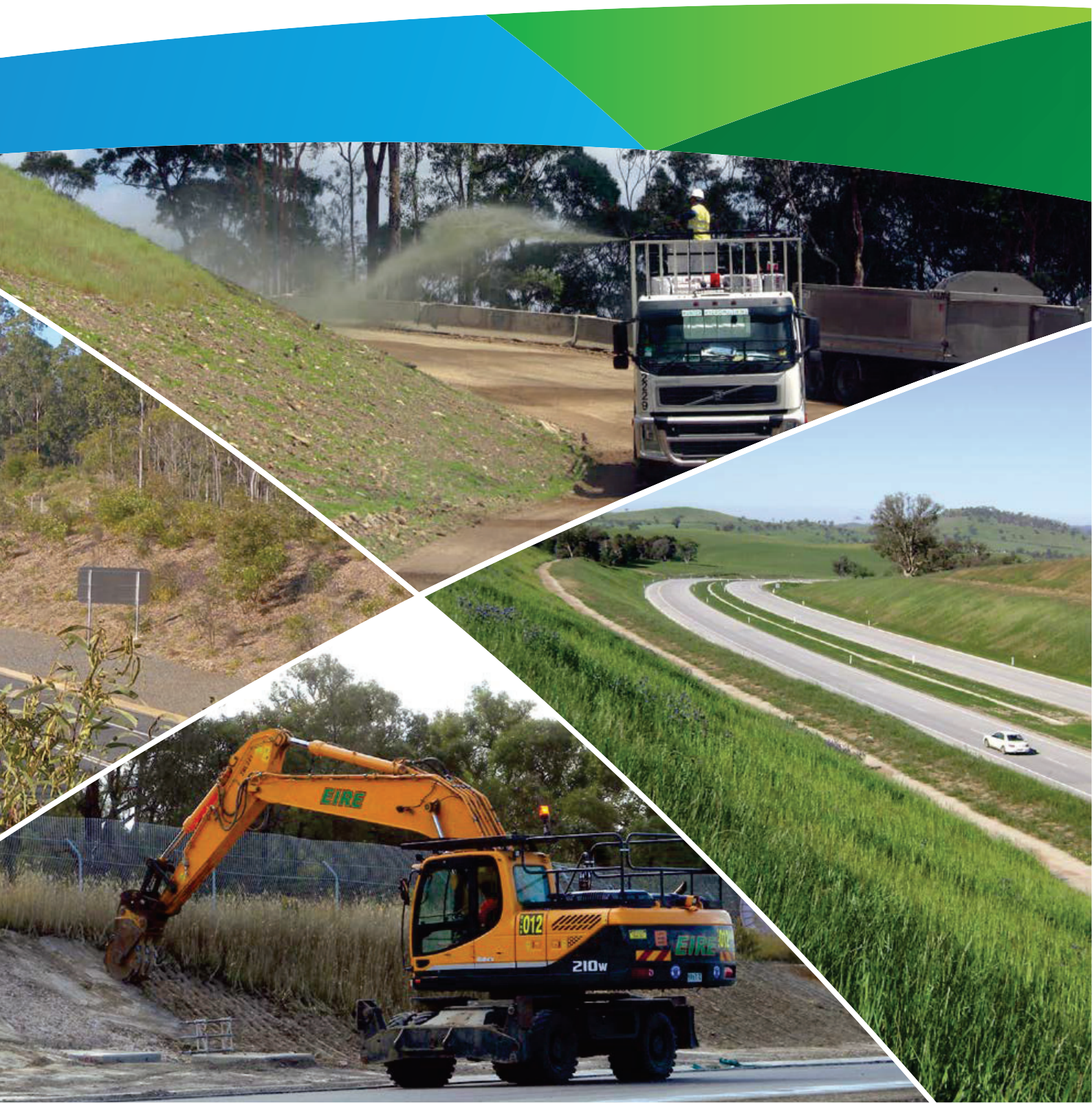
Roads & Maritime

Guideline for Batter Surface Stabilisation

using vegetation



About this release

	Guideline for Batter Surface Stabilisation using vegetation

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1.0	April 2015	Publication of Guideline for Batter Surface Stabilisation using vegetation

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Contents

Section 1
Use and scope of this guideline

The construction and maintenance of roads often results in long linear stretches of 'batter' adjacent to the road alignment that are exposed and at risk of erosion if left unstabilised. This document has been prepared to provide guidance for NSW Roads and Maritime Services staff and contractors on batter surface stabilisation solutions using vegetation.

1.1 Purpose

The purpose of this guideline is to provide guidance on the suitability of various batter surface stabilisation techniques using vegetation for a range of site conditions.

The Guideline considers:

- Factors that should be used to select appropriate batter surface stabilisation solutions
- The aspects of specific batter surface stabilisation techniques
- Existing Roads and Maritime specifications, procedures and guidelines
- Application for both temporary vegetation cover and long-term landscaping requirements
- The ability to use both temporary and long-term methods to achieve stability.

1.2 Scope

The Guideline addresses common batter surface stabilisation scenarios using vegetation that are likely to be encountered by Roads and Maritime staff and contractors during the construction and maintenance of roads in NSW regardless of their scale or extent of works. It includes sufficient detail on a range of batter surface stabilisation techniques to allow users of this Guideline to make informed decisions on which techniques are most appropriate for their given site. Users of this guideline must consider the whole of life maintenance costs and safety in design, construction and maintenance activities.

The Guideline does not address geotechnical or civil engineering aspects of batter surface stabilisation and a separate assessment of geotechnical stability should always be conducted. The techniques described in the Guideline can be used to aid geotechnical stability. It is important to note that the Guideline is for surface stabilisation. **All references to "stabilisation" should be read as "surface stabilisation".** Whenever there is doubt about the geotechnical stability of a batter contact your local Environment Officer for further advice on other disciplines and expertise to be sought (see Section 5 Contacts).

1.3 How to use this guideline

Readers are encouraged to use the digital version of this Guideline as hyperlinks are provided throughout to allow easy navigation between sections – they are indicated with blue underline.

The Guideline provides background information in Sections 2-6, and then uses that background information to detail a range of specific batter surface stabilisation techniques in Section 7 Fact sheets.

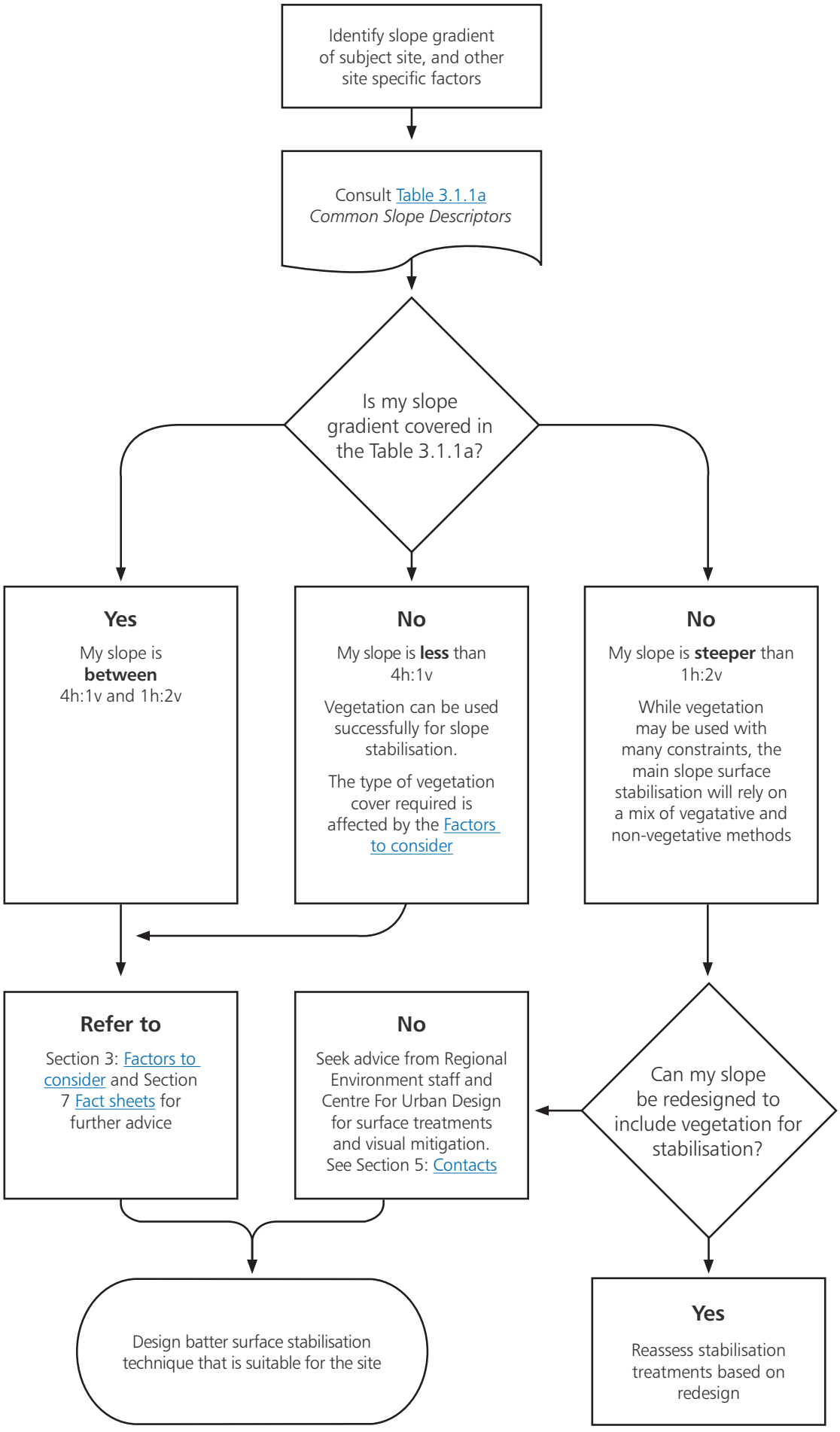
The limiting factor in most batter surface stabilisation scenarios is the batter slope. Section 2 provides a Decision support table that can be used to shortlist the batter surface stabilisation techniques that might be suitable for a given site, based on the slope of the batter/s in question. It also provides indicative information on the cost of each technique and the likely timeframe until erosion protection is achieved for each.

Once the slope of a batter has been used to shortlist potentially suitable batter surface stabilisation techniques, there are many other factors that must be considered in order to select the most appropriate batter surface stabilisation technique for a given site. Information on other Factors to consider is provided in Section 3.

Section 7 provides a series of fact sheets on the range of Batter Surface Stabilisation Techniques that are available, including detailed information on the Factors to consider as they relate to each technique.

The process for using this Guideline is shown in Figure 1.3, over page.

Figure 1.3: Process for using this guideline



Section 2
Batter surface stabilisation – Decision support table

Table 2 – Decision support table provides a summary of the slope conditions for each batter surface stabilisation technique that might be suitable, as well as the indicative cost of each to install and the time period until each technique will provide surface erosion protection (see Key below). The information should only be used for the purposes of short-listing potential stabilisation options for a particular site. The relevant factsheets should then be consulted to provide details about each technique and to select the most appropriate option/s from the shortlist.

Key

Suitability for Slope	
	Technique is likely to work for slope
	Technique may work for the slope, if supplemented with other techniques
	Technique is not likely to work for the slope

Indicative Cost (at time of publication)	
	Low (~ $0.15 – $1.50/m^2)
	Moderate (~ $1.50 – $5.00/m^2)
	High (~ $5.00 – $10.00/m^2)
	Very High (~ $10.00 – $35.00/m^2)

Time until erosion protection	
	Slow (relies on establishment of vegetation)
	Rapid (within 48 hours, but erosion protection will be enhanced with vegetation establishment)
	Rapid (within 48 hours)
	Immediate (effective as soon as installation is complete)

Table 2 – Decision support table

Batter stabilisation technique	Indicative cost	Time until erosion protection	Suitability for slope (described as horizontal run (h) to vertical rise (v) – see Table 3.1.1a)					
			4h:1v	3h:1v	2h:1v	1.5h:1v	1h:1v	1h:2v
Drill/Broadcast seeding	$							
Soil binder – Bitumen emulsion	$							
Soil binder – Tackifier	$							
Mulch/Topsoil mixes	$							
Hydroseeding	$							
Straw mulching	$							
Hydromulching – Standard	$							
Hydromulching – Bonded fibre matrix	$							
Hydromulching – Hydrocompost	$							
Erosion control blanket – Organic fibre	$							
Erosion control blanket – Synthetic	$							
Cellular confinement systems	$							
Compost blanket	$							
Placed turf	$							
2-D turf reinforcement mats	$							
3-D turf reinforcement mats	$							

Section 3
Factors to consider

The stability of a landform surface is a function of many factors. Some factors, such as site access (see Section 3.7) and Bioregion (see Section 3.6), are relatively constant over a significant area and not readily changed. However, other factors such as the growing media, vegetation type and (less often) slope length are variable and can be tailored to a specific site to achieve appropriate batter surface stabilisation. To ensure successful batter surface stabilisation, it is important that all relevant factors are considered. Generic information about these factors is discussed in the following sub-sections – this information can be used to help interpret the Fact sheets (see Section 7) about specific batter surface stabilisation techniques.

