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Lake Shoreline Stabilization Techniques

The most successful and least costly approach to dealing with erosion problems on lake shorelines involves mimicking natures own design and using native vegetation as much as possible.

SOFT armoring techniques (sometimes called bio-engineering) involves creating a naturally occurring slope with a combination of natural elements which includes rock and vegetation. Soft techniques will absorb the energy of the waves along the shoreline reducing the potential of erosion, strengthen the shoreline long term, prevent ongoing maintenance, maintain and enhance natural habitat, filter nutrients and pollution from upland runoff and help improve water quality.

HARD armoring (retaining walls, rock, rip/rap, concrete, gabions) have been traditionally used as erosion protection along shorelines. These methods, however, are difficult to implement and maintain successfully over a long period of time. In addition these techniques are often more expensive then soft armoring techniques and require the use of heavy equipment which causes damage to sensitive areas. Hard techniques (especially vertical retaining or gabion walls) enhance erosion of the shoreline at the base and sides of the wall, disrupt the normal flow and filtration of water from upland, provide almost no natural habitat for wildlife and are most expensive and troublesome to fix.

"Hard" Armoring = Bad for the environment

"Soft" Armoring = Good for the environment

"Soft" Armoring Options

Plant native species along your shoreline. By doing this you are creating a "living barrier" of protection that blends into the surroundings and creates a natural look.

In steeper, erosoin prone locations, consider using **live staking, Brush mattresses or brushlayering** and/or **vegetated riprap** in combination with plants, rocks and logs for practical and aesthetic purposes.

Many of the materials needed for soft shore techniques can be obtained locally and installed with light weight equipment, saving you money and the potential damage caused by heavy machinery.

Soft shore armoring is a successful long-term method of addressing the erosion concerns that led to shoreline armoring while at the same time restoring degraded habitat.

Using Logs and Rocks
Rocks and logs are an integral part of soft armoring that is really about following Mother Nature's example. When trees fall onto a bank or into the water, it acts as a nursery for many plants and wildlife species as it decays. It also helps to stabilize the shoreline and bank by obstructing the movement of runoff and the action of waves on the shore. By placing logs in strategic locations we too can protect the shoreline and make it look natural. Specifically placing rocks in certain locations can help to save banks at drainage outfalls or gullies, break the force of waves and provide shelter for fish and other wildlife. Rocks and logs help anchor plantings and speed up the naturalization of your shoreline.

Live Staking
Slopes with light erosion can be used in conjunction with other methods for areas with heavier erosion. Normally live staking can be installed to anchor wattles (bundled live fascine) to provide deep root vegetation with the potential of favorable moisture retention. Wattles are also useful for the capture of sediment, organic matter and seed that is carried by the runoff. This method can be done by taking woody plants that are native to the area and driving them into the dirt or subsrate of the eroded area so they can sprout roots and grow. Live staking is relatively low cost and can be easily done by the landowner.

Brush Mattress
A brush mattress consists of a thick (15 to 30cm) blanket of living cuttings and soil fill that is placed on a stream bank or lake shore to simultaneously re-vegetate and armor the bank. This method works well on badly eroded slopes because the dense layer of brush increases roughness, reduces velocities at the bank face and protects the bank from scour. As the live branches root and grow, they provide cover and reinforcement for the soil underneath. If these mats are used on stream banks, they trap sediments during high water and eventual plant growth will enhance aquatic habitat. This method is relatively cost effective but can be quite labour intensive depending on the area.

Vegetated Rip-Rap
Vegetated Rip-Rap combines the rock revetment techniques with vegetative techniques. It consists of a layer of stone or boulder armoring that is vegetated using pole planting, brushlayering and live staking. This technique works best for waterways or inland lakes where continuous and resistive bank protection measures are needed. Plants incorporated into the riprap will create a more natural look to the shoreline as well as create habitat for aquatic and terrestrial wildlife. Although an expensive and sometimes difficult method to implement depending on the land, this option offers an opportunity for the land owner to attain the immediate and long-term protection afforded by riprap with the habitat benefits inherent with the establishment of a healthy riparian buffer.

Recommended Shoreline Protection Methods

For the best chance of protecting your shoreline now and in the future we recommend the use of **"softer"** approaches. These methods are not only more cost efficient for both install and maintenance but also more durable, aesthetically pleasing and environmentally friendly. These methods will help create a healthy riparian zone on your land and allow the shoreline to blend in with its natural surroundings.

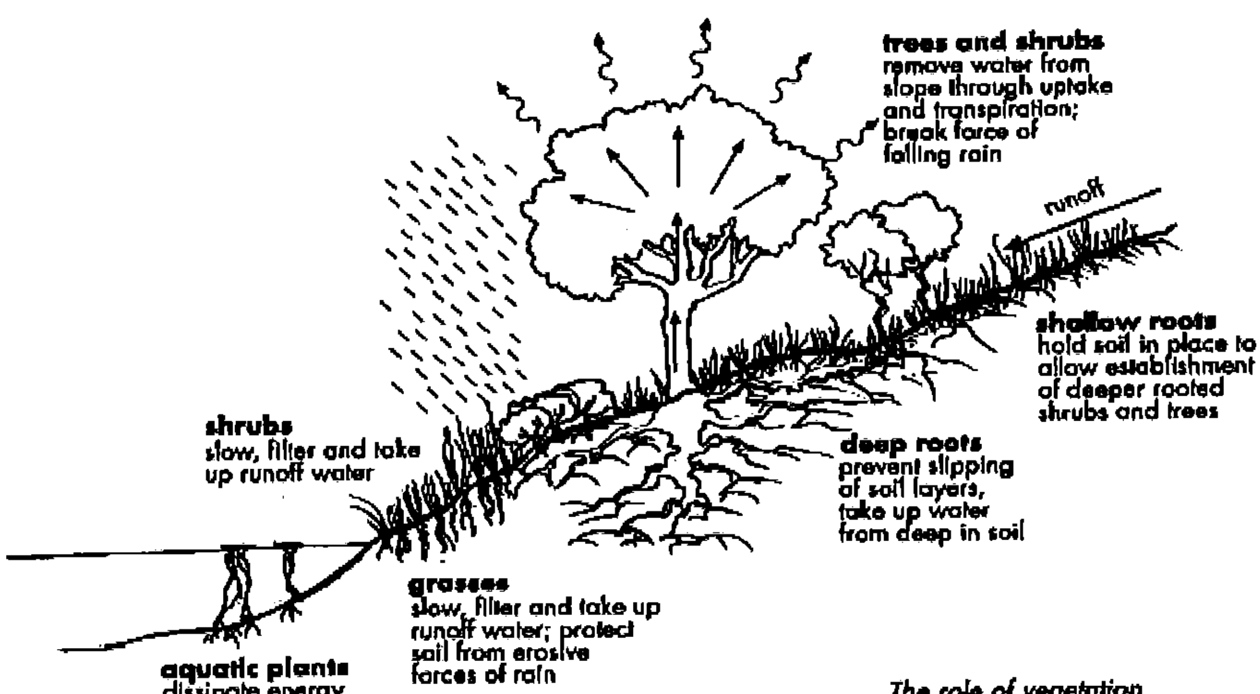
Plants and trees provide the best natural protection for the long run and by planting them early or leaving already existing ones alone you avoid potential costly and unfixable property loss. The most favorable soft approaches, such as the ones listed above, as well as others including: erosion control fabrics, hydroseeding, mulching and topsoiling are only just some of the ways you can help keep your shoreline as natural as possible and protect it from erosion.

