 30cm apart across the width of the blanket.

EROSION CONTROL BLANKET (CONT.)

- Roll the blankets down or horizontally across the slope, with adjacent rolls overlapped 5-8cm, in a shingle-style pattern.
- All blankets must be securely fastened to the soil surface by placing staples at least 15cm long, in appropriate locations.
- Staples must be placed along the central region of the blanket, staggering them, and spacing the staples at 2 per m² for steep slopes, 1-2 per m² for moderate slopes and 1 per m² for mild slopes.

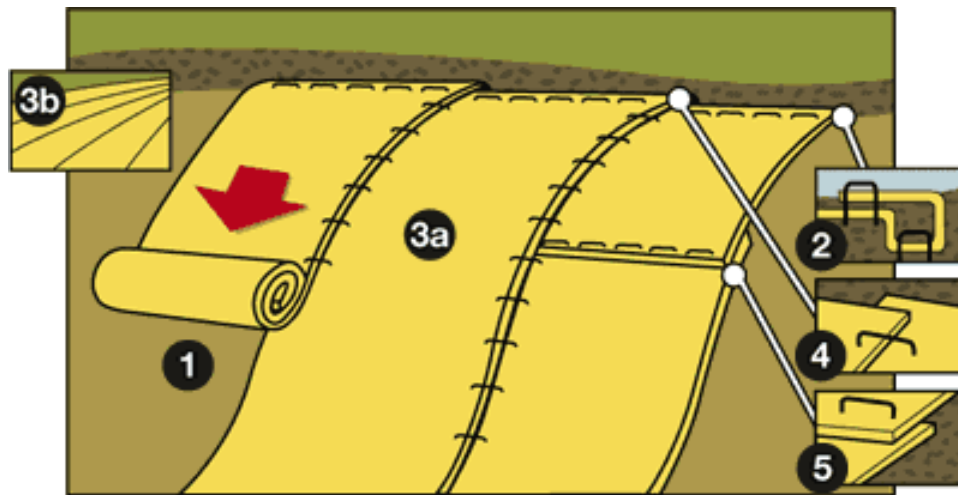


FIGURE 3.5-2 TYPICAL EROSION CONTROL BLANKET INSTALLATION (NORTH AMERICAN GREEN, 2003)

MAINTENANCE

- Blankets should be inspected regularly, especially after a heavy rainfall event.
- Blankets may break and have to be re-installed.

LIMITATIONS

- Temporary blankets may have to be removed to install permanent erosion control measures.
- Can be expensive if used over a large area.

ADVANTAGES

- Reduce the chances of erosion occurring which allows vegetation to develop.
- Easy to install and repair.
- High level of erosion control, uniform and long lasting.
- Biodegradable material is available.

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3.6 STRAW MULCH

DESCRIPTION & PURPOSE

Mulch is a material applied to a soil surface to conserve desired soil properties or to promote plant growth. Mulches hold moisture in place, reduce runoff and surface erosion, prevent surface compaction, help establish plant cover, control weeds and add nutrients to the soil.



FIGURE 3.6-1 STRAW MULCH APPLICATION (NORTH AMERICAN GREEN, 2003)

APPLICATION

Mulch can be used for both short and long term erosion control. Mulches may be used in areas where it has been graded and is commonly used with grass seeding. The straw is cut into the soil surface with a discer or a bulldozer tracking the surface. Whichever method is used, the mulch must be crimped into the soil to keep it in place.

IMPLEMENTATION

- Site grading should be carried out prior to mulching. Surface roughening and fertilization should be completed if seeding is required.
- Straw mulches can be applied by hand or machine. If applying by hand, it is best to divide the areas to be mulched into 100m sections. Place the straw in each section to facilitate even distribution.

MAINTENANCE

- All mulches should be inspected periodically, especially after rainstorms.
- Must be checked for erosion and decomposition.
- Additional mulch may need to be applied.

LIMITATIONS

- Mulch may not be uniformly applied.

ADVANTAGES

- Straw materials are locally available.

3.7 SLOPE TEXTURING

Soil texturing or tracking works well on slopes, large cuts and stockpiles. This temporary method is under-utilized and can be very cost effective when used in the right type of soil. Tracking is most successful when used on soils with a low to moderate erodability factor. The tracking process involves driving heavy construction equipment over the exposed area to create horizontal ridges/depressions perpendicular to the slope. Tracking on a slope will coarsen the soil surface, thereby reducing runoff velocities and erosion and trapping any sediment. It is very important that the tracking is perpendicular to the slope (operating equipment up and down slope) and not in the same direction of the slope. If the tracking is parallel to the slope it will promote erosion rills, rather than prevent them.

Supplemental erosion control methods, such as topsoil, seeding and mulching, work well with slope texturing to further combat erosion. Seeding must be done before tracking is completed. Fertilizer and mulch can then be applied. This low-cost procedure will greatly reduce soil erosion.