The following list of factors is not exhaustive. There may be other factors relevant to your site that may also require consideration (eg hydro-geography). Contact your local Environment Officer (see Section 5) for further advice on other site specific issues if required.

- Slope
- Level of erosion protection
- Growing media
- Soil and growing media testing
- Soil amelioration
- Bioregion
- Access requirements
- Duration
- Visual amenity and ecological outcome
- Vegetation type
- Establishment time until erosion protection
- Cost
- Preparation
- Rate of vegetation establishment
- Quality assurance and surveillance
- Establishment and maintenance.

3.1 Slope

The most significant aspects relating to the slope of a batter are the slope gradient and the slope length. For the purposes of this guideline, where a batter has complex shapes or multiple gradients, the selection of a stabilisation technique should be based on the steepest gradient and the longest slope on the given batter. Different stabilisation techniques may be used concurrently.

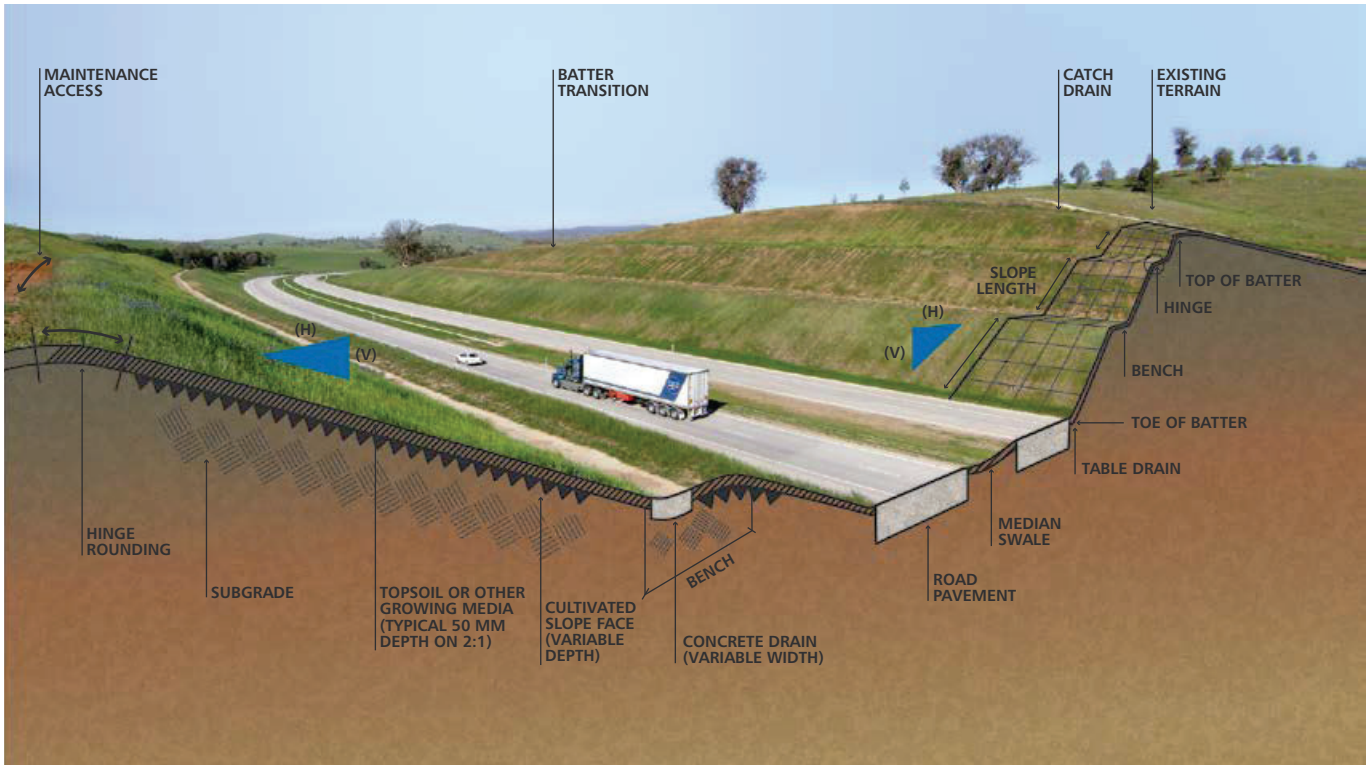


Figure 3.1: Typical profile of a batter.

3.1.1 Slope gradient

The slope gradient of a batter is usually the most significant parameter when considering any stabilisation technique. This must be determined using accurate site survey data, which may include site modifications during construction. Slope gradient can be defined in a number of ways, however the most common ways are as the horizontal run to vertical rise of the slope, ratio or as a percentage slope. Slopes can also be referred to as the angle however these are not widely used. For example:

- If a slope has a vertical rise of 1 metre over a horizontal distance of 10 metres it is referred to as having a slope of 10h:1v. This convention will be used throughout this document
- The slope percentage is calculated as the rise of the slope divided by the run, multiplied by 100. So a 10h:1v slope is [(1/10) x 100], which equals 10 percent.

When constructing roads and the associated batters, it is important to ensure that the batter slope gradient is appropriate for the geotechnical and erosion characteristics of the soil. If unsure, seek further advice (see Section 5).

In general, topsoil should not be placed on slopes steeper than 2h:1v without any additional means of stabilisation as there is a high risk of the topsoil slipping off the slope. Further, slopes steeper than 2h:1v are unsafe for access on the slope face without fall attenuation devices. The maximum thickness that topsoil should be applied on a given slope is summarised in Table 3.1.1b. Topsoil may be blended or conditioned with other materials to increase the depth if required.

The slope gradient influences:

- The ability to apply and hold topsoil or some other growing media on the slope
- The ability to incorporate ameliorants into the soil on the slope in-situ
- The type of machinery and equipement needed to prepare the slope and undertake stabilisation works and
- The erosion risk from run-off velocity and slip failures.

Table 3.1.1a provides examples of the common slope descriptors.

Figure 3.1.1: Topsoil being progressively applied over a prepared batter.

Table 3.1.1a: Common Slope Descriptors.

	Slope as 'x' in 1	Slope as horizontal run (h) to vertical rise (v)	Slope as percentage	Slope as degrees from horizontal	**Landscape** (adapted from NSW Department of Primary Industries, 2009)
	4 in 1	4h:1v	25%	14°	Moderate slope
	3 in 1	3h:1v	33%	18°	Steep slope
	2 in 1	2h:1v	50%	26°	Steep slope
	1.5 in 1	1.5h:1v	66%	33°	Very steep slope
	1 in 1	1h:1v	100%	45°	Very steep slope
	0.5 in 1	1h:2v	200%	63°	Very steep slope

Table 3.1.1b: Maximum Topsoil Thickness by Slope.

Slope	Maximum Topsoil Thickness
> 2 in 1	Seek advice from local environment officer.
3 in 1 ≤ 2 in 1	50 millimetres.
≤ 3 in 1	100 millimetres.

Note: the ability of a slope to hold topsoil is dependent on site-specific conditions and slope design. Seek advice if the batter topsoils need to be a different depth to those indicated in Table 3.1.1b.

3.1.2 Slope length

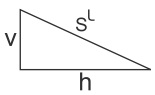
The length of the batter slope influences the potential for erosion.* As the slope lengthens, so does the potential overland flow and associated erosive forces. On very long slopes, these forces are generally observed as sheet erosion at the top of the batter, turning into rill erosion at the bottom of the slope (see Section 3.2). The distance over which this will occur is based on a number of factors including:

- Slope gradient
- Soil type
- Surface roughness
- Surface cover

To minimise the erosion caused by long slope lengths and to maximise the efficiencies of the stabilisation treatments applied to the batter, consider some general controls used in soil conservation such as breaking up the slope length with benches or terraces. It is critical that any control or bench be installed in a continuous line along the contour. Otherwise, gravity will direct water along the control and eventually concentrated flow will be directed to a single location where it could cause significant erosion. Gradient benches or terraces are constructed along the face of a slope to reduce erosion by capturing surface runoff and directing it to a stable outlet at a speed that minimizes erosion and prevents ponding. Concrete lining of these controls, such as catch drains, may be necessary to prevent erosion and infiltration to the slope.

* Slope length is the total distance from batter hinge to toe, calculated by:

$$S^L = \sqrt{(h^2+v^2)}$$



Advice can be sought from an independent soil scientist on the maximum slope length that should be allowed based on the erodability of the soil. Where advisory lengths are exceeded then consideration should be given to re-engineering the batter to conform with the slope length, or selecting a more robust stabilisation technique.

Figure 3.1.2a: A large batter slump due to insufficient batter preparation.

Figure 3.1.2b: A batter that had been incorrectly vertically scarified during construction, creating preferential flowpaths for runoff, which has started causing rill erosion.

3.2 Level of erosion protection

In most Roads and Maritime road construction projects upstream surface flows are diverted away from batters using catch drains and benches. This means that the batter surface stabilisation technique used and any subsequent vegetation that grows only has to withstand raindrop splash impact and overland flow generated on the batter itself. The stabilisation techniques described in this Guideline assume that upstream overland flows are diverted away from the slope. It is also important to ensure that water does not pond on or above the slope, particularly where dispersive soils are present.

There will be situations however, on lower standard or older roads where concentrated or overland flows are not diverted away from the slope. Such conditions will require more intensive stabilisation techniques to withstand the flow velocities and avoid erosion and slumping.

However, in all situations some volume of water will flow over a batter, and each stabilisation technique will provide a different degree of erosion protection to withstand the flow conditions. There are three broad categories of flow conditions, as described in Table 3.2.

Table 3.2: Flow Conditions.

Flow condition	Description
Raindrop splash impact	Minimal erosion potential. The first stage of the erosion process. The energy of raindrops hitting the soil surface can displace soil particles and destroy soil structure. This enables the soil particles to be transported downstream when either sheet flow or concentrated flow occurs. See Figure 3.2a.
Sheet flow	Moderate erosion potential. When water flows down a relatively smooth slope with a thin, consistent depth and is not concentrated into channels. See Figure 3.2b.
Concentrated flow	High erosion potential. When runoff is concentrated in well-defined channels. The concentration of the water results in increased velocity and energy and hence erosion potential. See Figure 3.2c.

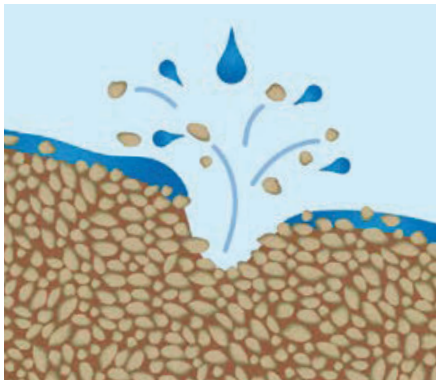


Figure 3.2a: Raindrop splash impact displacing soil particles and allowing downstream transport.

Figure 3.2b: Sheet flow over batter, Pacific Highway, Glenugie Upgrade.

Figure 3.2c: Concentrated flow on a batter during a heavy rain event.

3.3 Growing media

All of the stabilisation techniques presented in this Guideline should ultimately involve the use of vegetation to assist in the stabilisation process. All vegetation needs suitable growing media to germinate, grow and persist – this includes site-won soil, imported soil and other soil replacement products. During construction the natural soil profile is substantially disturbed by stripping, stockpiling and changing the landforms by cutting, filling and creating mounds or basins. Respreading topsoil can mix multiple soil layers and significantly alter the physical, chemical and biological properties of the soils from those that existed pre-disturbance.