Controlling shoreline erosion and doing work in and around a water body will generally requires at least two provincial approvals (Public Lands Act, Water Act), and possibly approval from Fisheries and Oceans Canada (federal Fisheries Act or Navigable Waters Protection Act).

Check to make sure you have all the required approvals and plans before you start doing any work on your shoreline!

For more information please check out our website:

http://esrd.alberta.ca/lands-forests/shorelands/default.aspx



The role of vegetation in minimizing erosion on a shoreline

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

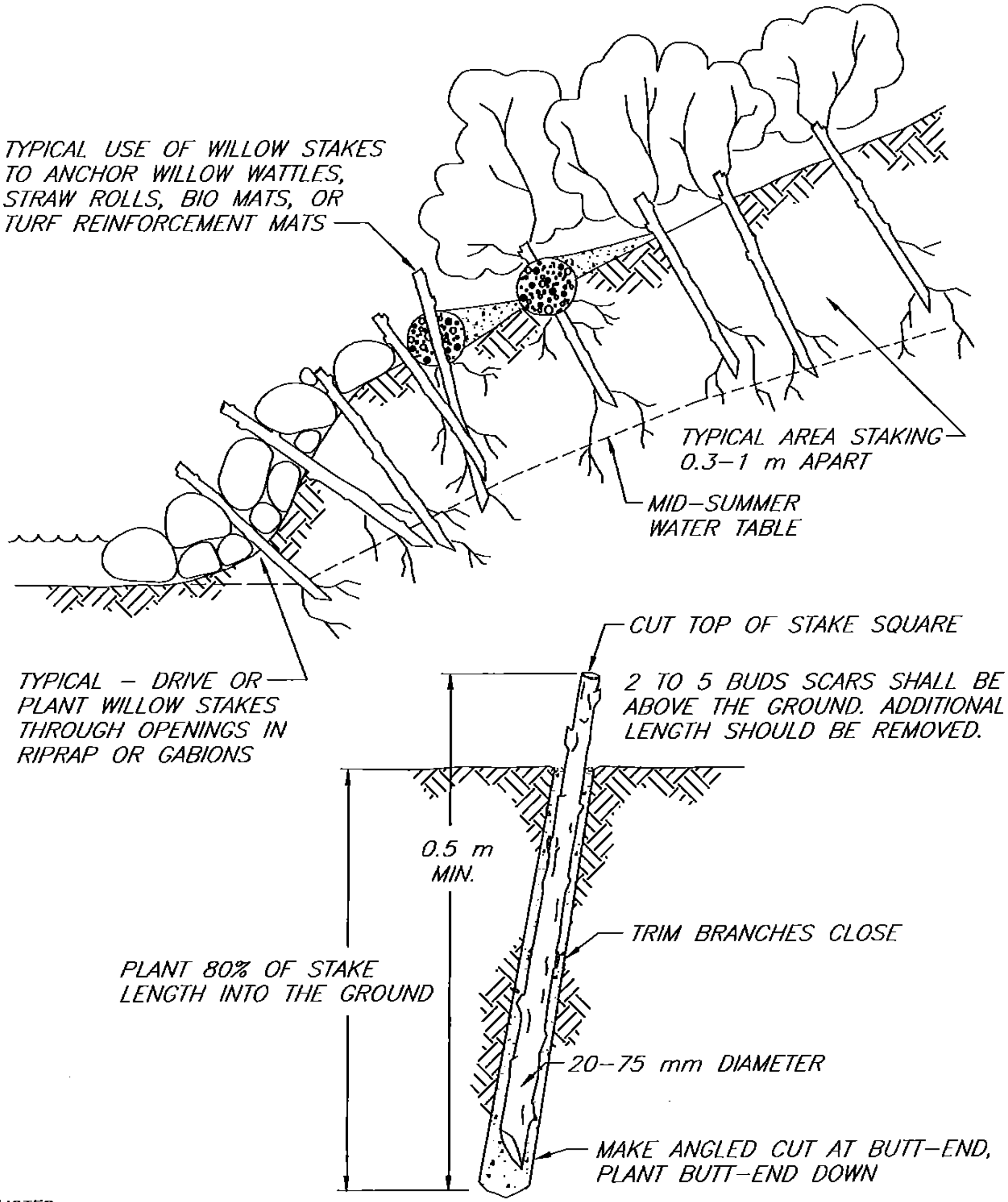
- Successful installation requires the use of freshly cut branches or stakes
  - Storage time of cut branches/stakes on-site prior to installation should be kept to as short a time period as possible
- Successful growth dependant on soil moisture and rainfall conditions
- Consultation with agrologist,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

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

Brushlayering Streambank Stabilization Techniques	B.M.P. #27b

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

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 with gradients greater than 1H:2V
- May be used on slopes with adequate sunlight, moisture, and wind protection to support vegetation
- May be used as bio-engineering stabilization in cases of historical shallow slope instability soil movements on eroded slopes and gullies
- May be used to reduce flow velocity and in sedimentation ponds to provide higher sedimentation duration of runoff impoundment
- Particularly appropriate for highway embankments that encroach upon riparian areas or floodways
- Slopes that need additional geotechnical and erosion reinforcement are good candidates for brushlayering
- Steeper slopes require the use of inert reinforcements such as geotextiles (ECBs, TRMs, coir netting), wire (twisted or welded gabion wire) or geogrids
- If either steady, long term seepage or temporary bank return flows after flood events are a problem, the brushlayers act as a horizontal drainage layer or conduits that relieve internal pore water pressure

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
- Of all vegetative biotechnical techniques, brushlayering has the greatest capacity for becoming successfully established, even in severe sites
- The use of synthetic geotextiles or geogrids provides long-term durability and greater security, especially if woody and herbaceous vegetation is established
- Can be used with other toe protection such as, rootwads, coir rolls, and log toes. Combining live brushlayering with rock toes is an effective and relatively low cost technique for re-vegetating and stabilizing streambanks
- Provide immediate soil stability and habitat
- Brushlayers and the pioneer vegetation that develops with them allow the establishment of a stable soil-root complex
- Both living and non-living brushlayers along streambanks enhance fish habitat, while slowing velocities along the bank during flooding flows
- They provide a flexible strengthening system to fill slopes. A bank can sag or distort without pulling apart the brushlayers
- Act as horizontal drains and favourably modify the soil water flow regime

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.)
- Plants may be damaged by wildlife
- Potential for low success rate
- Few precedents as this measure is generally not used on AT construction projects
- Brushlayers are vulnerable to failure before rooting occurs, and they are not effective at counteracting failure along very deep-seated failure planes

Construction

- First construct any lower bank or in-stream stabilizing measures such as a rock or log toe structure
- Excavate the first horizontal bench, sloping back into the hillslope at about 10%

- Install any drainage required along the back of each bench
- Place branches that are at least 1.8 m long on the bench
- Branches should crisscross at random with regard to size and age
- Place 20 branches per linear m on the bench, with the butts of the branches along the inside edge of the bench
- 20-45 cm of the growing tip should protrude beyond the face of the slope
- Cover and compact (add water if necessary) the brushlayer with 15 cm lifts of soil to reach the designed vertical spacing, typically 0.5 m to 1.2 m apart
- Slope the top of each fill bench back into the hill
- Construct another brushlayer
- When placed, the protruding tips of the cuttings are above the butts due to the back slope of the bench
- Proceed up the bank as desired
- The erosion and failure potential of the slope (i.e., drainage, soil type, rainfall, and length and steepness of the slope) determine spacing between the brushlayers
- On long slopes, brushlayer spacing should be closer at the bottom and spacing may increase near the top of the slope