FIGURE 3.7-1 TYPICAL TRACKED SLOPE (MHI)

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3.8 SILT FENCE

DESCRIPTION & PURPOSE

A silt fence is a sediment barrier that utilizes a standard strength geotextile (filter fabric) attached to a support fence. Silt fences slow the flow rate of runoff producing sedimentation. The sediment from sheet or overland flow is then deposited and prevented from entering streams.



FIGURE 3.8-1 TYPICAL SILT FENCE INSTALLATION (NILEX, 2010)

APPLICATION

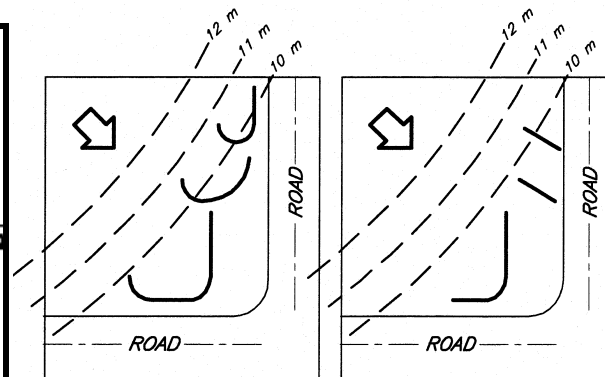
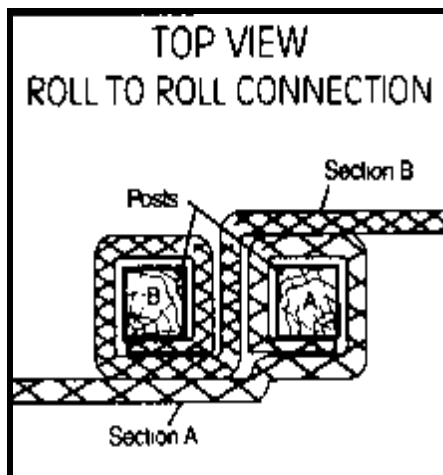
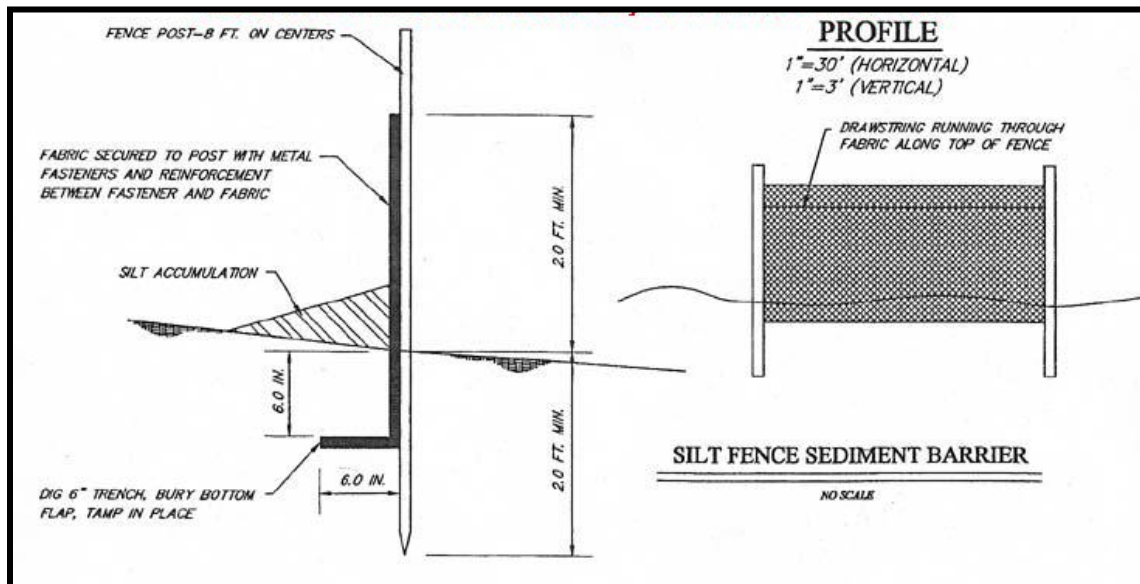
Silt fences are used to control sediment where rill or sheet erosion occurs. Examples include: along the banks of streams/channels, below the toe of exposed or erodible slopes, down slope of exposed soils and around temporary stockpiles. The size of the drainage area should be no more than 0.1ha per 30m of fence and the maximum slope no greater than 2:1. **Silt fences are used as a temporary measure until slope vegetation is established and should not be in place longer than one season.**

IMPLEMENTATION

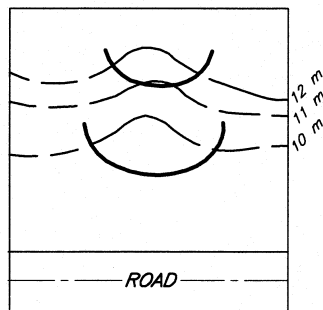
Proper silt fence installation is crucial to effectively control sediment. Silt fences can be purchased in rolls, with the fabric already attached to the posts.