3.3.1 Types of growing media

The most common growing media that will be used when undertaking revegetation works include:

- Topsoil – the upper, outermost layer of soil (usually the top 5–20cm) typically comprised of the O and A horizons and contains the highest concentration of organic matter and micro-organisms and is where most of the biological soil activity occurs. The depth and quality of topsoils around NSW have marked variance. Site-won soils may contain weed seed and other deleterious material, but also may contain a native seed bank that can be used for natural regrowth
- Subsoil – the soil beneath the topsoil and overlying the bedrock where the biological, physical and chemical characteristics often inhibit the establishment of plants and require significant amelioration to be a suitable growing media. The subsoil typically comprises the B and C horizons
- Compost – organic matter that has been decomposed and recycled as a fertilizer and soil amendment, or in some cases a dedicated growing media
- Ameliorated soils – additives blended with the soil to improve the growing media characteristics. Ameliorants may include lime, gypsum, fertilisers, compost or other organics. Ameliorated soils should be used in accordance with project specifications and soil test recommendations. Previously disturbed sites may not have any discernible soil horizons.

Growing media intended for use on batters should be provided to enable safe establishment of vegetation that is suitable for thin and dry soils only. The growing media should not be used for water infiltration to the structural batter.

Figure 3.3a: Topsoil being re-applied to a batter, after it was stripped and saved during the construction process.

3.3.2 Growing media quality

The quality and depth of topsoil will vary considerably across regions and sites. It is possible to improve the quality of this resource by direct supervision and surveillance of topsoil stripping activities and adjusting the stripping depth appropriately.

Topsoil is the most important growing media. During construction activities it should be collected and protected for future revegetation wherever possible. Essential elements for plant growth in the soil are accumulated in the topsoil by plant and soil organisms. Plant roots draw nutrients from the soil throughout the soil profile. As vegetative material falls from plants and plants die, the organic material and nutrients end up higher in the soil profile, forming the O horizon (see Figure 3.3.2).

Figure 3.3.1: Examples of different soil profiles from around NSW. The lower two images are supplied courtesy of SESL Australia Pty Ltd.

When stripping topsoils it is critical to:

- Avoid stripping during excessively wet or dry conditions
- Avoid compacting topsoil stockpiles
- Do not mix soil horizons contaminated with weed seeds or deleterious materials
- Revegetate topsoil stockpiles as soon as possible to re-initiate the processes of soil biota.

Topsoil stripping is ideally done after the soil profile is understood. Testing for soil quality can be done at this stage and unsuitable materials separated for improvement and reuse, or disposal. A soil stripping plan outlines the depths of stripping and any identified limitations. Ameliorants may be incorporated during stripping, in stockpile or in-situ (see Section 3.5).

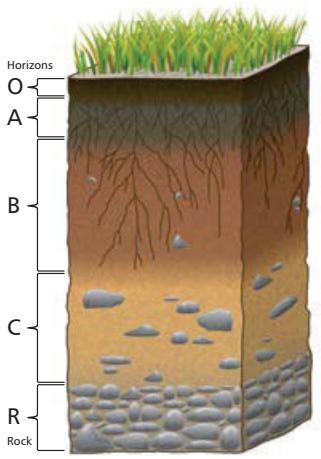


Figure 3.3.2: Soil Horizons.

If not properly managed, the process of stockpiling stripped topsoil can significantly impact soil biota and soil chemistry. The topsoil can change from an aerobic state to an anaerobic state and putrefy. Soil biota can die and the processes they control (carbon conversion, humus formation, water uptake, nutrient cycling, nitrogen fixation) can cease to function.

Site won topsoil and subsoils can usually be reused, but in cases where construction limitations mean that it is not always possible to adequately strip, manage and re-use topsoil, batter surface stabilisation works therefore often involve revegetating on subsoils that do not necessarily have soil properties to sustain plant growth. In these cases, soil amelioration will be required (see Sections 3.4 and 3.5).

The subsoil and/or growing media must not be compacted after preparation or placement over the batter slope. Compaction of the subsoil will causes loss of cohesion of the growing media to the slope, and compaction of the growing media will impair conditions for vegetation to germinate and establish. Note that when topsoil is properly stripped, managed and reused to its optimal quality, there will be benefits in reducing material costs.

There are also pre-existing factors that can limit the availability of topsoil during a construction project. Previous weed infestation at a location can mean that the topsoil can be inappropriate for reuse due to weed seed in the soil which will result in re-infestation of weeds. Topsoil can also be simply unavailable due to previous poor land management activities or existing site conditions.

If there is no topsoil available on site, a growing media must be imported. This could include topsoil from another location or manufactured products such as compost blanket.

No matter what the growing media is, project managers must understand its quality and suitability for the intended use. All growing media, either sourced from site or imported, must comply with the applicable standards for soil, mulch and soil conditioners (eg Australian Standard 4454). There are three basic steps to ensure that appropriate revegetation options are selected and that the chance for successful vegetation establishment is maximised – see Flowchart 3.3.

1. **Sample** and test the growing media at an appropriate soil laboratory and obtain a written report detailing recommendations of the materials suitability for re-vegetation. (see Section 3.4)

2. **Ameliorate** the growing media as recommended by an independent soil scientist. (see Section 3.5)

3. **Apply** the amelioated growing media to surfaces prepared in accordance with the chosen stabilisation technique requirements. (see Fact sheets)

Flowchart 3.3: Achieving suitable growing media.

3.4 Soil and growing media testing

Soils cannot be managed or ameliorated without soil testing data. Revegetation programs worth hundreds of thousands of dollars have failed on road projects due to the failure to undertake adequate soil testing and amelioration of the soil.

Sufficient soil samples must be collected to:

- Account for the different soil types within or proposed for the slope
- Ensure there is sufficient depth for the rooting depth of plants.

In the past soil sampling programs have focused only on the topsoil, however plant roots often extend into the subsoil and therefore understanding the physical and chemical properties of the subsoil is important. To ensure samples are representative of the stockpiled or in-situ soils, advice should be sought from an independent soil scientist on an appropriate sampling regime.

Soil testing should be undertaken as early as possible to allow sufficient time for amelioration, however if growing media conditions have changed (eg stockpile relocation; compaction; mixing with new materials) follow-up testing must be undertaken.

Soil sampling equipment must not contaminate the samples. Stainless steel is the preferred material for sampling equipment. The location of each sample should be recorded using a GPS. Samples should be placed in a sealable, heavy duty, clean, unused plastic bag. Check with the laboratory or a soil scientist for the minimum sample size required for the analysis – this is usually at least 500 grams of soil for each sample. The sample location, depth and date must be recorded on the bag. Samples from stockpiles must include the stockpile marker and sampling location.

A report should be requested from an independent soil scientist that includes results from the testing and recommendations on how to ameliorate the soil. Results will be improved if details of the stabilisation technique and recommended vegetation type are also provided. See Section 5 for contact details.

Figure 3.4: Collecting a soil sample in a clean sterile bag. (Source: SESL Australia Pty Ltd)

3.5 Soil amelioration

The ability to rapidly establish and sustain vegetation growth is essential for effective batter surface stabilisation. Therefore soils must be ameliorated as close as possible to optimum conditions for the desired vegetation outcome. Ameliorants must be mixed into the soil to be effective and may be added to both topsoil and subsoils. Amelioration methods and products are dependent on the growing media quality for each project and may even vary between sections or stages of a project. There is no single formula which will work in all situations.

3.5.1 Types of soil ameliorants

Typical soil ameliorants, and their target soil deficiency, are provided in Table 3.5.1a.

Table 3.5.1a: Typical Soil Ameliorants.

Soil Ameliorant	Target Soil Deficiency
Fertiliser	Nutrient deficiencies must be appropriate for target vegetation type (eg low phosphorus for natives).
Lime	Low pH.
Sulphur	High pH; legume stimulant in some conditions.
Gypsum	Dispersion; sodicity; soil structure; calcium to magnesium ratio.
Compost	Low organic carbon, structure, water holding capacity, calcium to magnesium ratio.
Wetting agents	Hydrophobicity.
Biological inoculants	Lack of natural soil biota such as Rhizobium, Mycorrhiza fungi and humates. High quality topsoil is not always available in the quantities needed to meet the objectives of a revegetation project. In such cases, infertile subsoils can be augmented by the incorporation of organic matter and biological inoculants. This practice can be an important tool to begin the process of rebuilding a soil and re-establishing native vegetation.

Table 3.5.1b – Soil Amelioration Matrix. (Source: SESL Australia Pty Ltd)

		pH (in water)		
		Low (<5.5).	Optimum (5.5–7).	High (>7).
Ratio ca:mg	Low (<3) – These are typically dispersive soils, which are erodable and usually low in Ca.	Add $CaCO_3$ (Lime); raises pH and Ca.	Add CaSO4 (Gypsum).	Add Sulphur or Iron Sulphate + gypsum.
	Optimum (3–8).	Add Magrilime: lime/ dolomite 50:50.	Do nothing.	Add Sulphur or Iron Sulphate.
	High (>8) – these are non-dispersive soils which are subject to compaction.	Dolomite or magnesite; raises pH and Mg.	Add Epsom Salts or Sulphate of Mg.	Add Sulphur + Epsom Salts.

3.5.2 Soil amelioration in-situ

Ameliorants applied to the soil surface can be washed away during rainfall, so must be incorporated into the soil. The depth of amelioration required depends on the desired outcome. Common ameliorants for plant growth such as lime, compost and fertiliser are typically incorporated to a depth of 150 millimetres to 300 millimetres. In some situations, such as highly dispersive subsoil, it may be necessary to incorporate gypsum to a depth of one metre.

It can be difficult to ameliorate soil in-situ on a batter, particularly when the slope gradient is steeper than 3h:1v. Conventional earthmoving equipment can only safely operate on the contour across slopes ≤ 3h:1v. This allows soil ameliorants to be applied cost effectively with broadcast type fertiliser spreaders and then be incorporated into the soil using ripper tynes or scarifiers on machinery such as tractors, bulldozers or graders (see Figure 3.13b).

A bulldozer is only able to work perpendicular to contours on slopes > 3h:1v and < 1h:1v and only under ideal soil conditions. While it may be possible to apply the ameliorants to the slope, it is inappropriate to scarify or rip the slope perpendicular to contours as any ruts in this direction can concentrate flow and will significantly increase the erosion potential of the batter. On slopes steeper than 3h:1v soil ameliorants can be lightly incorporated by excavators using the bucket teeth on a swivelling head attachment or track rolling up the slope, however in most instances the depth of amelioration is too shallow and much of the loose soil needed to provide an appropriate seed bed is lost down the slope.

Figure 3.5.2a: Track rolled batter with horizontal scarification, and seed beginning to germinate.

In these circumstances it is better to use a stabilisation technique that applies and sufficiently holds soil ameliorants on the batter surface and allows them to leach into the soil profile over time (eg Compost blanket). Ameliorants applied to steep slopes by Hydroseeding or Hydromulching are likely to be washed off the slope. Multiple applications of ameliorants will be required over time and this is rarely accounted for in project budgets and difficult to reapply over a partially vegetated site.

Figure 3.5.2b: Lime applied to a batter waiting to be incorporated.

3.5.3 Soil amelioration during soil stripping

Soil amelioration is most effective if undertaken during the soil stripping phase. Ameliorants are applied to the soil prior to soil stripping and they are then easily incorporated during the stripping and stockpiling process.

The type of amelioration and its effectiveness over time must consider the duration and lag between construction stages (see Section 3.8 Duration).

Amelioration using lineal windrows is an easy and effective method where space permits.

3.5.4 Soil amelioration within a stockpile

In some situations soil can be ameliorated in a stockpile. This can only be achieved if the stockpile is of sufficient width to allow a bulldozer to create a flat running area for machinery or trucks to apply the ameliorants. The bulldozer can then furrow the ameliorants into the stockpiled soil. The depth of amelioration must be accurately recorded and marked as the process of amelioration must be repeated once the ameliorated layer has been removed from the soil stockpile and respread.

Stockpiles must be worked and managed carefully to ensure natural soil structures and chemistry are not destroyed.

Figure 3.5.4: Topsoil stockpile that has been set up to allow machinery to apply and incorporate ameliorants.

3.5.5 Amelioration post-establishment

Soils should be retested after initial vegetation establishment to determine if maintenance applications of soil ameliorants are required. This should be done six to twelve months post establishment or if there is evidence of vegetation stress.

3.6 Bioregion

There are 17 bioregions in NSW (see "What is a bioregion?" at NSW Environment and Heritage) Throughout Australia bioregions have been further divided into subregions, which are based on finer differences in biophysical attributes including geology and vegetation. Knowing in which bioregion the batter occurs will assist with selecting the appropriate stabilisation treatment and species in the vegetation mix.

The soils used should match the habitat and ecology of the context of the batter. Retention of locally-occurring materials will provide the best base for the target vegetation type.