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
- Installed during soil fill operations which result in the branches being inserted deeply into the slopes and thereby increasing the likelihood that the branches will encounter optimum soil and moisture conditions
- Live cuttings are most effective when implemented during the dormancy period of chosen plant species
- Live willow branches (or cuttings of other adventitiously-rooting species) at least 1.8 m long, with a minimum diameter of 20 mm
- Heavy equipment is usually employed for the construction of embankments

- A bucket loader and/or backhoe or excavator can facilitate the work
- Water should be available for achieving optimum soil moisture

Inspection and Maintenance

- Inspection frequency should be in accordance with the PESC and TESC Plans
- Inspect planted areas at least twice per year or after significant storm events (1:2 year storm and/or 40 mm rainfall in 24 hours)
  - 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
- The live cuttings or branches should establish successfully without irrigation requirements given the proximity to water
- Inspect the cuttings for adequate vegetative establishment (as evidenced by root and shoot production from the imbedded stems) and for signs of localized erosion such as rilling from runoff or sloughing from stream scour
- Brushlayer treated streambanks should also be inspected for localized slope movements or slumps
- These localized slope failures and/or areas of poor vegetative establishment can often be repaired by re-installing the brushlayers in these zones
- The site should be examined for possible signs of flanking erosion, which must be addressed with ancillary protective measures lest the flanking threatens the integrity and effectiveness of the protective brushlayer fill
- As with all resistive streambank structures, flanking is always a potential problem
- If frozen soil is employed in constructing the soil lifts between brushlayers, some settlement may occur when the soil thaws. This settlement may falsely signal a slope failure
- The most likely causes of failure are the following:
  - Inadequate reinforcement from the brushlayer inclusions, i.e., too large a vertical spacing or lift thickness for the given soil and site conditions, slope height, slope angle, and soil shear strength properties
  - Inadequate tensile resistance in the brushlayers as result of too small an average stem diameter and/or too few stems per unit width

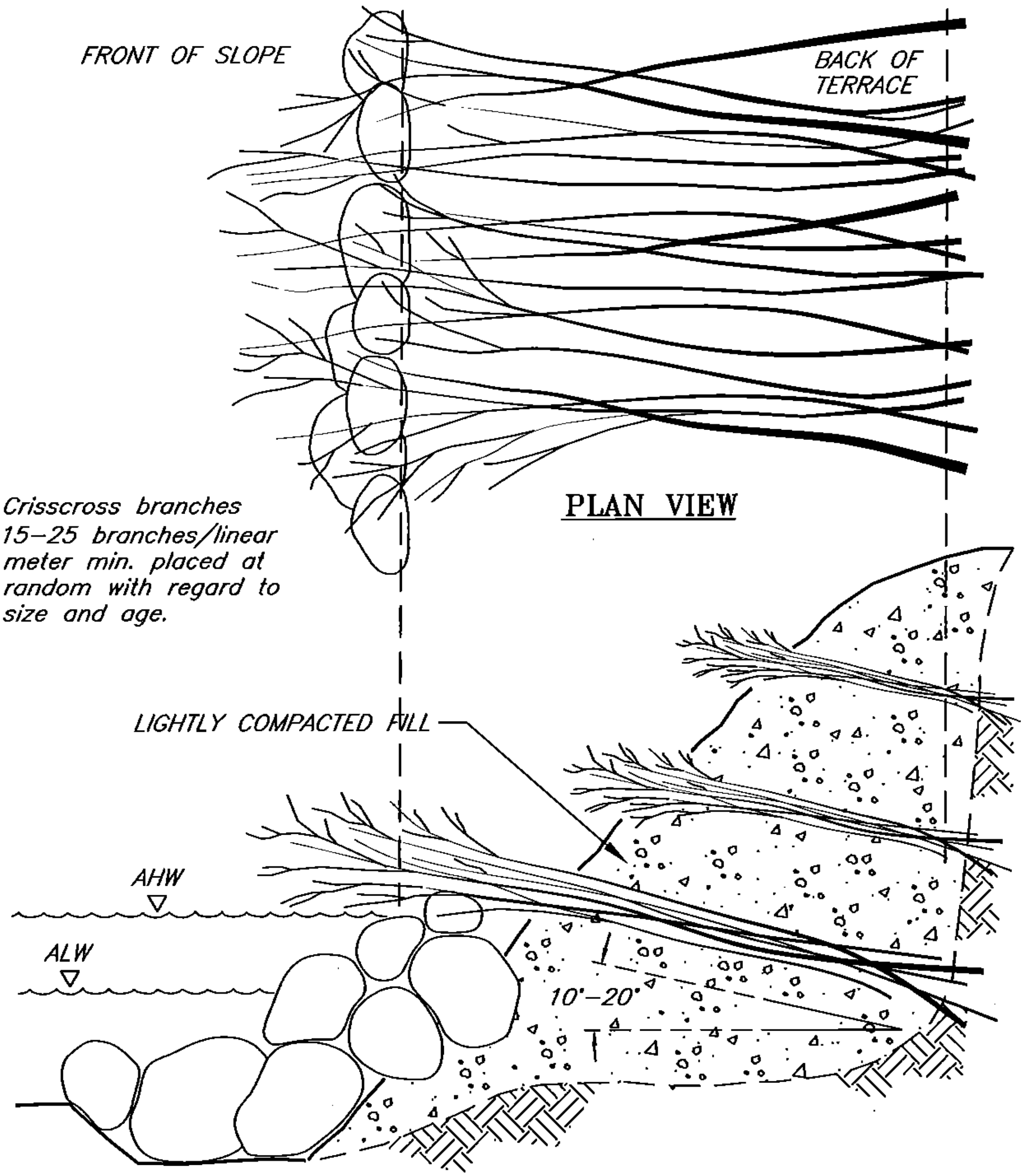
  - Failure to properly consider seepage conditions and install adequate drainage measures, e.g., chimney drain, behind brushlayer fill, and conversely inadequate moisture applied during installation, and inadequate attention to construction procedures and details

Design Considerations

- Live branches and brushy cuttings are used to make brushlayers
- Up to 30% of the brush may be non-rooting species that provide immediate strength to the soil mass, but will then rot away
- Plant material harvesting and installation should be performed during its dormant season (late fall to early spring) or in other seasons if soil moisture is available
- The ideal plant materials for brushlayers are those that:
  - root easily
  - are long, straight and flexible
  - are in plentiful supply near the job site
- Willow makes ideal brushlayer material, and some species of *Baccharis*, *Cornus*, and *Populus* also have very good rooting ability
- All cuttings should be soaked for a minimum of 24 hours, whether they are stored or harvested and immediately installed
- Brushlayer reinforced fills must have adequate internal stability
- This means that the tensile inclusions, i.e., the brushlayers, should have a sufficient unit tensile resistance and/or be placed in sufficient numbers to resist breaking in tension
- The inclusions must also be sufficiently long and "frictional" enough to resist failure by pullout
- Allowable velocity for brushlayering is 3.7 m/s and allowable shear stress is 19 to 300 N/m^2 depending on how long the brushlayers have had to establish
- Schiechtl & Stern (1996) suggest an allowable shear stress of 140 N/m^2

Similar Measures

- Seeding
- Mulching
- Hydroseeding
- Hydromulching
- Rolled erosion control products (RECP)
- Live Staking