- An anchor trench is first excavated along the contour on the upslope side. The trench should be at least 15cm deep and 15cm wide.
- Unroll the silt fence and position the posts against the downstream wall of the trench. This allows the fabric to face upstream.
- Pound the posts into the ground, past the depth of the trench.
- Turn the ends (~2m) of fence upslope in “J” or “L” shapes to retain flow. The fence should be patterned in a series of “J’s”.
- The trench is then finally backfilled. The soil must be compacted over the fabric to ensure no gaps exist between the fence and the ground. Application may be repeated to form patterns of silt fences.

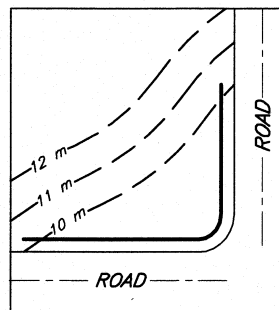
SILT FENCE (CONT.)



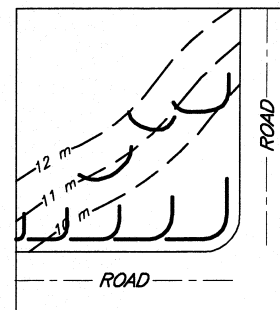
"J" CONFIGURATION



"SMILE" CONFIGURATION



AVOID LONG INSTALLATION



COMBINATION OF "SMILE" AND "J" CONFIGURATIONS

FIGURE 3.8-2 TYPICAL SILT FENCE CONFIGURATIONS (ALBERTA TRANSPORTATION, 2003)

SILT FENCE (CONT.)

MAINTENANCE

- Inspect fence following every heavy rainfall or snowmelt event.
- Remove accumulated sediment that is higher than one-third of the fence.
- Make all proper repairs to fence as required.

LIMITATIONS

- Difficult to maintain and install in windy areas.
- May fail under high runoff events.
- Cannot handle channel flow volumes.

ADVANTAGES

- Simple to install and remove.
- Low cost of materials.

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3.9 CHECK DAMS

DESCRIPTION & PURPOSE

A check dam can be constructed of rocks, sandbags, logs or specific products designed for use as check dams. Synthetic permeable barriers or georidges are plastic products specifically designed for use as check dams. The check dam is placed across a drainage ditch perpendicular to the grade. The purpose of a check dam is to reduce the flow velocity and retain sediment.



FIGURE 3.9-1 CHECK DAMS CONSTRUCTED USING GEORIDGES (NILEX, 2010)

APPLICATIONS

Check dams can be temporary or permanent structures designed to slow the speed of runoff and limit soil erosion. Check dams can reduce a long steep slope to a series of successive mild slopes. To properly limit soil erosion, the check dams must extend entirely across the ditch and part way up the side slope. The check dam will cause water to pond in front, thereby slowing the incoming flow and causing the sediment to settle out. It is also important for check dams to be properly spaced in order to accommodate the runoff. Check dams should not be used in channels that will experience storm water runoff velocities of higher than 1.5m/s.

IMPLEMENTATION

- The center of the dam must be at least 15cm lower than the outer edges of the ditch.
- To avoid large quantities of ponded water in front of the structure, the dam should be no higher than 60cm.
- It is important to trench in the dam at least 10cm.
- If rocks are used in the structure, $D_{50} = 75$ to 150mm sized-stones should be used. If the sole purpose of the dam is to trap sediment, the rocks size should not exceed 15cm.
- At the downstream end, a ~2m rock apron must be installed in order to dissipate high flows.
- Generally, for a ditch grade of 1%, check dams should be spaced 30m apart, for a 2% grade, use 15m spacing and 10m spacing for a 3% grade, etc. (spacing = $30 / \% \text{ grade}$).

CHECK DAMS (CONT.)