It is not always possible to keep topsoils to a specific location due to materials management and construction space. In road projects, the constructed landforms usually change the aspect and microclimates, which in turn affects the possible vegetation types that can be supported on them. Therefore, it is better to match the conditions for target vegetation outcomes using species selected from the bioregion.

Specific ecological and biodiversity issues such as fauna or adjacent threatened species must be considered in the batter revegetation where possible.

See Section 3.10 Vegetation Type and the Roads and Maritime Biodiversity Guideline (2011) for further information.

3.7 Access requirements

The access to a batter that needs to be stabilised can influence the type of stabilisation technique that can be used. Appropriate and safe access is often required for both installation and maintenance of the chosen technique. Proper installation and sufficient maintenance are often critical in achieving successful batter surface stabilisation, so access requirements should be a key consideration when selecting a technique for a given situation.

During installation, machinery such as excavators will require access to the batter and operational space at the batter to be stabilised (eg the reach of an excavator arm to prepare the batter surface or apply stabilisation materials onto the surface). For some more intensive batter surface stabilisation techniques (eg cellular confinement systems, turf, erosion control blankets) manual handling might be required for all or some of the installation. In these cases, the steepness of the batter must be considered in regard to worker safety. Specialised safety equipment such as rigging and harnesses or elevated work platforms might be required, with qualified operators.

Where access is difficult, techniques that can hydraulically apply stabilisation materials (eg Hydromulching, Tackifier) can be considered. However, the preparation requirements of these techniques should be considered, as they may still require significant works to prepare the batter surface prior to application that can only be effectively done using machinery (see Figures 3.13a and 3.13c).

Access for maintenance must be considered and planned during the design phase. Maintenance requirements vary significantly between different batter surface stabilisation techniques, and range from basic monitoring through to full re-application. Many stabilisation techniques will require irrigation for initial setting of tackifiers and germination of seeds, so the ability to apply water should be considered. Access may become limited if the batter is adjacent to a road that is opened to traffic.

3.8 Duration

When planning a batter surface stabilisation project, the timeframe over which the stabilisation is required will be an important aspect in deciding which technique to employ. Where vegetation is an integral part of the stabilisation technique, the Vegetation Type (see Section 3.10) will influence the duration over which the technique remains effective.

All long-term stabilisation techniques must be enduring and match at least the design life of the road infrastructure. Permanent vegetated areas must achieve 40–100 years, although a stable site will grow in perpetuity.

The effective duration of temporarily unvegetated, or the non-vegetative components of vegetative stabilisation techniques, can vary significantly, from as little as one month up to several years. The cost of a stabilisation technique is often proportionate to its effective duration, so the period that stabilisation is required should be considered in conjunction with long-term landscape requirements. There is little value in investing in an expensive technique that can remain effective for up to three years, if final landscaping will be installed in a matter of months.

The duration claims of proprietary products should be carefully scrutinised, as they are often reliant on ideal conditions that are rarely present on dynamic construction sites. Correct implementation using manufacturers' instructions and advice from soil scientists, landscape designers and ecologists will maximise the effective duration for these proprietary products. The Fact sheets (see Section 7) at the end of this Guideline provide some indicative duration timeframes for generic stabilisation techniques.

3.9 Visual amenity and ecological outcome

Often there are competing needs in a given revegetation situation. A challenge for batter surface stabilisation is to ensure that temporary stabilisation techniques and the final desired permanent landscape outcome do not conflict each other. Rapid surface cover using non-local grasses is often needed to provide temporary stabilisation and to maintain the desirable soil properties, but these grass species may out-compete the native species that are part of a landscape plan to provide a permanent visual amenity and ecological outcome.

The long-term visual amenity and ecological outcome should always be considered when short-term stabilisation techniques are being planned. There are numerous techniques that can be used to successfully transition from short-term stabilisation to the long term visual amenity and ecological outcome, such as:

- Using non-vegetative options (eg – bitumen emulsion, erosion control blankets) for short-term stabilisation
- Using sterile or non-invasive cover crops that last only for the required duration
- Progressively install the final landscape design as construction zones are completed
- Integrate temporary and permanent (landscape) stabilisation solutions by applying compatible cover crop and enduring species.

Figure 3.9: Cover crops used for erosion protection and weed suppression. (Source: Landloch Pty Ltd)

3.10 Vegetation type

In roadside batters, the design is not intended to allow water infiltration, so the vegetation type must be suitable for both free-draining soil and non-retaining water management. It must be appropriate to the condition of the soil regardless of the surrounding vegetation type (eg trees cannot be supported on thin topsoil placed over a cut rock batter). The vegetation selected must also be suitable for the climatic conditions and the ongoing maintenance schedule for the batter. Local rainfall predictions must be considered and for low or zero watering programs species must be hardy and drought tolerant.

Vegetation used for batter surface stabilisation can broadly be divided into two categories – temporary and permanent.

Vegetation used to provide temporary batter surface stabilisation is referred to as a 'cover crop'. The use of fast growing cover crops is often an essential step in slope stabilisation irrespective of the final revegetation outcome. The purpose of the cover crops is to provide surface cover to protect the soil from raindrop splash erosion and surface flows, anchor the soil with their roots, increase soil carbon (from sloughing of roots), restart the biological processes in the soil and suppress weeds. To be effective, at least 70 percent surface cover must be achieved to adequately protect batters from rain drop impact.

Much of the stabilisation of the batter surface is provided by a healthy and well developed prolific root system of both cover crop and long-term vegetation. Often a number of different species of cover crop are required due to their varying characteristics (habit, root type, tolerance to soil conditions etc). Common cover crop species for NSW roadsides include:

- Japanese Millet (*Echinochlora esculenta*). Other millets may be used with approval from Roads and Maritime
- Rye Corn (*Secale cereale*)
- Red Clover (*Trifolium pratense*)
- Rye Grass (*Lolium multiflorum*).

Cover crops are seasonal and should be selected considering the time of year that they will be used. Japanese Millet is a warm season grass and Rye Grass is a cool season grass. It is important to include both grasses in the transitions between cool and warm seasons. Roads and Maritime Regional Environment Staff (see Section 5 Contacts) can provide advice on grass and legume species that are suitable for use as a cover crop in a given area.

Permanent vegetation is grown as part of the landscape plan, and will be designed to achieve various visual amenity and ecological outcomes (see Section 3.9 Visual amenity and ecological outcome). Permanent vegetation commonly consists of native species that are suited to the local environment and specific site conditions (see Section 3.6 Bioregion) and will be successful with minimal intervention or maintenance.

Both temporary cover crop and permanent landscape treatments selected for vegetative batter surface stabilisation should have the following attributes:

- Reliable growth and establishment
- Resilient and self-regenerating (this may not be desirable in some temporary situations)
- Be readily available at low cost
- Minimal roadside hazard including fire, sightlines and collision
- Provide soil surface cover to minimise erosion
- Adaptability to poor and variable soils and climatic conditions
- Low maintenance requirements
- Low potential to attract animals (road kill risk) if the batter is adjacent to the road.

Regional Environment Staff and the Centre for Urban Design (see Section 5 Contacts) are able to provide specialist advice relating to vegetation type, including seed germination and testing, and landscape treatments.

3.11 Establishment time until erosion protection

Erosion is the process by which soil particles are displaced and then transported. The various batter surface stabilisation techniques aim to protect soil particles from the effects of erosion and minimise their displacement and transport. Each stabilisation technique will provide a different level of erosion protection. The level of erosion protection is largely related to the level of surface cover provided, but is also related to the type of cover that is provided. Some stabilisation techniques will also provide erosion protection more rapidly than others, often depending on the Rate of vegetation establishment (see Section 3.14) when vegetation is involved.

Increased soil surface cover will protect soil particles from the effects of raindrop impact and flow, hence reducing the likelihood of erosion. It is considered that 70 percent soil surface cover is required to achieve an appropriate level of erosion protection. This cover can be provided in a variety of ways and includes both natural products (eg – vegetation, mulch) and artificial products (eg – Erosion control blanket), or a combination of products and methods. Cover can be measured in a variety of ways, see your local Environment Officer for assistance.

The timing for when erosion protection is required is a critical factor when selecting a batter surface stabilisation technique. Immediate erosion protection might be required where a construction site is being closed down either temporarily on permanently. Techniques that do not rely on vegetation to establish in order to provide the protection (eg – Hydromulching, Erosion control blankets) will be required in these circumstances. Where a construction site is still under development and other erosion and sediment controls remain in place, immediate erosion protection might not necessarily be required. In these circumstances it might be desirable to use vegetation to stabilise a batter, using techniques such as Drill / Broadcast seeding or Hydroseeding. Different vegetation types will establish and provide erosion protection quicker than others, so the Rate of vegetation establishment (see Section 3.14) should be considered in relation to site-specific requirements.

To ensure maximum erosion protection is achieved as quickly as possible, it is essential that stabilisation techniques are applied or installed correctly. Any product that is rolled onto a batter must be adequately trenched and anchored at the top and bottom of the batter, and then securely pinned at regular intervals down the slope, to ensure that water cannot flow underneath and cause erosion. Incorrect installation can result in worse erosion than if no protection was applied, as flows are concentrated at weak points where they have more energy to displace and transport soil particles.

Figure 3.11: Effective soil surface cover, provided by a combination of Turf Reinforcement Mat and seeded grass that has begun to establish through it.

Specific installation requirements for various products and materials are available from the suppliers, but application and installation of these products must be designed in consideration of other constructability and site requirements.

If further advice is required, Soil Conservationists (see Section 5 Contacts) are able to provide specialist advice relating to erosion risk and a stabilisation technique that will provide erosion protection within a suitable timeframe. Also refer to individual fact sheets for guidance on preparation requirements for each method.

3.12 Cost

Stabilisation treatments must be considered as a whole of life cost, including maintenance and safety in all activities – the upfront installation costs should not be considered in isolation. There are various costs involved in a thorough batter surface stabilisation project, such as site testing, investigations, materials, handling, establishment and maintenance, and monitoring. Costs of establishment can be minimised by simulating surrounding vegetation conditions where possible.

Batter surface stabilisation techniques that utilise minimal materials and site preparation are likely to incur higher establishment and landscape management costs in re-work, weed removal or slope repair for patchy or un-vegetated parts of the batter.

The costs of vegetative treatments for batter surface stabilisation can be divided into:

- Design and specification, usually a one-off cost
- Investigations and testing, which may be recurrent depending on risk factors
- Monitoring, which are usually recurrent for up to three years after completion
- Materials, including transport to site and measured in bulked quantities or per-square metre application
- Site management and preparation, usually a one-off cost
- Establishment, usually charged as a group of activities per month for 6 months
- Maintenance, usually charged per activity per day for a set number of days over 1 to 3 years.

There are no firm percentages for the proportion of costs between activities or materials, as site location, access, seasonal constraints and origin of materials all influence the total cost.

The highest value is gained by assuring quality controls and not requiring rework or protracted establishment, so the costs of some treatments and methods should be compared to the cost of inaction, rework or repair when selecting inappropriate methods.

3.13 Preparation

The surface of the constructed batter on which the soil, growing media or stabilisation materials will be placed must be appropriately prepared such that no slumping or displacement will occur regardless of saturation, desiccation or exposure to wind, and vegetation establishes successfully.

Soils on road projects are often highly compacted, creating conditions that are not ideal for long term stabilisation, and that are unsuitable for plant establishment and growth. Seeds require intimate contact with the soil or light soil cover to germinate. Plants require uncompacted growing media for root penetration. An open soil structure is required for water infiltration and the exchange of carbon dioxide, and a roughened soil surface is required to ensure organics and plant propagules are kept on the slope and that water does not wash off the surface.

Therefore, before any batter surface stabilisation can be undertaken, the batter must be appropriately prepared in order for the stabilisation technique to key into the batter surface and remain in place. Where the final slope gradient is going to make batter preparation difficult (eg access and safety), consideration should be given to undertaking the preparation in conjunction with the construction and formation of the batter.

Figure 3.13a: Contour ripping across a batter using an excavator. Note that on batters ≤ 3h:1v this can also be done with a bulldozer.

Figure 3.13d: Contour scarification across a batter. Lime amelioration is being applied prior to topsoil application.

Preparation requirements vary between stabilisation techniques, so it is necessary to consult any relevant guidelines, specifications or manufacturer instructions. However, some general principles apply.

For stabilisation techniques that need to hold themselves on the batter (eg – Hydromulching, Straw Mulching, Compost

Figure 3.13b: Track rolling a batter in preparation for the application of a stabilisation technique.

Figure 3.13c: Pad roller preparing a batter in preparation for the application of a stabilisation technique.