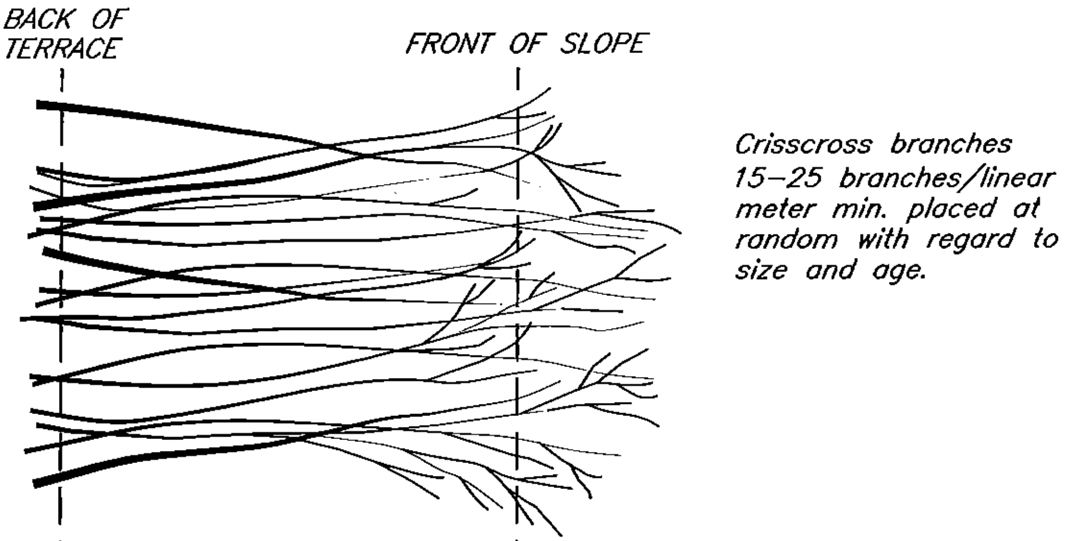


NOTES:

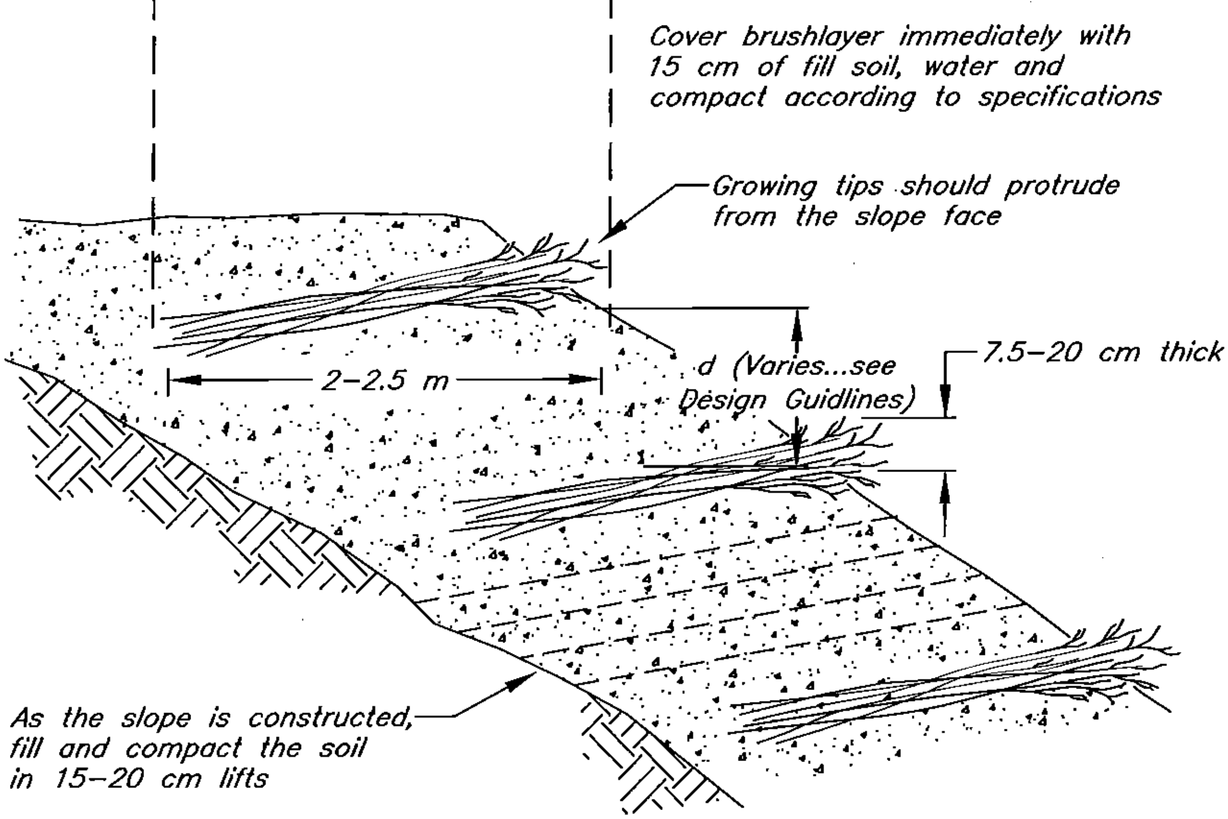
1. Tilt branches down into the slope 10°–20° min.
2. Brushlayering may be constructed with non-compacted or compacted backfill without damage to the brush layer.
3. Branches irrespective of length, should protrude 20–45 cm beyond the face of the slope.