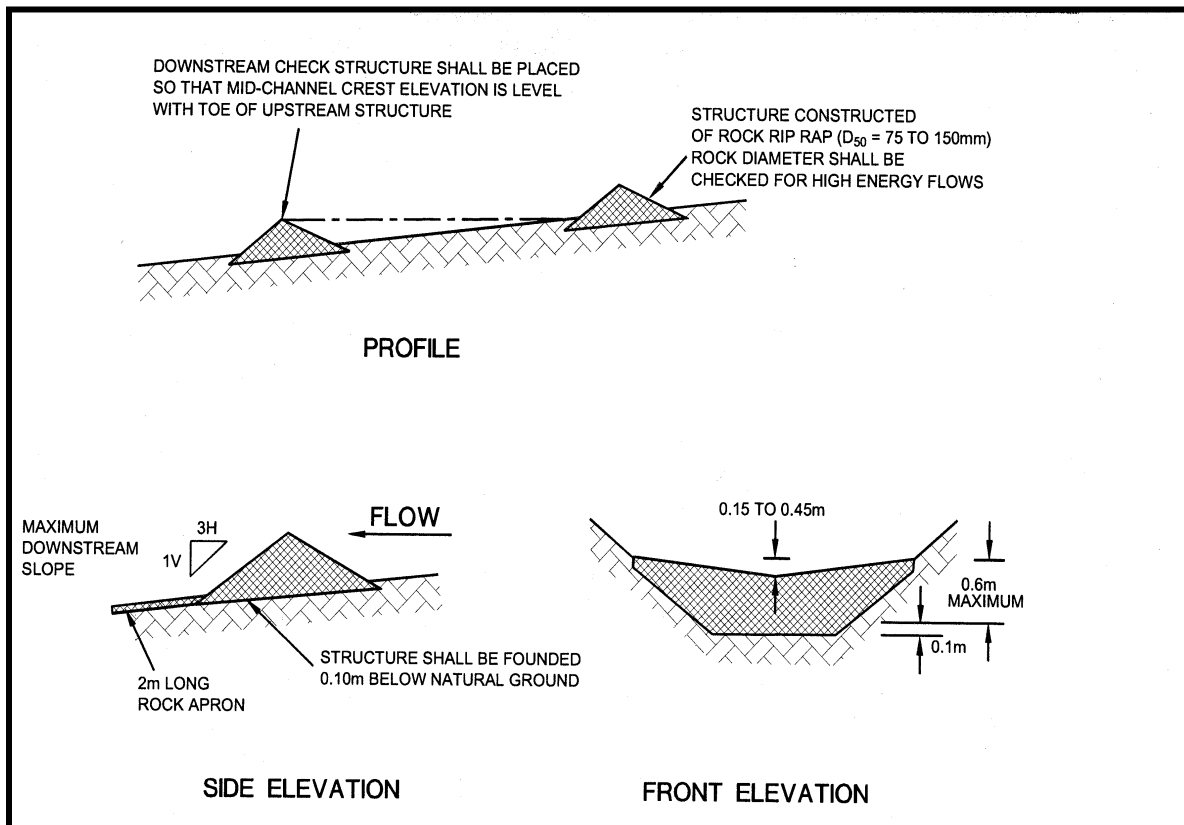


FIGURE 3.9-2 GENERAL CHECK DAM LAYOUT (ALBERTA TRANSPORTATION, 2003)

MAINTENANCE

- Dams should be checked after high rainfall events.
- Sediment must be removed when depth reaches $1/3$ of the height of the dam.
- Structure must be repaired/replaced when it starts to show signs of failure.

LIMITATIONS

- If constructed improperly, water will flow around the structure.
- Synthetic barriers become brittle in the winter and easily damaged.

ADVANTAGES

- Cheaper than placing rip-rap along the entire ditch.
- Easy to install/remove.

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3.10 WATTLES

DESCRIPTION & PURPOSE

Wattles are a type of sediment control and flow retarder that can be used in a similar manner to silt fences or check dams. They are constructed from tubular netting filled with straw fiber or a similar organic fiber. The netting can be made from a UV-stabilized black synthetic plastic or if desired a biodegradable material. Wattles are available in various diameters and lengths, but typically are 8-12" in diameter and 15-25' in length. Wattles made with plastic netting will generally last 3-5 years, with the straw bio-degrading and the netting breaking down to small pieces from sunlight. Wattles made with biodegradable netting will only last a year, due to the rapid breakdown of the fiber netting.

APPLICATION

Wattles work best when used on slopes. They help to stabilize slopes by shortening the effective slope length and by slowing, spreading and filtering overland water flow. This helps to prevent sheet erosion as well as rill and gully development, both of which occur when runoff flows are uninterrupted down a slope. They are commonly used in conjunction with erosion control blankets.



FIGURE 3.10-1 EXAMPLE OF WATTLES USED ON A SLOPE (MHI, 2008)

WATTLES (CONT.)

IMPLEMENTATION

Wattles are typically installed in a 5-7.5cm deep trench that is constructed along the contour, perpendicular to the slope or direction of flow. Ends of the wattles should be turned up the slope to retain water and prevent it from flowing around the end of the wattle.

Wattles are secured to the sub grade by 45-60cm stakes or anchors spaced every 0.9-1.2m across the length of the wattle. The stakes are driven through the center of the wattle and into the ground with approximately 5cm projecting above the top of the wattle. A stake should be placed within 5-15cm of the end of the wattle. When joining two wattles, tightly abut both ends or overlap the wattles approximately 15cm.