Blanket, Hydrocompost, Tackifier), compacted or smooth surfaces need to be roughened and some rocky surfaces require scarification. This uneven surface assists to hold the products in place and provide any vegetation time to establish.

When undertaking any surface roughening or scarification, the works should always be undertaken along the contour of the slope. It is generally inappropriate to undertake these works vertically as any vertical ruts can concentrate flow and will significantly increase the erosion potential of the batter.

On slopes ≤ 3h:1v conventional earthmoving equipment such as graders, bulldozers and tractors can be used to contour scarify slopes. For slopes > 3h:1v an excavator must be used. The excavator should have a swivelling head attachment that allows the bucket to be rotated 90 degrees allowing the teeth to be dragged horizontally across the slope. Care needs to be exercised when deep ripping sodic, dispersive or magnesic soils, as water ponding in the rip lines can cause tunnel erosion and potentially result in a cascading gully erosion failure down the slope. Short 2h:1v slopes can be vertically track-rolled with earthmoving equipment to roughen and/or scarify the surface.

For stabilisation techniques that involve the use of rolled products (eg – Cellular Confinement Systems, Erosion control blankets) that are manually anchored to the batter, intensive preparation is usually required to ensure a smooth, uniform, uncompacted surface that provides intimate contact between the product and the surface. Obstructions such as tree stumps, clods, rubble, tracks (eg – machinery or footprints) should be removed as they can create voids under the product where water can pool and potentially undermine the stabilisation.

If further advice is required, Soil Conservationists (see Section 5) are able to provide specialist advice relating to the preparation requirements of specific stabilisation techniques.

3.14 Rate of vegetation establishment

Generally, rapid vegetative cover improves resistance to surface erosion by shielding the ground from raindrop erosion, binding the topsoil with fibrous roots, and bonding the topsoil to lower soil layers by structural roots and mychorriza. However, fast growth is not always an indicator of establishment, as newly germinated and fast-growing plants may fail to establish (i.e. anchor and become self-reliant) on site. All vegetation has strong external influences – climate, rain, fertilisers, conditioners, the season of application and the natural growing seasons of that species.

There is also generally a correlation being fast-growing plants that are short-lived, and slower-growing plants that are longer-lived. Some short-lived species are also prolific in self-propagation and capable of replacing themselves after a quick period, but not all such species are appropriate for use in many NSW bioregions and some are listed as environmental weeds. Generally, best results are achieved when diversity is broadened.

The site conditions also impact the rate of vegetation establishment. Seed mixes are usually specified to match the surrounding environment and landscape, but subtle differences such as change of aspect of the batter face, diversion of overland flows or removal of upper canopy and unshaded ground will affect the vegetation results. Poor quality or mismanaged materials or preparation – including soil profiles, soil amelioration and conditioning, competition with weeds or aggregation of incompatible materials - will lead to vegetation failure even in an ideal climate.

Seed mixes with both temporary cover crop and long-term native mixes will need to go through the stages of succession, which are: cover crop > pioneer species > secondary species > tertiary (final) vegetation. There may need to be multiple applications and establishment of temporary vegetation depending on construction program and requirements. The rate of vegetative establishment from cover crop to tertiary species may span years, so management activities should focus on successful establishment of cover crop and early surface cover, with periodic monitoring for other long-term species following. Most broadscale revegetation activities compress the sequence of succession to increase the rate of establishment. In some circumstances, forced establishment of secondary or tertiary species will lead to vegetation failure due to over-demand of soil nutrient and moisture.

The landscape design must describe the expectations for rate of establishment and vegetation cover when growing from seed, but the construction team must consider the climate and season of application, rates of growth for the whole species mix, and landscape management activities that may enhance or impede vegetation establishment.

3.15 Quality assurance and surveillance

As all batter surface stabilisation using vegetation has various factors that all contribute to a successful outcome, the timing and intensity of quality assurance and surveillance greatly affects the outcome. Each stabilisation technique will have different requirements, and these can be specified in the construction documentation.

The Fact sheets (see Section 7) include guidance on the quality assurance and surveillance that must be considered for each technique during implementation. It is critical to undertake quality assurance and surveillance during the installation, establishment and maintenance of batter surface stabilisation activities to ensure that the technique is being delivered as specified. There are significant cost savings to be achieved if inputs (eg seed, fertiliser) to installation or maintenance are reduced, and hence the temptation to cut corners always exists.

The most effective method of quality assurance and surveillance is to be present during the application / installation to oversee the activities and ensure rectification of problems at the time they occur rather than later. Table 3.15 details some of the quality assurance issues that might need to be considered and some of the quality assurance and surveillance methods available.

Table 3.15: Quality assurance issues

Quality assurance issue	Description and Surveillance
Soil testing	Any stabilisation technique that requires the establishment of vegetation requires soil tests and reports to determine any limitations and describe the recommended amelioration for the intended vegetation. See Section 3.4 Soil Testing and refer to relevant contract or supplier specifications. Surveillance can be undertaken by checking that the required tests have been completed including correct sample sizes and origin location of test samples, and reports received. Soil quality must comply with relevant specifications, which may require screening or removal of other deleterious materials.
Soil preparation	Generally, the timing, site conditions and period between soil preparation and application are critical for success. Each stabilisation technique has specific soil preparation requirements. See Section 3.13 Preparation and refer to relevant contract or supplier specifications.
Growing media placement	Surveillance can be undertaken by observing the activity of growing media placement and the final outcome of placement. Surveillance should include compaction, consistency of material, depth, uniform thickness and coverage in accordance with the project specification, timing of application.
Soil amelioration	Where limitations in soil quality for the establishment of vegetation have been identified, soil amelioration may be required to ensure it is appropriate for use. See Section 3.5 Soil Amelioration and refer to relevant contract specifications. Surveillance can be undertaken by checking that the recommended ameliorants have been used and effectively applied.
Seed germination and purity	Where a stabilisation technique involves the use of seed to establish vegetation, it is important to ensure that the seed will provide a high level of germination to achieve good cover, and only contains the intended species (purity). Requirements will be detailed in relevant contract or supplier specifications. Surveillance can be undertaken by requesting a "Certificate of Provenance" from the seed supplier.
Product certification	Surveillance can be undertaken by checking the certification from suppliers of products (eg – straw) that the material is free from weed seeds and meets quality controls as detailed in relevant contract or supplier specifications.
Application rate (seed, mulch, binder, soil ameliorant, compost)	The success of many stabilisation techniques depends on sufficient application of inputs (eg – adequate mulch to provide soil surface cover). Application rates will be detailed in relevant contract or supplier specifications. Surveillance can by undertaken by observing the inputs used during the preparation of materials (eg – mulch into a hydromulch mixture), or by checking the outcome on the ground (eg – level of soil surface cover). Application rate is usually expressed as "kg / ha".
Seed carrier application	Seed is distributed across a broad area along with various 'carrier' mediums (eg mulch), depending on the stabilisation technique being used. All sprayed or blown applications require complete coverage of the surface to be stabilised. Surveillance can be undertaken to ensure the batches to be sprayed contain the correct seed and medium mixes, and are prepared correctly before each application.

Quality assurance issue	Description and Surveillance
Seed application method	Different vegetation species require different germination conditions. The seed should be applied using a method that is appropriate to create these conditions. This may require the seed to be applied separately prior to the application of an erosion protection medium, or within the erosion protection medium itself (eg – a surface germinating seed should not be covered by thick mulch and a deep germinating seed should not be suspended in a thinly applied material). Requirements will be detailed in relevant contract or supplier specifications. Surveillance can be undertaken by observing how and when seed is applied (eg – separately and prior to the erosion protection medium, or batched with other materials and applied with the erosion protection medium).
Mulch type	There are many forms of mulch available, and some techniques require the use of specific forms to achieve maximum success (eg – Hydromulching – Bonded fibre matrix). Mulches derived from processed organic materials are generally able to be hydraulically applied or blown onto batters. Requirements will be detailed in relevant contract or supplier specifications. All mulches must comply with relevant standards and Roads and Maritime specification. Surveillance can by undertaken by observing the type of mulch that is used. Mulches derived from mineral materials are not recommended for batters except for very specific hydraulic or structural conditions (eg rock mattresses).
Soil surface cover	Effective erosion protection (see Section 3.11) is usually obtained once ~70 percent soil surface cover is achieved. However each stabilisation technique will also require a minimum thickness of the relevant product in order to be effective (eg – minimum 20mm thickness for Straw Mulching). Requirements will be detailed in relevant contract or supplier specifications. Surveillance can by undertaken by observing the soil surface cover achieved on the ground. The time to achieve effective slope stabilisation will depend on the composition of materials and the site conditions.
Ensure application coverage by multiple passes in different directions	For stabilisation techniques that involve the blown application of materials (eg – Hydromulching, Soil binder, Compost blanket), the application over each area should be undertaken with a sufficient number of passes in different directions where possible to avoid "spray shadow" (ie areas missed because they are not in direct line of sight of the applicator such as uneven ground or overhangs). Surveillance can by undertaken by observing the application and / or the soil surface cover achieved on the ground.
Ensure the area is moist before application	For stabilisation techniques that include glues or tackifiers that need to set, a moist surface will assist in gluing the product to the soil surface. For techniques that use seed for the establishment of vegetation, the moisture underneath the mulch layer will also assist with germination. Requirements will be detailed in relevant contract or supplier specifications. Surveillance can by undertaken by observing the application.
Installation of rolled products	Rolled products (eg – Erosion control blankets) require specific installation methods to ensure success. Products need to be correctly anchored at the top and bottom of the batter and down its length. They also need to be overlapped with the top length laid over the top of the length below (similar to roof tiles) to ensure water does not flow underneath and undermine the product. Product specific requirements will be detailed in relevant contract or supplier specifications. Surveillance can be undertaken by observing the installation and/or inspection of the final product on the ground.
Compost quality	Compost is a material that may be a manufactured product or derived from site materials, and as such the quality can vary significantly. Whatever the origin, poor quality compost can be insufficiently processed, and cause 'nitrogen drawdown', apply uneven or incorrect levels of nutrients and can contain weed seeds and pathogens if not pasteurised appropriately. Australian Standard 4454 is often used as a minimum benchmark for the required compost quality. Requirements will be detailed in relevant contract or supplier specifications. Surveillance can be undertaken by requesting certification from the compost supplier that the material was produced according to the required specifications and testing of the compost if derived from site materials.

3.16 Establishment and maintenance

Establishment means the short-term period and process required for vegetative materials to germinate and become self-sustaining. During this phase, some activities may be required to achieve establishment, such as watering, weed management, fertilising, application of other landscape materials and monitoring and management of ancillary controls and fences. A batter using vegetative techniques for stabilisation cannot be considered complete until establishment is achieved.

Maintenance means the management activities and programme required for long-term slope stabilisation after establishment is complete, and may extend beyond the life of the construction contract. An appropriate maintenance program is critical for the effectiveness of the stabilisation technique employed. The cost of regular maintenance is typically only a small percentage of the overall cost of the technique and is far more cost-effective than re-implementing the works or completely re-working a batter because of a failure. With tight project margins, re-working failed batters and slopes can have a major impact on costs, especially where the batter slope is above an operating road.

Batter surface stabilisation solutions should be designed so that maintenance requirements are minimised, especially for locations that are steeper than 1h:2v or where access for bulk landscape materials is very limited. Maintenance requirements vary greatly between stabilisation techniques, and should be guided by contract and / or supplier specifications, as well as site-specific conditions (eg – periods of drought or extreme weather).

Maintenance should include a program of routine checks and activities, but also include re-active checks and activities following rainfall. Occasional maintenance should be done to slash dead temporary crops, remove standing dead vegetation from cut slopes, repair rolled products or target noxious weeds. Select herbicides should be used for weed management to target the correct form or species of weed for each particular site. If too much spraying or inaccurate spraying is done, then the long-term vegetative cover will also be damaged and impaired. For assistance in preparing a targeted weed management program, please contact your local government officer (see Section 5).

It is critical to attend to minor maintenance issues (eg – loose erosion control blanket) promptly, as they can quickly result in major issues or even complete batter failures if not fixed prior to rainfall.