BRUSHLAYERING WITH ROCK TOE PROTECTION

FILE: BRLAY-RT



PLAN VIEW

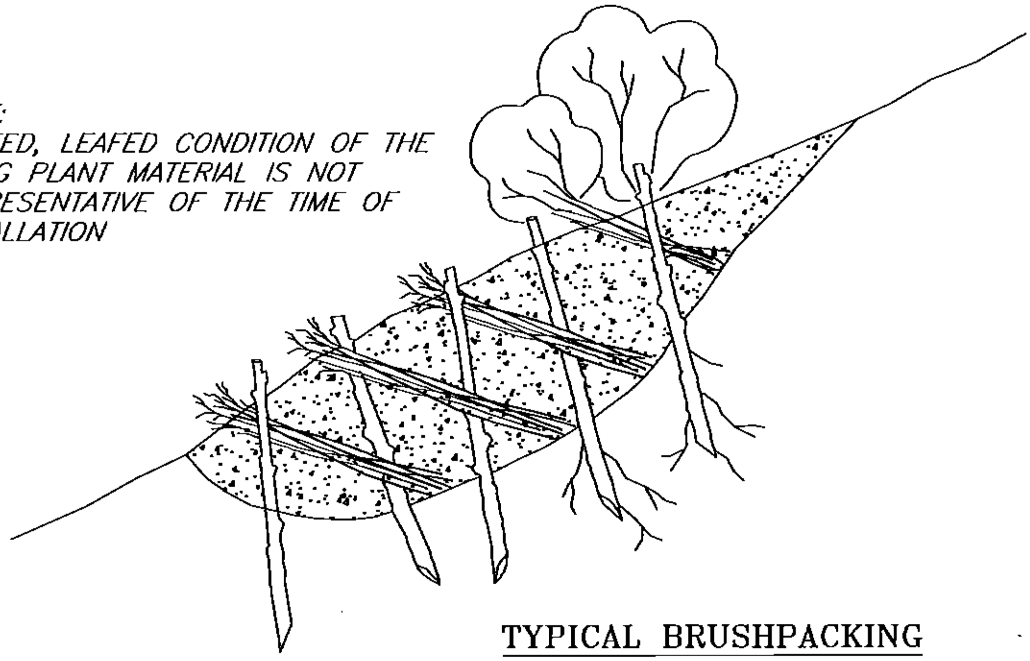


TYPICAL BRUSHLAYERING WITH SLOPE CONSTRUCTION

BRUSHLAYERING

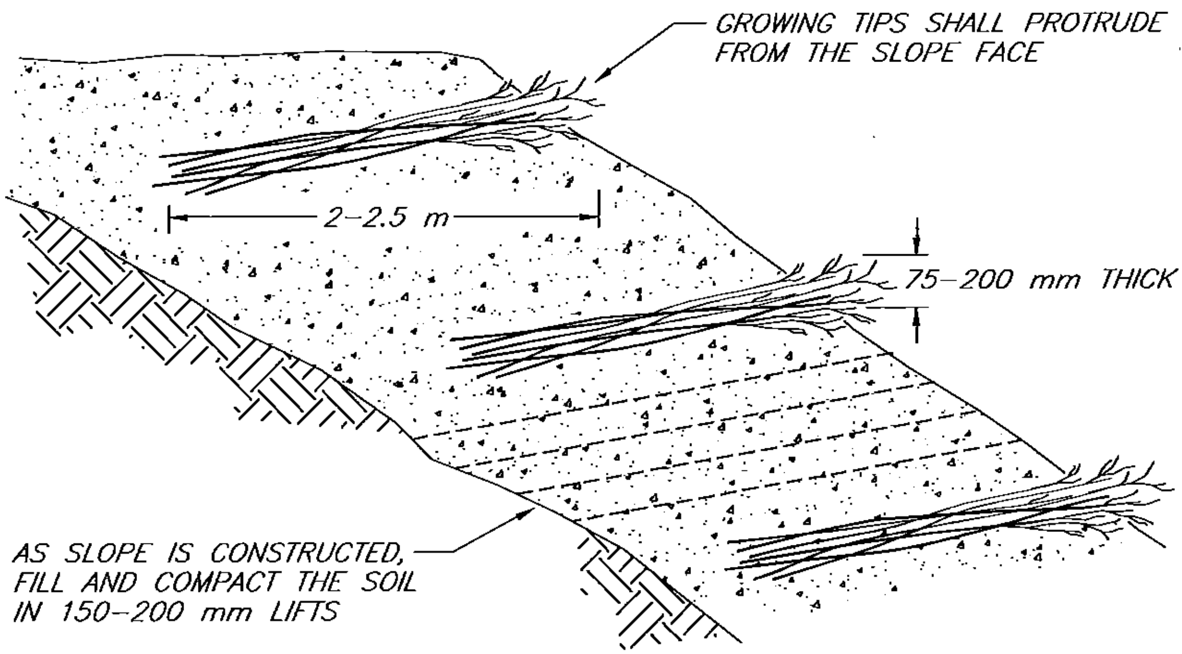
FILE: BRSHLAYR

NOTE:
ROOTED, LEAFED CONDITION OF THE LIVING PLANT MATERIAL IS NOT REPRESENTATIVE OF THE TIME OF INSTALLATION



TYPICAL BRUSHPACKING

COVER BRUSHLAYER IMMEDIATELY WITH 150 mm OF FILL SOIL, WATER AND COMPACT ACCORDING TO SPECIFICATIONS



TYPICAL BRUSHLAYERING WITH SLOPE CONSTRUCTION

NOTE:

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BRUSHLAYERING

FILE: BRSHLAYR

Vegetated Riprap Streambank Stabilization Techniques	B.M.P. #45

Description and Purpose

- Vegetative Rip-Rap combines the widely-accepted, resistive, and continuous rock revetment techniques with vegetative techniques. It consists of a layer of stone and/or boulder armouring that is vegetated, optimally during construction, using pole planting, brushlayering and live staking techniques
- Continuous and resistive bank protection measures, such as riprap and longitudinal rock toes are primarily used to armour outer bends or areas with impinging flows
- The stream energy is resisted by the continuous protection, and is subsequently directed downward into the streambed
- The riprap will resist the hydraulic forces, while roots and branches increase geotechnical stability, prevent soil loss (or piping) from behind the structures, and increase pull-out resistance
- The roots, stems, and shoots will help anchor the rocks and resist 'plucking' and gouging by ice and debris

Applications

- Vegetated Rip-Rap is appropriate where infrastructure is at risk, and where redirective and discontinuous bank protection measures have been rejected or deemed inappropriate
- Vegetative Rip-Rap techniques are sometimes considered mitigation for some of the impacts caused by riprap
- Incorporating large and dense trees may be beneficial where thermal pollution is occurring, along north-facing banks (trees will cast shade) and where cover is necessary to protect fish (rearing habitat)

Advantages

- Correctly designed and installed, Vegetated Rip-Rap offers an opportunity for the designer to attain the immediate and long-term protection afforded by riprap with the habitat benefits inherent with the establishment of a healthy riparian buffer
- Above ground components of the plants will create habitat for both aquatic and terrestrial wildlife, provide shade (reducing thermal pollution), and improve aesthetic and recreational opportunities
- When graded or "self-launching" stone is used, riprap is self-adjusting to small amounts of substrate consolidation or movement
- The revetment can sustain minor damage and still continue to function adequately without further damage

- The rough surface of the riprap dissipates local currents and minimizes wave action more than a smooth revetment (like concrete blocks)
- Stones are readily available in most locations, and materials are less expensive than many other "hard armouring" techniques
- The rock provides a large amount of aquatic habitat
- Rip-Rap is easily repaired by placing more rock where needed
- The fibrous roots of the chosen vegetation prevents washout of fines, stabilizes the native soil, anchors armour stone to the bank, and increases the lift-off resistance
- The vegetation also improves drainage of the slope by removing soil moisture for its own use
- Vegetated Rip-Rap has a more natural appearance, and is therefore more aesthetically pleasing, which is frequently a matter of great importance in high-visibility areas
- In addition, environmental clearances are frequently easier to obtain if the project has biotechnical and habitat enhancement benefits incorporated into the design
- There are many environmental benefits offered by Vegetated Rip-Rap, most of which are derived from the planting of willows or other woody species in the installation
- The willow provides canopy cover to the stream, which gives fish and other aquatic fauna cool places to hide
- The vegetation also supplies the river with carbon-based debris, which is integral to many aquatic food webs, and birds that catch fish or aquatic insects will be attracted by the increased perching space next to the stream
- An additional environmental benefit is due to the use of rock, as the surface area of the rocks is substrate that is available for colonization by invertebrates
- The small spaces between the rocks also provide benthic habitat and hiding places for small fish and fry
- The brushlayering methods reach out over the water, and provide shade and organic debris to the aquatic system

Limitations

- Vegetated Rip-Rap may be inappropriate if flow capacity is an issue, as bank vegetation can reduce flow capacity, especially when in full leaf along a narrow channel
- In remote areas large rocks may be difficult to obtain and transport, which may greatly increase costs

- Riprap may present a barrier to animals trying to access the stream

Construction

The vegetation obtained should be poles of adventitiously-rooting native species (such as willow, cottonwood or dogwood), with a minimum diameter of 38 mm, and be sufficiently long to extend into the vadose zone below the riprap.