Vertical spacing for slope installations should be determined by site conditions: slope gradient and soil type are the main factors. A good rule-of-thumb is 1:1 slopes = 10 feet apart, 2:1 slopes = 20 feet apart, 3:1 slopes = 30 feet apart, etc. However, adjustments may have to be made for the soil type. For soft, loamy soils, adjust the rows closer together. For hard, rocky soils, adjust the rows further apart.

MAINTENANCE

- Wattles should be inspected regularly, especially after a heavy rainfall event.
- Wattles may break and have to be re-installed.

LIMITATIONS

- Labour intensive to install (hand installation).
- Designed for slope surfaces with low flow velocities.

ADVANTAGES

- Function well in freeze-thaw condition.
- Low cost solution to sheet flow and rill erosion on slopes.
- Low to medium cost flow retarder and silt trap.
- Can be used on slopes too steep for silt fences or straw bale barriers.
- Biodegradable options are available.

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3.11 STRAW BALE BARRIERS

DESCRIPTION & PURPOSE

Straw bales are erosion resistant materials that act as a sediment trap from overland or ditch flow. This type of barrier dam is a temporary measure used to control soil erosion in ditches. The dam will cause water to pond allowing sediment to settle out while the water filters through the bales. It is a low-cost technique and it is easy to install/remove.

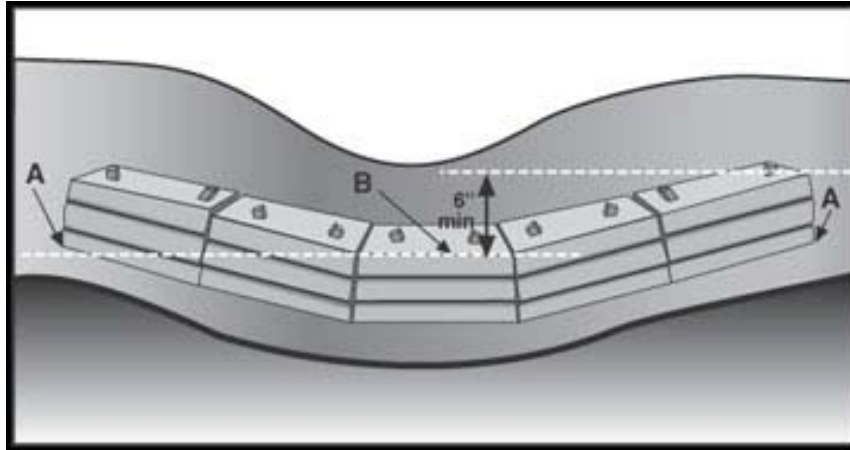


FIGURE 3.11-1 TYPICAL STRAW BALE INSTALLATION (ALBERTA TRANSPORTATION, 2003)

APPLICATION

Straw barriers are typically used at the bottom of cut/fill slopes and in ditches/gullies. Barrier dams should only be used in small catchment areas and should never be built in natural streams.

IMPLEMENTATION

- The ditch slope should not exceed 2% and the drainage area less than 0.8ha.
- The bales should be placed in one single layer.
- Straw bales should be dug into a trench at least 10cm deep. Place the excavated material against the upstream side of the bales.
- Wooden stakes should be placed in the ground deeper than the trench and spaced at no less than two per bale.
- Straw bale check dams should be placed so the top of the downstream check dam has an elevation level with the base of the upstream check dam.

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STRAW BALE BARRIERS (CONT.)