Section 4
Glossary

Word	Definition
Batter	The uniform side slope of a cutting or an embankment.
Batter face	The surface area between the top and toe of the batter.
Batter rounding	Curvature that is applied to improve the stability and appearance of the road at the intersection of the extension of the road crossfall and/or existing surface (hinge point), with the batter slope of an embankment or cutting.
Batter transition	The zone on the leading edges of the landform in which the batter slope of an embankment or cutting meets the existing terrain.
Bench	A ledge constructed in a batter or natural slope for the purpose of providing adequate horizontal sight distance, greater security against batter slippage or to assist with batter drainage.
Dispersive soils	Soils that are high in relative levels of dissolved sodium or magnesium, which causes the soil particles to repel each other when wet and separate into single particles. As such, dispersive soils are unstable and prone to erosion by water.
Gradient	The degree of inclination with respect to the horizontal, expressed as rise or fall in a certain longitudinal distance. Also known as slope.
Growing media	Growing media is a combination of mineral, organic matter, water, air and living organisms in variable proportions.
Hinge / hinge point	The point in the cross-section of a road at which the extended batter line would intersect the extended verge line.
Magnesic soils	Soils that are high in dissolved magnesium compared to other ions, which enhances the dispersive (see above) effects of sodium.
Roads and Maritime	NSW Roads and Maritime Services.
Sodic soils	Soils that have too much sodium compared to other ions, which causes the soil to become dispersive (see above).
Stabilise	To modify any material on a slope to improve or maintain its load carrying capacity (eg saturation), and to prevent erosion or slippage of that slope.
Slope	An inclined surface. Also known as Gradient.
Vegetation	All plant matter that is remnant, sown or planted occurring on the or adjacent to the batter.

Section 5
Contacts

Name	Contact Details
Roads and Maritime Centre for Urban Design	Landscape Advisor (02) 8588 5776
Roads and Maritime Regional Environment Staff	The Environment Managers by region are as follows: Head office (02) 8588 5766 Northern region (02) 6640 1072 Pacific Highway (Nth) (02) 6640 1375 Pacific Highway (Sth) (02) 4924 0281 Motorways (02) 8588 4372 Southern region (02) 6492 9515 Southwest region (02) 6923 3419 Sydney region (02) 8849 2516 Western region (02) 6861 1628 Hunter region (02) 4924 0440
Services	The Registered Contractors list is kept updated on the following web page: www.rms.nsw.gov.au/doingbusinesswithus/tenderscontracts/registeredcontractors.html

Section 6
References

NSW Department of Primary Industries March (2009), *Saving Soil – A landholder's guide to preventing and repairing soil erosion,* NSW Department of Primary Industries

Roads and Maritime Biodiversity Guidelines (2011)

Roads and Maritime contract specifications

- G36 (Environmental Protection)
- G38 (Soil and Water Management)
- G40 (Clearing and Grubbing)
- R176 (Native Seed Collection)
- R178 (Vegetation)
- R179 (Landscape Planting).

Section 7
Fact sheets: Batter surface stabilisation techniques

The following fact sheets provide details on some of the common batter surface stabilisation techniques that are used on Roads and Maritime road construction projects. There are many variations of the techniques available on the market as proprietary products, and also new and alternate products and equipment that may not be covered in this Guideline. As with any construction process using vegetation, regionally-specific requirements should also be employed to ensure success. Please contact your local Environment Officer (see Section 5) if you would like to clarify the details or suitability of a particular product.

Each fact sheet can be removed from the Guideline and used as standalone information. The following fact sheets are included:

The fact sheets detail how each of the techniques relate to the Factors to consider (see Section 3). The fact sheets have been prepared to be consistent with, and complementary to, the Roads and Maritime contract specifications G36 (Environmental Protection), G38 (Soil and Water Management), G40 (Clearing and Grubbing), R176 (Native Seed Collection), R178 (Vegetation) and R179 (Landscape Planting). Specifications for various materials and installation methods as referenced in R178 and R179 are found in various other Australian Standards, Roads and Maritime guidance documents and other industry documents. These include the correct site and weather conditions that affect the safe implementation of these techniques.

Roads & Maritime

Drill / Broadcast seeding

Drill seeding involves seeding using a mechanical disc seeder towed by a tractor.

Drill seeders have metal discs that create small furrow and seed is placed into the furrow. Broadcast seeding involves the mechanical spreading of seed on the soil surface using a trailer or truck mounted spinning type or agitator type seed spreader. Following the seeding, the soil should be harrowed to cover the seed with a thin layer of soil.

Figure FS1a: Direct seeding a batter. (Source: Martin Sullivan)

Figure FS1b: Air seeding native grass using a 4WD. (Source: Martin Sullivan)

FACTOR	DETAIL
Slope	Mechanical seeders are either truck or trailer mounted and as such they cannot work safely across slopes steeper than 3h:1v. Hand seeding can be undertaken on small areas that are steeper than 3h:1v.
Level of erosion protection	Once vegetation has established, raindrop splash erosion and sheet flow.
Growing media	Topsoil.
Soil amelioration	Soil ameliorants are delivered with seed. Fertiliser can cause seed burn.
Bioregion	Areas with high rainfall or strong winds may need additional surface protection that is appropriate to the species being used. Drill seeding is ideal for locations where species tend to have longer dormancy.
Access	Installation – access will be required for machines to apply seed. Maintenance – access may be required to water vegetation as it establishes and remove weeds as necessary.
Duration	Completely dependent on 'Vegetation type' (see below).
Visual amenity and ecological outcome	Drill / broadcast seeding is appropriate for the use of cover crops, grasses, legumes and many natives. However, there is significant scope within these types of vegetation to plant a desirable selection of species to meet visual and ecological outcome requirements.
Vegetation type	Cover crops, grasses, legumes and many natives.
Establishment time until erosion protection	Drill / broadcast seeding does not provide any erosion protection until the vegetation establishes. Optimum erosion protection is provided once 70 percent soil surface cover is achieved. A mulch cover is often recommended to provide raindrop splash and erosion protection during establishment.
Cost (at time of publication)	Low if suitable weed free topsoil and suitable machinery is available in the immediate area: • \$0.15 – \$0.50 / m^2 depending on location and area seeded • \$3 – \$5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for watering in dry conditions and weed suppression (where necessary).
Preparation	Planning by relevant experts and agronomists to develop the appropriate species, seeding rates, ameliorants and watering requirements. Soil surface should be scarified and topsoil / subsoil should be ameliorated (where necessary) based on results of soil tests.
Rate of vegetation establishment	Slow and highly variable, depending on Vegetation type and Bioregion.
Quality assurance and surveillance	Quality assurance and surveillance should consider: soil preparation; soil testing; soil amelioration; seed germination and purity; application rate. Seed should be buried in the soil two to three times its diameter to ensure intimate contact with the soil and access to soil moisture. Drill seeders typically place the seed at depths greater than 50 millimetres. Poor plant establishment can result as the shoots use all the available energy in the seed to push through the depth of the soil. Broadcast seeders apply the seed to the soil surface and can result in poor soil contact. It is desirable to lightly harrow or roll the seeded area to ensure intimate soil contact.
Establishment and maintenance	Establishment and maintenance costs can be high depending on the quality of topsoil used, the presence of weed seeds in the topsoil and the surrounding vegetation. Maintenance might include: • Erosion repairs if rain occurs prior to vegetation establishment • Maintenance application of ameliorants • Weed control if topsoil is poor, weeds are adjacent or vegetation establishment is slow • Watering immediately after application of seed / mulch in dry conditions and in rural areas to establish the vegetation • Ongoing specialist advice if performance is poor.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 2

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Soil binder – Bitumen emulsion

Soil binders are a range of products that are applied to the soil surface to effectively glue the soil particles together, forming a crust that is resistant to erosion in varying degrees. They can also be referred to as soil stabilisers.

Bitumen emulsion is a specific type of soil binder that can be used for a variety of applications. There are different types of bitumen emulsion, but the type that should be used for batter surface stabilisation is Anionic Slow Setting Bitumen emulsion. Cationic bitumen emulsion, which is typically used for road sealing, is not suitable for use in vegetation areas.

Bitumen emulsion should be applied at a rate of one litre of undiluted residual bitumen emulsion per square metre. It can be diluted up to 50/50 with water, and the diluted emulsion sprayed to achieve the application rate (1L/m^2). It is generally applied with conventional agricultural spray bars, and can be used in a variety of ways.

Bitumen emulsion can be sprayed directly onto the soil surface to simply bind the soil together. It can also be used in conjunction with Straw Mulching (see Fact Sheet 6) to provide temporary batter protection, or open weave Organic fibre Erosion control blankets (see Fact Sheet 10) to provide an increased level of erosion protection for higher velocity flow situations. Application with Straw Mulching or Organic fibre Erosion control blankets will also aid in vegetation establishment, conserve moisture in the soil, increase infiltration and minimise temperature fluctuations. For all applications, 100 percent soil surface cover is critical to ensure effective erosion control.

Figure FS2a: Application of bitumen emulsion (darker area) over straw mulch.

Figure FS2b: Uneven establishment of grass through bitumen emulsion.

FACTOR	DETAIL
Slope	≤ 3h:1v but the length of the slope should be limited.
Level of erosion protection	If used standalone or in conjunction with Straw Mulching, bitumen emulsion will withstand raindrop splash erosion and low velocity sheet flow. If used in conjunction with an open weave Organic fibre Erosion control blankets (see Fact Sheet 10) bitumen emulsion will withstand low velocity concentrated flow. If vegetation is established, erosion protection will be enhanced.
Growing media	Can be applied to any growing media or soil surface cover (eg – organic fibre erosion control blankets). If the soil is dispersible it should be ameliorated prior to application.
Soil amelioration	Bitumen emulsion provides no soil amelioration. If vegetation is to be established, soil amelioration might need to be undertaken prior to installation to provide suitable conditions for the desired vegetation type.
Bioregion	Avoid application during low humidity or in areas with very dry or very wet soil, around wetlands, riparian areas or other sensitive receivers.
Access	Installation – application machinery (eg – agricultural spray bar) will need access to the batter. If necessary, access for applying Straw Mulch (see Fact Sheet 6), Organic fibre Erosion control blankets (see Fact Sheet 10) or undertaking soil amelioration may also be necessary. Maintenance – access may be required for erosion repairs or repeat applications if rainfall occurs prior to any vegetation establishment. Depending on site conditions, access may also be required for weed control, repeat applications of ameliorants or watering vegetation.
Duration	Bitumen emulsion will remain effective for 3 – 12 months, depending on site conditions and level of disturbance. Much longer stabilisation will be achieved if vegetation is established along with straw mulch or organic fibre erosion control blankets – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	Bitumen emulsion is a dark colour that provides minimal visual impact, but alone it provides no ecological value. The establishment of vegetation will improve the visual amenity and has the potential to improve ecological outcomes.
Vegetation type	None if used directly on the soil as a binder. All vegetation types if used to stabilise growing media while vegetation establishes.
Establishment time until erosion protection	Erosion protection will usually be achieved after 24 hours curing time, though slow-breaking emulsion may take longer in humid areas.
Cost (at time of publication)	Moderate if suitable machinery and materials are available in the area: • $1.00 - $5.00 / m^2 depending on location • $3 - $5/$m^2$ to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Bitumen emulsion can be applied to any surface, however maximum effectiveness will generally be achieved when the surface is uniformly roughened. Roughening should be done along the contour (ie – horizontally) rather than down the slope, to ensure runoff is not concentrated into channels.
Rate of vegetation establishment	Establishment of any vegetation used in conjunction with the bitumen emulsion is completely dependent on the Vegetation Type and Bioregion (see above).
Quality assurance and surveillance	Soil preparation; seed germination and purity (if used in conjunction); application rate; seed application method; soil surface cover; ensure application coverage by multiple passes in different directions; ensure the area is moist prior to application.
Establishment and maintenance	If used in isolation and while a complete surface crust remains, very little establishment and maintenance should be required. If used in conjunction with vegetation and/or if the surface crust breaks, the following establishment and maintenance might be required: • Reapplication if heavy rain or flow damages the surface crust • Watering vegetation during dry periods • Weed control if topsoil is poor, weeds are adjacent to the seeded area or vegetation establishment is slow • Maintenance applications of ameliorants.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Roads & Maritime

Soil binder – Tackifiers

Soil binders are a range of products that are applied to the soil surface to effectively glue the soil particles together, forming a crust that is resistant to erosion in varying degrees. They can also be referred to as soil stabilisers.

For the purposes of this fact sheet 'Tackifier' refers to all soil binders other than bitumen-based (see Fact Sheet 2), and includes products that are based on polymer, cementitious or organic (natural) ingredients. Commonly used products include:

- Guar gum – a natural organic tackifier that comes from seeds in the guar plants
- Starch-based – a natural organic tackifier that comes from cornstarch
- Polymer-based – chemical products that are engineered for specific purposes, and can contain additional beneficial ingredients such as fertiliser.