Vegetated Rip-Rap with Willow Bundles

- Grade the bank to the desired slope where the riprap will be placed, such that there is a smooth base
- Dig a toe trench for the keyway (if required) below where the riprap will be placed
- Place 10 to 15 cm (5 to 8 stem) bundles on the slope, with the butt ends placed at least 30 cm in the low water table
- This will probably involve placing the poles in the toe trench before the rock is placed, if standard riprap rock is being used
- Digging shallow trenches for the willows prior to placing them on the slope will decrease damage to the cuttings from the rocks, and may increase rooting success because more of the cuttings will be in contact with soil
- The bundles should be placed every 1.8 m along the bank, and be pointed straight up the slope
- Once the bundles are in position, place the rock on top of it to the top of the slope
- The bundles should extend 0.3 m above the top of the rock
- If the bundles are not sufficiently long, they will probably show decreased sprouting success, and therefore, a different technique should be chosen

Vegetated Rip-Rap with Bent Poles

- Grade back the slope where the riprap will be placed, such that there is a smooth base
- Dig a toe trench for the keyway (if required) below where the riprap will be placed
- If non-woven geotextile is being used, lay the fabric down on the slope, all the way into the toe trench, and cut holes in the fabric about 0.6 to 0.9 m above the annual low water level
- Slip the butt ends of the willow poles through the fabric and slide them down until the bases are at least 15 cm into the perennial water table, or at the bottom of the toe trench, whichever is deepest

- If using filter gravel, lay it down on the slope, and place a layer of willow poles on top of the gravel, with the bases of the cuttings at least 15 cm into the perennial water table, or at the bottom of the toe trench, whichever is deepest
- Place the largest rocks in the toe trench
- Ensure that they lock together tightly, as they are the foundation for the structure
- Place the next layer of boulders such that it tapers back slightly toward the streambank
- Bend several willow poles up, such that they are perpendicular to the slope, and tight against the first layer of rocks
- Now place the next layer of rocks behind these poles
- Placement will require an excavator with a thumb, as someone will have to hold the poles while the rocks are placed
- As the poles are released, they should be trimmed to 30 cm above the riprap
- This last step should be repeated until all the poles have been pulled up, and the entire slope has been covered

<u>Vegetated Rip-Rap with Brushlayering and Pole Planting</u>

There are two methods of constructing brushlayered riprap; one involves building up a slope, and the other works with a pre-graded slope – neither method can be used with non-woven geotextile

Method 1 (building up a slope):

- Lay the bank slope back to somewhat less than the desired finished slope
- Dig a toe trench, if needed, and lay the key rocks into the trench. Pack soil behind these rocks, with filter gravel in between the soil and rocks
- Continue installing riprap 0.9 to 1.2 m up the bank
- Slope the soil back into the bank at a 45° angle, such that the bottom of the soil slope is in the vadose zone
- Place a layer of willow cuttings on top of the soil, with the butt ends extending into the vadose zone, and the tips of the branches sticking out 30 to 60 cm
- Place the next layer of stones on top of the initial rocks, but graded slightly back, and repeat the soil and brush layering process
- When finished, trim the ends of the willow branches back to 30 cm
- Do not cut shorter than 30 cm, as the plant will have difficulty sprouting

Method 2 (pre-graded slope):

- Lay the bank slope back to the desired finished grade, and dig a toe trench if self-launching stone is not being used
- Place the largest rocks in the key-way, and fill in behind with filter gravel and soil
- Continue installing riprap 0.9 to 1.2 m up the bank
- Place the bucket of an excavator just above the layer of rocks at a 45° angle
- Pull the bucket down, still at a 45° angle, until the water table is reached, or the stream is dry, to the elevation at the bottom of the key trench
- Pull up and back on the bucket; this will provide a slot in the bank into which willow poles can be placed
- Throw in some willow poles (about 18 poles per linear m), ensuring that the butt ends are at the bottom of the trench
- Release the scoop of earth, and allow it to fall back in place on the slope
- Then place the next layer of rock on top of the branches, flush with the slope
- If self-filtering stone is not being used, filter gravel should be placed behind the rocks
- Repeat the process, beginning again with pulling back a scoop of soil
- Continue this process to the top of the slope, or if preferred, use joint-planted riprap on the upper slope, where it is difficult to reach the perennial water table with the excavator bucket
- When finished, trim the ends of the branches back such that only 30 cm extends beyond the revetment

Construction Considerations

- The technique can also be used in conjunction with other techniques, particularly resistive techniques, designed primarily to protect the bank toe (Vegetated Rip-Rap and Rootwad Revetments) and redirective techniques (Bendway Weirs, Spur Dikes, and Vanes)
- While riprap is very effective at arresting bank erosion and providing relatively permanent bank protection the environmental consequences can be less than desirable and should, therefore always be taken into account when selecting an environmentally-sensitive streambank stabilization treatment
- Scour counter-measures are sometimes required for continuous and resistive rock bank protection
- One alternative is a rock-filled key trench, designed with appropriate scour analysis

- Another counter-measure that may be employed is the use of graded, self-launching stone

Filter Material:

- Some sort of filter material is typically used to prevent piping of fine soils from below the riprap, if self-launching stone is not used
- There are two choices: non-woven geotextile fabric or graded filter gravel
- Non-woven geotextile fabrics are not recommended for use in Vegetated Rip-Rap, as roots have difficulty penetrating the fabric
- If non-woven geotextile fabric is required, one can cut holes in the fabric where the vegetation is placed
- Small slits in the fabric are especially appropriate with the bent pole method
- Filter gravel is the preferred filter media for Vegetated Rip-Rap

Rock Size:

- There are two options for rocks – self-launching/self-filtering rock or standard riprap
- The advantage of self-launching/self-filtering rock is that the revetment will build its own toe, by self-launching, in any scour hole that forms
- The different sizes of rock act as their own filter medium, so no geotextile fabric or filter gravel is needed
- This decreases cost, and also makes installation less labour-intensive for two of the three methods of installation
- Using self-launching stone is dependent on a source of graded rock, which is not always available

Inspection and Maintenance

- Riprap should be visually inspected as frequently as outlined in the PESC and TESC Plans, with focus on potential weak points, such as transitions between undisturbed and treated areas
- Soil above and behind riprap may show collapse or sinking, or loss of rock may be observed
- Inspect riprap during low flows annually, to ensure continued stability of the toe of the structure
- Treat bank or replace rock as necessary

Design Considerations

- It often takes many years for riprap to become vegetated if vegetation is not integrated into its design and construction at the outset
- Flanking, overtopping or undermining of the revetment due to improperly installed or insufficient keyways is one of the biggest reasons for failure of riprap
- Improperly designed or installed filter material can also cause undermining and failure of the installation
- Undersized stones can be carried away by strong currents, and sections of the revetment may settle due to poorly consolidated substrate
- Vegetation may require irrigation if planted in a nondormant state, or in extremely droughty soils

<u>Vegetated Rip-Rap with Willow Bundles</u>

Is the simplest to install, but it has a few drawbacks:

- This technique typically requires very long (3 to 7m) poles and branches, as the cuttings should reach from 15 cm below the low water table to 30 cm above the top of the rock
- Only those cuttings that are in contact with the soil will take root, and therefore, the geotechnical benefits of the roots from those cuttings on the top of the bundle may not be realized