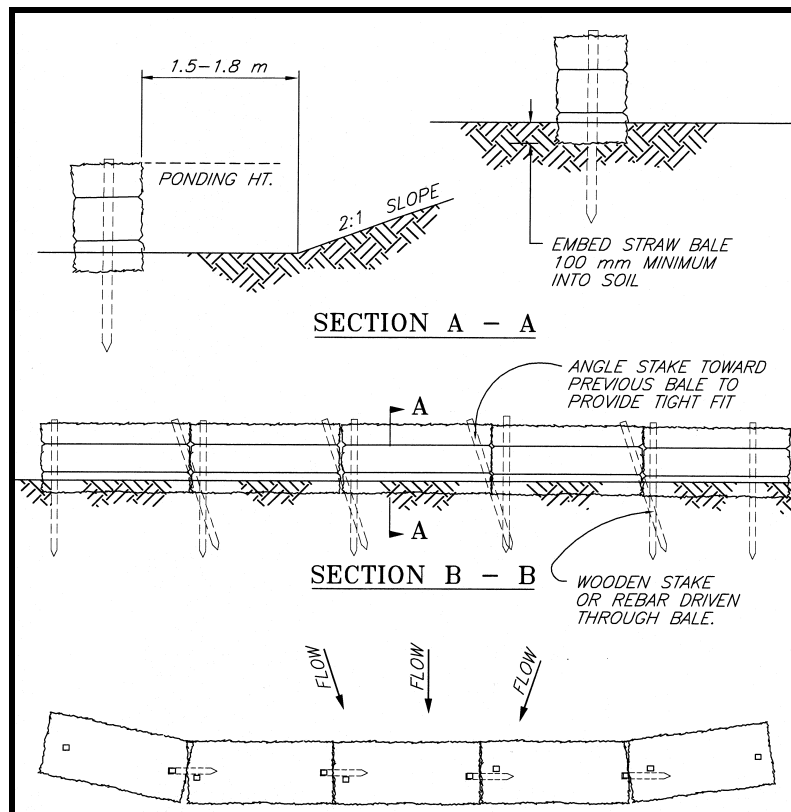


FIGURE 3.11-2 TYPICAL DESIGN SPECIFICATIONS FOR STRAW BALE CHECK DAM (ALBERTA TRANSPORTATION, 2003)

MAINTENANCE

- Regular inspection is necessary and highly important after a severe rainfall event.
- Accumulated sediment must be removed once the sediment reaches two-thirds the height of the barrier.
- The straw bale barrier can be removed once vegetation has been established.

LIMITATIONS

- May frequently fail due to flow under/around the bale or due to high flow.
- Sediment may have to be removed regularly.
- Limited to a six-month duration.

ADVANTAGES

- Easily installed and removed.
- Low cost alternative.
- Materials are locally available.

3.12 RIP RAP

DESCRIPTION & PURPOSE

Rip rap is a permanent erosion control measure made up of large, clean, loose stones that provide a stable erosion resistant ground cover. Rip rap is durable, heavy and flexible, making it quite effective in erosion control. Examples of locations for rip rap include: channel banks, dike slopes, culvert inlet and outlets and bridge abutments. The purpose of rip rap is to protect the soil, slow the runoff, and stabilize the slopes. It is very important to understand that rip rap can offer outstanding protection if installed properly. If the rip rap does not have some type of filtration mechanism below it, or is not shaped properly, failure is very likely to occur. If the installation is flawed, water will flow beneath the rip rap and undermine the soil below. If the rip rap apron is not shaped correctly, water may flow over to unprotected areas adjacent to the rip rap causing erosion.



FIGURE 3.12-1 TYPICAL CULVERT RIP RAP INSTALLATION (MHI, 2007)



FIGURE 3.12-2 SHORELINE RIP RAP (MHI, 2007)

RIP RAP (CONT.)

APPLICATION

If there is a high risk for erosion potential, rip rap should be placed at the site as early as possible after the soil has been disturbed and prior to any flow occurring.

IMPLEMENTATION

- The construction sequence involves excavation and grading of the area to be protected, applying a layer of geosynthetic matting or gravel as a filter and finally distributing a specific thickness of rip rap. Ideally, rip rap should be installed when water flow is the lowest; otherwise use of a cofferdam is needed.
- It is essential to have some manner of filter mechanism between the soil to be protected and the rip rap to prevent undermining.
- Size and placement of rip rap are highly dependent on flow velocities. Higher flow velocities require larger rip rap.
- When protecting drainage channels, rip rap blankets should be keyed in at both the upstream and downstream ends.
- Rip rap specifications for culvert protection are specified in the MHI Hydraulic Design Manual. Contact the Senior Road Design Engineer, Technical Standards Branch, for guidance.

MAINTENANCE

- Extremely fast flow rates may disrupt or dislodge rip rap from the slope.
- Debris may have to be removed.
- Check for any undermining of rip rap.

LIMITATIONS

- Transport of rock to site can be expensive and time consuming if quarries are not locally available. Rock itself can be expensive if supplies are limited.
- Angular rock may appear unnatural.
- Rip rap does not provide a range of aquatic habitat for multiple species and life stages, unlike a natural, vegetated bank.

ADVANTAGES

- Can be used on any size of waterway.
- Simple to install, easy to repair.
- Durable, long lasting and nearly maintenance free if properly installed.

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3.13 TURF REINFORCEMENT MATTING

DESCRIPTION & PURPOSE

Turf Reinforcement Mats (TRMs) provide excellent long-term erosion protection. They also assist in the establishment of vegetation while permanently reinforcing vegetation for applications where the forces exerted by water exceed the shear limits of unreinforced vegetation.

Typical applications include high flow channels, stream banks, shorelines and other areas where rock rip rap would typically be used. TRMs can sometimes provide significant cost savings over rock rip rap, as well as aesthetic benefits. TRMs can eliminate the need to quarry, process and haul rock providing environmental benefits for the project. There are a large variety of TRM products in the marketplace with many differences in product performance. Ensure you use a product that is suitable to the flow velocities your site will experience.



FIGURE 3.13-1 SHORELINE TURF REINFORCEMENT MAT (NILEX)

TURF REINFORCEMENT MATTING (CONT.)

IMPLEMENTATION

Installation of TRM is very similar to installing erosion control blanket. Installation specifications will vary depending on the specific product you are using and in what scenario you are implementing the product.