Soil binders are mixed with water and applied to batters hydraulically. They are extremely versatile and can often be used for other applications, such as binding mulches, straw / hay, seeded batters, organic fibre erosion control blankets and compost. Individual product specifications should be used to guide the use and application of each product, noting that some manufacturer's claims might be based on ideal conditions, which are rarely available on dynamic road construction sites.

The effectiveness of tackifiers can be significantly affected by soil type. Heavy and / or well compacted soils may limit the ability of the tackifier to penetrate the soil and form a sufficiently thick surface crust.

Impacts on downstream environments should be considered when selecting an appropriate tackifier. Some are fully biodegradable, while others are photo/chemical degradable.

Figure FS3a: Tackifier applied with a green dye.

Figure FS3b: Water cart application of a tackifier. (Photo: Vital Chemical Pty Ltd)

FACTOR	DETAIL
Slope	Tackifiers are likely to be effective on slopes ≤ 3h:1v Some manufacturers claim their products will be effective on slopes up to 1h:1v. Application rate will generally increase with steepening slopes.
Level of erosion protection	Dependent on the specific product, but generally raindrop splash erosion and sheet flow.
Growing media	Can be applied to any growing media or soil surface cover (eg – organic fibre erosion control blankets).
Soil amelioration	Generally none. Some advanced products contain added ingredients that can assist with soil amelioration.
Bioregion	Organic tackifiers are generally suitable in all bioregions, but some types may turn the soil hydrophobic. Areas with prolonged or frequent rainfall reduce the effectiveness of tackifiers by leaching or slippages when wet.
Access	Installation – access will be required for machines to apply the tackifier. Proximity will depend on the application distance of the specific machine. Maintenance – access may be required for repeat applications.
Duration	Short term. Duration varies dramatically, from as little as one month to more than a year. Factors that influence durability include the specific product type, the application rate and the type of activity on the batter. Some are designed to withstand heavy activity such as haul roads, while others will not withstand any disturbance at all.
Visual amenity and ecological outcome	Unless a dye is applied, tackifiers are generally not visible once set and will have no impact on visual amenity or ecological outcome. If they are used in conjunction with seeding, the vegetation type will influence this factor.
Vegetation type	Many tackifiers are appropriate to stabilise the growing media but still allow the germination of seed. As they are designed to degrade over time, they are suitable for use with any vegetation type.
Establishment time until erosion protection	Maximum erosion protection is achieved once the tackifier has cured, which can vary from almost instant to 24 hours, depending on the specific product.
Cost (at time of publication)	Low if suitable weed free topsoil is available in the immediate area and application equipment is available on site: • $0.15 - $0.50/m^2 • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if necessary • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Tackifiers can be applied to any surface, however maximum effectiveness will generally be achieved when the surface is uniformly roughened. Roughening should be done along the contour (ie – horizontally) rather than down the slope, to ensure runoff is not concentrated into channels. Pre-wetting of the surface should be undertaken to assist with adhering the tackifier.
Rate of vegetation establishment	Establishment of any vegetation used in conjunction with the tackifier is completely dependent on the Vegetation Type and Bioregion (see above).
Quality assurance and surveillance	Soil preparation; seed germination and purity (if used in conjunction); application rate; seed application method; soil surface cover; ensure application coverage by multiple passes in different directions; ensure the area is moist prior to application.
Establishment and maintenance	If used in isolation and while a complete surface crust remains, very little establishment and maintenance should be required. If used in conjunction with vegetation and/or if the surface crust breaks, the following establishment and maintenance might be required: • Reapplication if heavy rain or flow damages the surface crust • Watering vegetation during dry periods • Weed control if topsoil is poor, weeds are adjacent to the seeded area or vegetation establishment is slow • Maintenance applications of ameliorants.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Mulch / Topsoil mixes

Mulches are homoegenous materials that are derived from organic products.

They can be laid as a blanket directly over the batter surface to be vegetated, or can be used in combination with other stabilisation techniques, such as under- or overlays for organic and synthetic erosion control blankets. They can also be blended with topsoil or compost to provide a relatively stable product that holds growing media in place and provides erosion protection.

Mulches are applied to batters hydraulically, airblown, mechanically or spread manually and may be applied lightly or thickly depending on the material and performance requirements. Mulches provide protection to the batter surface from raindrop, wind and overland flow erosion and can act as a blanket for seed protection, weed suppression, dust control and soil moisture conservation. Commonly used products include:

- Straw – covered separately in Fact Sheet 6
- Shredded vegetation – generally bark and upper canopy material that cannot be milled and is processed for further use (does not include tub-ground mulch which can only be used with caution and specific approval)
- Woodchip – derived from processed hardwood and softwood timbers and some post-consumer wood waste. Apply with caution on acidic soils
- Blended mulches – organic material combined with other materials including tackifiers, topsoil, compost and/or conditioners. The ratio of growing media to mulch must be advised by the soil scientist.

Although most mulches can have multiple purposes, products available as garden or landscape mulches (including fine composts) are not always compatible for use in slope stabilisation. Mulches sourced from site-won material are generally not appropriate for reuse without further processing. Individual product specifications should be used to guide the use and application of each mulch, noting that some manufacturer's claims might be based on ideal conditions, which are rarely available on dynamic road construction sites. Mulch selection must also consider the soil type and soil reports.

Mulches perform in all seasons and climates, although their effectiveness can be influenced by microclimate, aspect, thickness of application and drainage controls. Impacts on downstream environments should be considered when selecting an appropriate mulch as some can float and clog drainage inlets and channels, and some contain tannins that can leach and drain into downstream waterways.

Figure FS4a: Mix of 60% soil and 40% shredded mulch from local vegetation at Glenugie Upgrade on rock cutting.

Figure FS4b: Woodchip and shredded mulch from local paper mill on planted 2h:1v cuts at Woomargama Bypass.

FACTOR	DETAIL
Slope	Generally acceptable ≤ 4h:1v. Might be effective up to ≤ 1.5h:1v, if combined with a supplementary stabilisation technique, depending on the geology and drainage design.
Level of erosion protection	Excellent for most erosion types except concentrated flows. Mineral mulches (including rock mattresses) should be used on non-dispersive soils in locations of concentrated flows.
Growing media	Can be applied over any growing media. Some forms of mulch may be mixed with growing media to enhance adhesion to the slope surface in rural areas only.
Soil amelioration	Requirements subject to soil report recommendations. Fresh mulch should not be used in acidic environments. Breakdown of woodchip mulches can result in nitrogen being drawn out of the soil (nitrogen draw-down), so additional amelioration with nitrogen may be required.
Bioregion	Suitable for use in all bioregions, but the rate of biodegradation will be faster with increased humidity, temperature and moisture.
Access	Installation – direct access for machines is preferred, but some mulches can be airblown or hydraulically applied up to 100 metres from the access point. Maintenance – access may be required for erosion repairs or repeat applications for light mulches if heavy rainfall occurs prior to any vegetation establishment. Depending on site conditions, access may also be required for weed control, repeat applications of ameliorants or watering vegetation.
Duration	Extremely variable – mulch and mulch blends will remain effective anywhere from 2–12 months, depending on the type of mulch used. Much longer stabilisation will be achieved if vegetation is established with the mulch – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	Mulch and mulch blends alone provide little value for visual amenity or ecological outcomes. Good outcomes can be achieved if vegetation is established with the mulch, but will vary according to the Vegetation Type.
Vegetation type	Cover crops, grasses, legumes, native ground covers, shrubs and trees.
Establishment time until erosion protection	Some fine materials will wash out immediately, but mulch and mulch blends will provide instant erosion protection. Additional erosion protection will be provided once vegetation (if used) is established. It should be noted that it may not be possible to achieve 70 percent vegetation cover using this technique – however, the mulch pieces will provide part of the soil surface cover, in addition to any vegetation that has established.
Cost (at time of publication)	Low, but variable depending on availability of weed-free mulch: • Call local landscape suppliers or Environment Officers for availability and cost if mulch is not available on-site • $3 - $5/m² should be allowed to strip and ameliorate topsoil (if necessary), then mix with mulch and respread mulch / topsoil mix • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Soil scarification and amelioration of subsoil and topsoil.
Rate of vegetation establishment	Vegetation establishment is generally moderate to rapid, although will largely depend on the type of mulch or mulch blend used, the Vegetation Type and the Bioregion.
Quality assurance and surveillance	Soil preparation; soil testing; soil amelioration; seed germination and purity; seed application rate; seed carrier application rate (where specified); binder type and application rate (where specified); mulch application rate; soil surface cover.
Establishment and maintenance	• Site won topsoils may also contain a seed bank of native or weed seeds • The soil must be appropriately managed to pressure the native seed for natural regrowth • Weed seed infested topsoil should be managed as per relevant specifications.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 5

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Hydroseeding

Hydroseeding is the hydraulic application of seed and soil ameliorants using purpose built equipment. The seed and ameliorants are added to a tank fitted with an agitator and pump.

The agitator mixes and then applies the materials via a cannon from the top of the unit or via hoses. The largest and most powerful hydro-seeders can apply seed up to 100 metres away from the unit.

A seed carrier is commonly used to ensure even mixing of the seed in the tank and help it stick to the soil surface. The seed carrier allows visual inspection of the seed application rates and also protects the seed as it passes through the hydro-seeder pump. The seed carrier is normally shredded recycled paper or wood fibre and is applied at 200kg / hectare.

Hydroseeding is mainly used where suitable topsoil is available. Native plant seeds can be applied on subsoil and rocky slopes but vegetation establishment is generally poor.

IMPORTANT NOTE: Hydroseeding is not hydromulching – it is simply a method of applying seed. It does not offer erosion protection until vegetation establishes. It's normally used in situations where conventional seeding equipment such as drill seeders cannot be used due to access limitations or slope steepness. Hydroseeding is often undertaken prior to hydromulching or straw mulching, which will then provide erosion protection until vegetation establishes.

Figure FS5a: Hydroseed application on a prepared batter.

Figure FS5b: Diverse vegetation establishment resulting from hydroseeding overlaid with hydromulch on the Kempsey Bypass.

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FACTOR	DETAIL
Slope	< 2h:1v if followed by hydro mulching. The slope is limited by the topsoil application.
Level of erosion protection	Sheet flow less than maximum permissible velocity of the soil.
Growing media	Topsoil.
Soil amelioration	Very low. Multiple applications required. Ameliorants easily washed off the slope.
Bioregion	Hydroseeding for temporary cover will work in all NSW bioregions, but success will depend on the amount of follow-up rain. Extreme weather conditions will cause failure in hydroseeding from inadequate moisture and death of germinated seed, or the seeding mix being washed off the batter prior to root establishment. Hydroseeding with native seed mixes are more difficult to establish reliably and consistently, as many native seeds require specific climatic conditions to germinate, and may have natural periods of dormancy. Species that have tropical or rainforest origins typically do not work in hydroseeding due to the size and type of seed. Hydroseeding works well in bioregions with little climatic variation.
Access	Installation – access will be required for hydro-seed machines to apply the seed. Proximity will depend on the application distance of the specific machine – truck-mounted units are fixed and will need to be immediately adjacent to the batter, whereas machines fitted with hoses may be able to apply seed up to 100 metres from the access point. Maintenance – access may be required for erosion repairs or repeat applications if rainfall occurs prior to establishment. Depending on site conditions, access may also be required for weed control, repeat applications of ameliorants or watering vegetation.
Duration	Completely dependent on 'Vegetation type' (see below).
Visual amenity and ecological outcome	Hydroseeding allows the use of any Vegetation Type (see below), subject to seed availability, and hence any visual amenity and ecological outcome requirements can be tailored in the seed mix.
Vegetation type	Cover crops, grasses and legumes, native ground covers, shrubs and trees.
Establishment time until erosion protection	No erosion protection is provided until vegetation establishes. Optimum erosion protection is usually provided once 70 percent soil surface cover is achieved. A hydromulch cover is often recommended to provide erosion and raindrop protection during establishment.
Cost (at time of publication)	Low if suitable weed free topsoil is available in the immediate area: • $0.40 - $2.00/$m^2$ depending on location and area seeded • Additional $3 - $5/$m^2$ to strip, ameliorate and respread topsoil if necessary • Maintenance costs can be high depending on conditions (see below).
Preparation	Soil surface should be scarified and topsoil and subsoil should be ameliorated. Advice should be sought by relevant experts and agronomists to develop the appropriate species, seeding rates, ameliorants and watering requirements.
Rate of vegetation establishment	Slow – highly variable.
Quality assurance and surveillance	Soil preparation, soil testing, soil amelioration, seed germination and purity, application rate and purity, seed carrier application (where specified), seed application method, binder application rate (where specified).
Establishment and maintenance	Establishment and maintenance can be intensive depending on site conditions, and could include: • Erosion repairs or repeat applications if rain occurs prior to vegetation establishment • Maintenance application of ameliorants • Weed control if topsoil is poor, weeds are adjacent to the seeded area or vegetation establishment is slow • Watering in dry conditions to establish vegetation.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 6

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Straw mulching

Straw mulching is the application of a cereal or cane toppings straw material to the soil surface to provide raindrop splash erosion protection and moisture retention and thermal insulation.