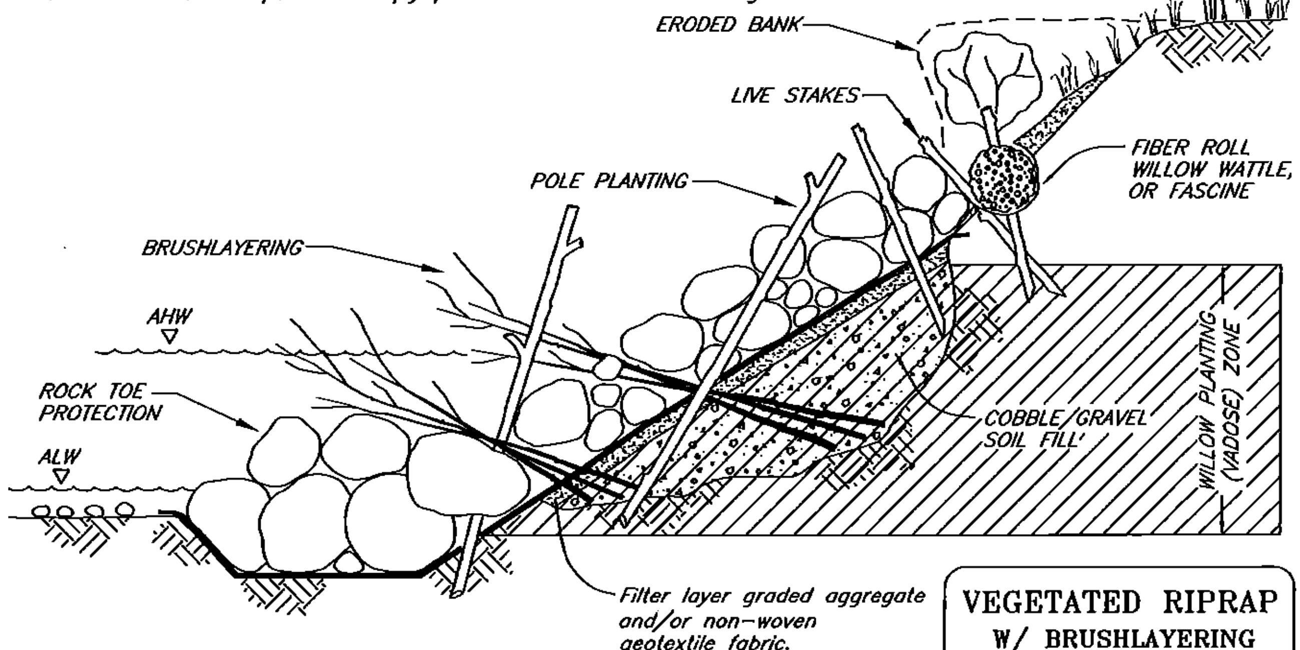
<u>Vegetated Rip-Rap with Bent Poles</u>

- Is slightly more complex to install
- A variety of different lengths of willow cuttings can be used, because they will protrude from the rock at different elevations
- The angle can be three to one, or forty-five degrees
- A tree and root growth will develop the entire length of each pole planted

<u>Vegetated Rip-Rap with Brushlayering and Pole Planting</u>

- Is the most complex type of riprap to install, but also provides the most immediate habitat benefits
- The installation of this technique is separated into 2 methods; one method describes installation when building a bank back up, while the other is for a well-established bank
- If immediate aquatic habitat benefits are desired, this technique should be used
- May not provide the greatest amount of root reinforcement, as the stem-contact with soil does not extend up the entire slope

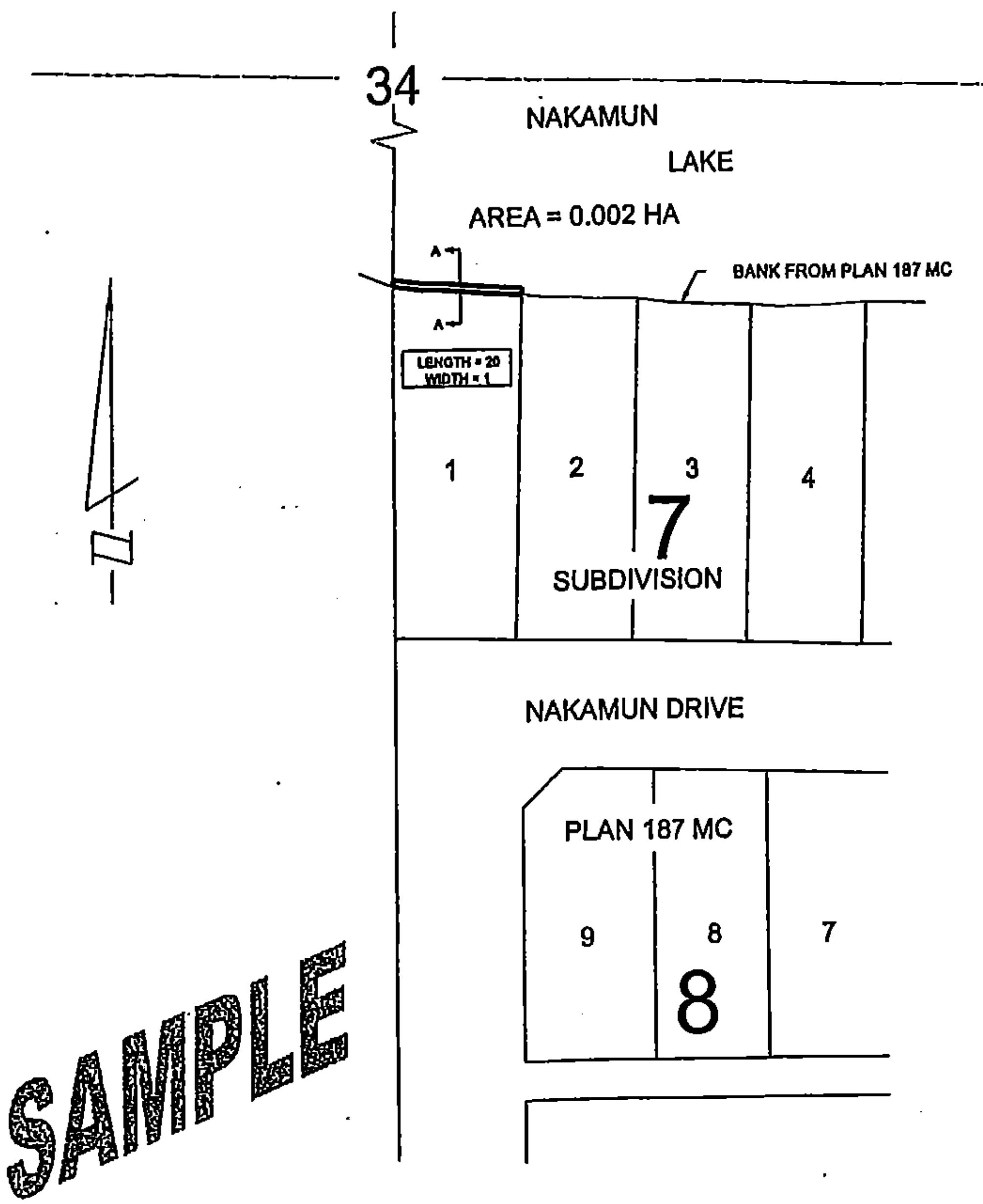
NOTES:
1. Install willow pole planting and brushlayering during bank grading and riprap placement to ensure good contact with 'native ground' and/or soil fill.
2. Willow poles and brush layers shall extend down into expected soil moisture zones (vadose).
3. Cut small holes or slits in geotextile fabric as necessary.
4. Place soil fill (cobbles, gravel, soil) around cuttings.
5. Place riprap carefully, do not end dump. Some damage to brush layers and willow poles is unavoidable and acceptable. Deeply planted willow material will regenerate.