- Prepare the soil for installation. Remove rocks and roots and ensure the soil is well graded. Spread seed and fertilizer as required.
- Ensure TRM is laid out in the direction of flow, with ends being keyed in with a 15cm x 15cm trench at both the upstream and downstream ends.
- The TRM is to be stapled into the soil according to the manufacturer's installation specifications.

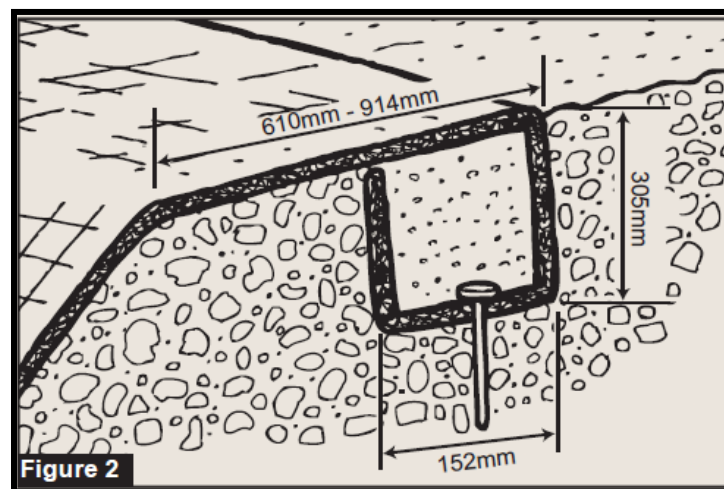


FIGURE 3.13-2 TYPICAL INSTALLATION OF TRM (PROPEX)

MAINTENANCE

- Mats should be inspected regularly, especially after a heavy rainfall event.
- Mats may break and have to be re-installed.

LIMITATIONS

- Plant growth is mainly dependant on underlying soils.
- Can become undermined if installation is not completed properly.
- Can be expensive if used over a large area.

ADVANTAGES

- Provides immediate protection from surface erosion.
- Longevity can be considerable depending on the type of product used.
- Degree of erosion protection is high and there is a wide range of products available.

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3.14 SOIL BIOENGINEERING

DESCRIPTION & PURPOSE

Soil bioengineering is use of living plant materials to perform an engineering function. It is often a hybrid between hard armouring engineering solutions and conventional reclamation sciences (Polster, 2008). Bioengineering can be used as the primary means of erosion control or it can be used in combination with hard armouring such as rip rap. An example of this technique would be using willow staking with rip rap or using willow staking with wattles. Willow staking involves pounding short sections of willow into the ground so it develops roots and assists in holding the soil in place. Willows are ideal for use in bioengineering projects as they sprout both roots and shoots rapidly.

There are many other bioengineering principles that can be used for erosion and sediment control. Some of these techniques include wattle fences, brush mattresses and live silt fences. There are numerous techniques used with willows, far more extensive than what is mentioned in this guide. It is important to remember that bioengineering techniques must be developed for the specific site you are treating.



FIGURE 3.14-1 EXAMPLE OF BIOENGINEERING – BRUSH MATTRESS CONSTRUCTION (MHI, 2007)

SOIL BIOENGINEERING (CONT.)

APPLICATIONS

Due to the broad range of options which bioengineering presents, its methods are suitable for a number of scenarios. Bioengineering options can be used on slopes, flat areas and adjacent to stockpile sites.

IMPLEMENTATION

Due to the large variety of bioengineering methods, it is not within the scope of this document to provide specific installation instructions for each and every method. If it has been decided that bioengineering options will be implemented, then it is advised that the designer seek out specific installation documents. Shown below are a set of example instructions for brush wattles.

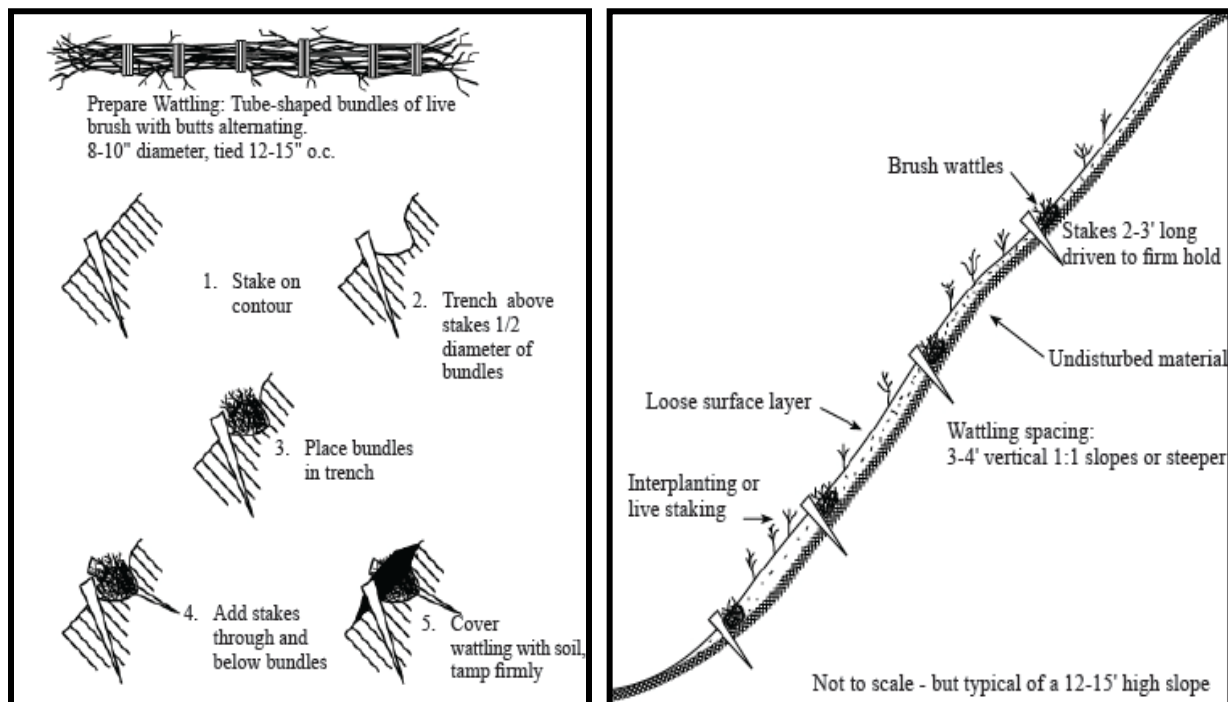


FIGURE 3.14-2 EXAMPLE OF DESIGN SPECIFICATIONS FOR BRUSH WATTLES (UNIVERSITY OF NEBRASKA)

MAINTENANCE

- Bioengineering structures should be inspected regularly, especially after a heavy rainfall event.
- Bioengineering structures may break and have to be re-installed.
- Accumulated sediment must be removed once the sediment reaches two-thirds the height of the barrier.

LIMITATIONS

- Expensive, may be labour intensive to install.
- Re-vegetated areas are subject to erosion until plants are established.
- Plants may be damaged by wildlife.

SOIL BIOENGINEERING (CONT.)

ADVANTAGES

- Establishes vegetative cover and root mat.
- Reduces flow velocities on vegetative surface.
- Traps sediment laden runoff.
- Aesthetically pleasing once established.
- Grows stronger with time as root structure develops.
- Usually has deeper root structure than grass.

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3.15 DUST CONTROL MEASURES

Dust control measures help to reduce and prevent wind erosion by protecting the soil surface within the right-of-way, borrow areas and stockpiles. Several dust control measures are available to choose from, ranging from easy, cost-effective techniques to more advanced, site-specific methods. Contractors will typically spray the soil surface with a fine mist of either water or dust control solution as a preventative measure for wind erosion control. Certain locations in the province are prone to windier conditions or finer-grained soils, thereby increasing the need for more substantial dust control measures. Other techniques include the use of physical barriers such as fences or vegetation, mulches, straw crimping and slope texturing. In areas where wind erosion potential is high, it is important to limit the amount of bare soil exposed and to minimize ground disturbance.

Dust control is simply good housekeeping. The best method of controlling dust is to prevent its production.

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4.0 MONITORING, MAINTENANCE AND REMOVAL

Monitoring and maintenance of ESC measures are important steps in any ESC plan. It is important to know how well the ESC plan works at the varying construction stages. To further guarantee that the installed measures are working properly, monitoring and maintenance are strongly recommended. It is also important to remember to remove temporary measures when necessary. ESC measures can be removed if re-vegetation of the bare soil was successful, if there is no visible erosion occurring and if there is no visible sediment accumulation.

On-site monitoring should be carried out frequently during the course of the project. The following is a list of questions to consider when evaluating the condition of installed ESC measures:

- Are the measures effective or should alternate measures be taken?
 - Is there evidence of excessive sediment loss?
 - Are rill/gullies present?
- Are the materials in sufficient condition to work properly?
 - Is there sediment accumulation that should be removed?
- Are there measures that can be removed?
 - Is site vegetation adequate to maintain soil stabilization?
 - Is sediment still accumulating behind the BMP?
 - Are permanent measures functioning properly?

If post-construction monitoring and maintenance is required, then responsibility roles will have to be coordinated. Final stabilization of the site will be achieved when all soil disturbing activities have been completed and a vegetative cover has been established.

5.0 REFERENCES

Alberta Transportation. 2003. Design Guidelines for Erosion and Sediment Control for Highways. EBA Engineering Consultants Ltd for Alberta Transportation, 2002, Alberta.

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