VEGETATED RIPRAP
W/ BRUSHLAYERING
& POLE PLANTING

VGRIPRAP

TOWNSHIP 56, RANGE 2 WEST 5



PLAN SHOWING LOCATION
OF
BANK STABILIZATION

PLAN PREPARED FOR :
PLAN PREPARED BY :
FILE #:

SCALE: 1:1000
DISTANCES IN METRES

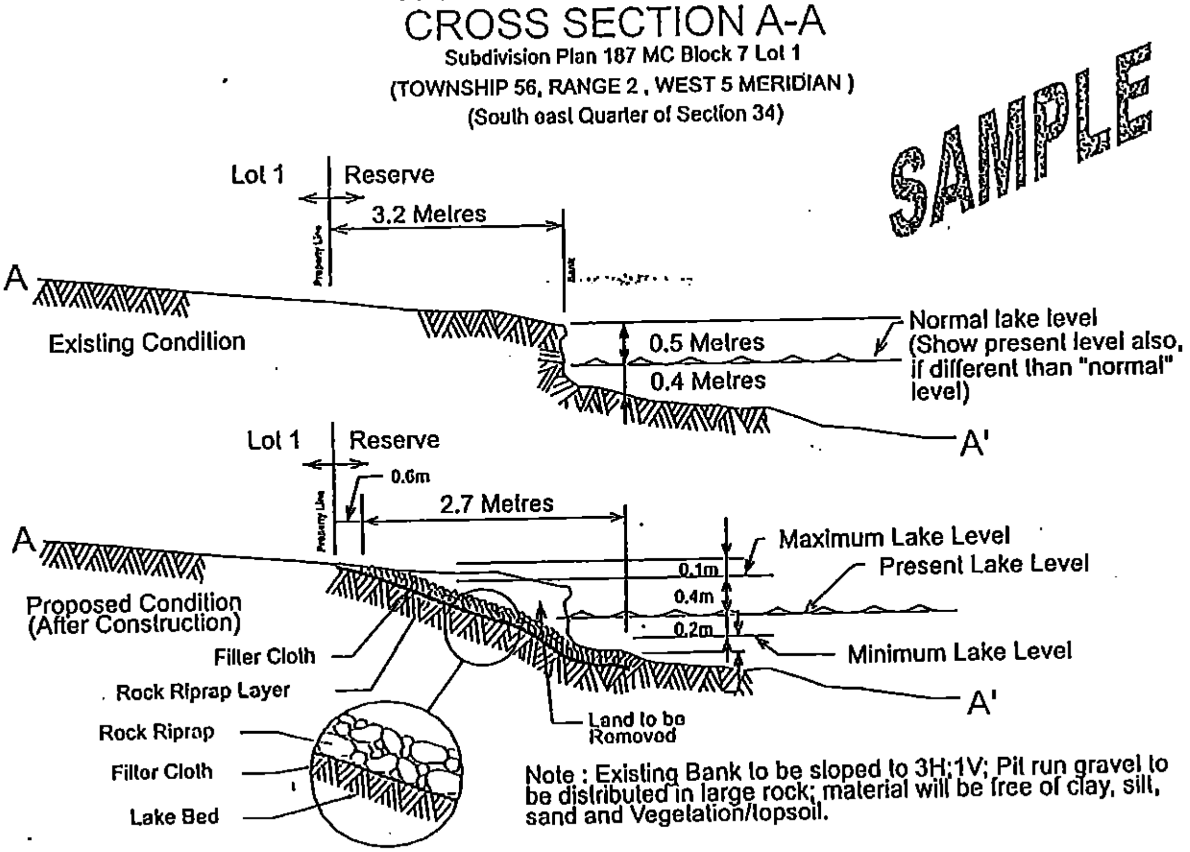
SAMPLE OF PLAN REFERENCING BASE "D"

BANK STABALIZATION
CROSS SECTION A-A

Subdivision Plan 187 MC Block 7 Lot 1

(TOWNSHIP 56, RANGE 2 , WEST 5 MERIDIAN)

(South east Quarter of Section 34)



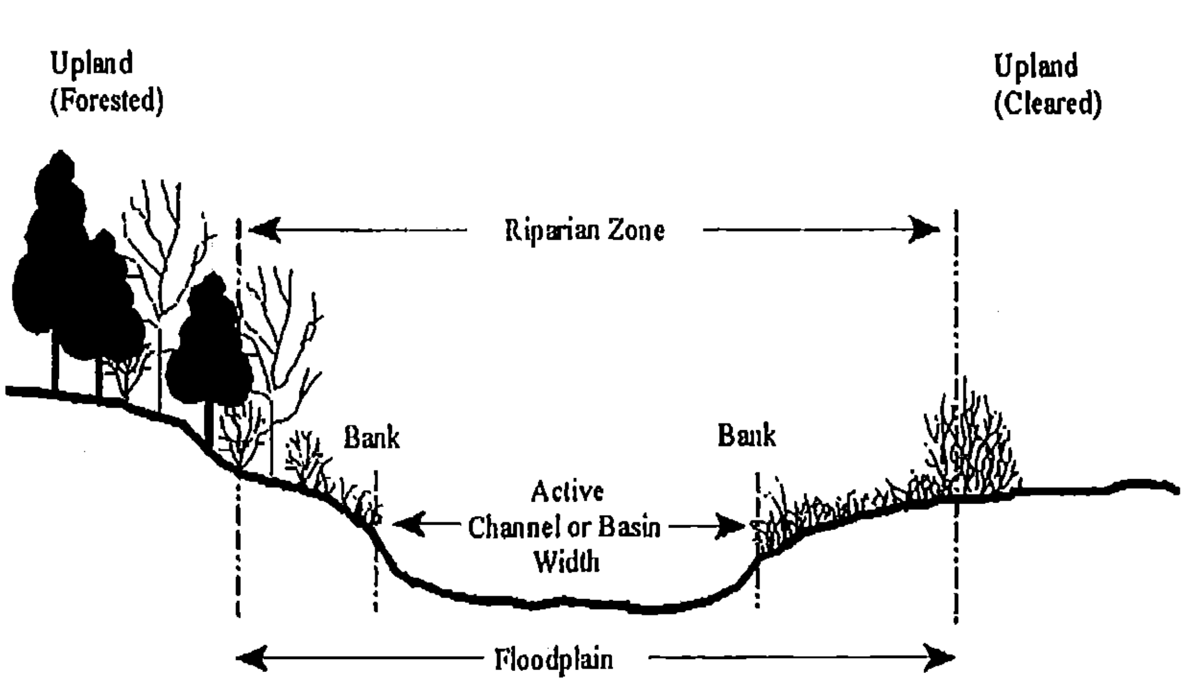
PLAN PREPARED FOR :

PLAN PREPARED BY :

FILE #:

DISTANCES IN METRES

LEGISLATION AFFECTING WATER BODIES IN ALBERTA*



PUBLIC LANDS ACT
WATER ACT
ENVIRONMENTAL PROTECTION & ENHANCEMENT ACT
MUNICIPAL GOVERNMENT ACT
SAFETY CODES ACT *Alberta Private Sewage System Standard of Practice*
FISHERIES ACT *(Federal)*
NAVIGABLE WATERS PROTECTION ACT *(Federal)*

* Not all applicable legislation is depicted in the table, only the most commonly encountered.

Respect Our Lakes