These properties make it a very effective method for vegetation establishment (particularly grasses). Despite this, the use of straw mulch has declined due to the difficulty in obtaining cheap and weed free straw. Hay can be used when the establishment of pasture grasses and weeds is not an issue.

If vegetation is to be established, the topsoil must be tested, ameliorated and seeded (normally Hydroseeding) prior to the application of the straw mulch. When straw is used as seed mulch, it is important that the application rates are sufficient to retain moisture in the soil (~25mm), but not too deep that a physical barrier is formed and all sunlight is restricted (~50mm).

Straw and hay can be spread by hand or with a straw blower. For large jobs, using a trailer or truck mounted blower unit is the most practical application method. Straw mulch should be applied at a rate of 5000kg/hectare (approximately 250 bales). The distance that straw or hay can be blown depends on the hay blowing equipment, wind conditions during application, straw characteristics, and whether the material is being applied upslope or downslope (cuts or fills). When wind is favourable, straw can be blown up to 45 metres. However in adverse conditions the application of straw may not be possible.

Once applied, the straw is susceptible to movement with moderate to high winds, so is usually applied with some form of binder, such as Bitumen emulsion (see Fact Sheet 2) or Tackifier (see Fact Sheet 3). The straw and bitumen emulsion can either be applied at the same time or the bitumen emulsion applied as an overspray. Tackifiers are often applied over the straw, and can be used with low quantities of Hydromulch to assist in binding the straw together.

However if a binder is used it only glues the straw to itself, not the soil surface. As such it is critical that all upstream flows are diverted away from the batter so the straw is not dislodged by overland flow. As an alternative, straw can also be crimped, rolled, or punched into the soil. These measures will bury portions of the stems into the soil and can increase erosion protection because of the more intimate contact of straw with the soil surface. The potential for compaction is increased and should be considered if using these treatments.

NOTES: Straw mulch should not be used on dispersive soils unless they are suitably ameliorated with gypsum. *Triticale* species must not be used in the Tablelands, Central Slopes and Western Plains regions, in order to prevent the spread of "wheat rust" in wheat growing areas.

Figure FS6a: Straw mulch being applied with a trailer mounted straw blower.

Figure FS6b: Straw mulch being ineffectively applied in adverse wind conditions.

FACTOR	DETAIL
Slope	≤ 2h:1v
Level of erosion protection	Raindrop splash erosion only.
Growing media	Topsoil.
Soil amelioration	Straw mulching provides little or no soil amelioration. Depending on the results of soil tests, the subsoil and topsoil should be ameliorated prior to seeding (if relevant) and the application of straw mulch
Bioregion	Straw mulching is appropriate for use in all NSW bioregions, and can be used at any time of year for erosion control purposes. Straw mulching is an excellent thermal cover for seeded batters in frost-prone and cool climate areas, and soil moisture retention in hot and dry areas. Careful planning should be untertaken for the application of straw mulch in windy areas or hot seasons as dry straw can be a fire risk and is easily blown from site. In wet sites, ensure that the species origin of the straw will not host pathogens or other plant diseases that may affect agricultural areas.
Access	Installation – Straw mulch has a limited application distance so machinery will need access immediately adjacent to the batter. If necessary, access for soil amelioration may also be necessary. Maintenance – access may be required for erosion repairs or repeat applications if rainfall occurs prior to establishment. Depending on site conditions, access may also be required for weed control, repeat applications of ameliorants or watering vegetation.
Duration	Straw mulch will remain effective for 2 – 6 months. Much longer stabilisation will be achieved if vegetation is established with the straw mulch – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	Straw mulch (& binder if used) alone provides little value for visual amenity or ecological outcomes. Good outcomes can be achieved if vegetation is established with the straw mulch, but will vary according to the Vegetation Type.
Vegetation type	Cover crops, grasses and legumes.
Establishment time until erosion protection	Immediate if only straw mulch is used. Up to 24 hours if a binder is used, to allow for curing.
Cost (at time of publication)	Moderate if suitable weed free topsoil is available in the immediate area: • $0.60 - $5.00/m^2 depending on location, area to be treated and availability of weed free straw • Additional $3-$5/m^2 to strip, ameliorate and respread topsoil, if necessary • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Soil scarification and amelioration of subsoil and topsoil.
Rate of vegetation establishment	Vegetation establishment is moderate to rapid.
Quality assurance and surveillance	Soil preparation; soil testing; soil amelioration; seed germination and purity; seed application rate; seed carrier application rate (where specified); seed application method; binder type and application rate (where specified); straw mulch weed certification certificates; straw mulch application rate; soil surface cover.
Establishment and maintenance	Establishment and maintenance can be relatively intensive depending on site conditions, and could include: • Watering (dependent on rainfall and Vegetation Type) • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow • Re-application if vegetation does not establish or there is damage from wind or water erosion.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Roads & Maritime

Hydromulching – Standard

Hydraulic Mulch (Hydromulch) consists of various types of organic fibrous materials (eg – paper / wood pulp, wood fibre, straw fibre or milled cane fibre) mixed with water and sprayed onto the soil surface in slurry form that sets to provide a layer of temporary protection from wind and water erosion. There are three broad types of Hydromulching: Standard (this Fact Sheet), Bonded fibre matrix (Fact Sheet 8) and Hydrocompost (Fact Sheet 9).

Standard Hydromulches should be applied at the specified rate, generally between 1,500 and 3,500 kilograms per hectare. They are manufactured containing around 5 percent Tackifier (see Fact Sheet 3), soil ameliorants, and sometimes seed. However ideally the seed should be applied separately prior to mulching, to ensure good contact with the soil. Food-based dyes are commonly added to provide a blue or green colouring.

Standard Hydromulch provides a degree of short term soil surface protection from raindrop splash erosion and low volume sheet flow in low to moderate rainfall erosivity environments. It is essential that upstream flows are diverted away from the batter.

IMPORTANT NOTE: Aged organic materials should be used to prevent nitrogen draw-down.

Figure FS7a: Standard Hydromulch being applied to a batter on the Hunter Expressway.

Figure FS7b: Hydromulch application on a shallow gradient batter, with green dye for visibility.

FACTOR	DETAIL
Slope	< 3h:1v On slopes ≥ 3h:1v Hydromulch can potentially be used in combination with a suitable supplementary stabilisation technique, such as an open weave organic fibre erosion blanket.
Level of erosion protection	Raindrop splash erosion and low volume sheet flow. Bonded fibre matrix or Hydrocompost will withstand heavier flow conditions.
Growing media	Topsoil.
Soil amelioration	Low. Only very small quantities of ameliorants are retained in the mulch. Ameliorants are easily washed off the slope so multiple applications may be required. The quality of the growing media and the Vegetation Type will determine the type and quantity of ameliorants that are required.
Bioregion	Hydromulching for temporary cover will work in all NSW bioregions, but success will depend on the amount of follow-up rain. Extreme weather conditions will cause failure in hydromulching from inadequate moisture and death of germinated seed, or the seed and mulch mix being washed off the batter prior to root establishment. Hydromulches with native seed mixes are more difficult to establish reliably and consistently, as many native seeds require specific climatic conditions to germinate, and may have natural periods of dormancy. Species that have tropical or rainforest origins typically do not work in hydromulching due to the size and type of seed. Hydromulching is appropriate to use in areas where the may be sudden changes in climatic conditions, or where straw mulching cannot be applied.
Access	Installation – Access will be required for Hydromulch machines to apply the mulch (and seed, where used). Proximity will depend on the application distance of the specific machine – truck-mounted units are fixed and will need to be immediately adjacent to the batter, whereas machines fitted with hoses may be able to apply mulch up to 100 metres from the access point. Maintenance – Access may be required for re-application, watering, applications of ameliorants or weed control.
Duration	Hydromulch will remain effective for 2 – 6 months. Much longer stabilisation will be achieved if vegetation is established with the Hydromulch – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	Hydromulch alone provides little value for visual amenity or ecological outcomes. Good outcomes can be achieved if vegetation is established with the Hydromulch, but will vary according to the Vegetation Type (see below).
Vegetation type	Cover crops, grasses, legumes, native shrubs.
Establishment time until erosion protection	Hydromulch will provide erosion protection as soon as the mulch sets (12 - 24 hours), however only offers a low level of protection. Vegetation (if used) will provide significantly better erosion protection once established. Bonded fibre matrix or Hydrocompost will provide better erosion protection than Standard Hydromulch, in a similar time period.
Cost (at time of publication)	Low if suitable weed free topsoil is available in the immediate area: • $0.70 - $2.50/m^2 depending on location and area treated • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Scarified soil and amelioration of topsoil and subsoil.
Rate of vegetation establishment	Vegetation establishment is slow and variable.
Quality assurance and surveillance	Soil preparation, soil testing, seed application method, seed application rate, seed germination and purity, mulch type and application rate, soil surface cover, binder application rate, soil ameliorant application rate; application coverage by multiple passes in different directions, ensure the area is moist prior to application.
Establishment and maintenance	Establishment and maintenance can be relatively intensive depending on site conditions, and could include: • Reapplication if heavy rain or flow washed hydromulch off the slope • Watering vegetation during dry periods • Maintenance application of ameliorants • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 8

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Hydromulching–Bonded fibre matrix

Hydraulic Mulch (Hydromulch) consists of various types of organic fibrous materials (eg – paper / wood pulp, wood fibre, straw fibre or milled cane fibre) mixed with water and sprayed onto the soil surface in slurry form that sets to provide a layer of temporary protection from wind and water erosion. There are three broad types of Hydromulching: Standard (Fact Sheet 7), Bonded fibre matrix (this Fact Sheet) and Hydrocompost (Fact Sheet 9).

Bonded fibre matrix (BFM) Hydromulches contain a high percentage of long fibres and are generally applied at a rate of 4,000 to 6,000 kilograms per hectare. BFMs should not be applied immediately before, during or immediately after rainfall or if the soil is saturated. They are generally manufactured containing around 2-4 percent cross-linked adhesive, around 1 percent polymer tackifier (see Fact Sheet 3) and soil ameliorants. The cross-linked adhesive should be biodegradable and should not dissolve or disperse upon rewetting. Food-based dyes are commonly added to provide a blue or green colouring.

BFM is designed to provide increased performance compared to Standard Hydromulch. This includes longer term erosion protection by providing complete soil surface cover, improved seed germination and hence revegetation outcomes and a greater ability to suppress weeds.

Figure FS8a: Correctly applied BFM Hydromulch – note 100% coverage. (Source: Landloch Pty Ltd)

Figure FS8b: Poorly applied BFM Hydromulch – note ineffective coverage. (Source: Landloch Pty Ltd)

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FACTOR	DETAIL
Slope	≤ 1h:1v On steep slopes the BFM Hydromulch can be anchored or covered using a suitable supplementary stabilisation technique (eg – open weave organic blanket, turf re-enforcement mat) to increase likelihood of success.
Level of erosion protection	Raindrop splash erosion or sheet flow. May withstand concentrated flow if combined with a supplementary stabilisation technique (see above).
Growing media	Topsoil.
Soil amelioration	Moderate. Only a small quantity of ameliorants can be retained in the mulch. Ameliorants can be washed off the slope and re-application may be required. The quality of the growing media and the Vegetation Type will determine the type and quantity of ameliorants that are required.
Bioregion	BFM hydromulch is appropriate for use in all NSW bioregions, but success will depend on the seed mix and application of seeds prior to covering with BFM. It is best used in areas prone to erosion from weather events, and with seed mixes that are aggressive pioneer species.
Access	Installation – Access will be required for Hydromulch machines to apply the mulch (and seed, where used). Proximity will depend on the application distance of the specific machine – truck-mounted units are fixed and will need to be immediately adjacent to the batter, whereas machines fitted with hoses may be able to apply mulch up to 100 metres from the access point. Maintenance – Access may be required for re-application, watering, applications of ameliorants or weed control.
Duration	BFM Hydromulch will remain effective for 6–12 months. Much longer stabilisation will be achieved if vegetation is established with the BFM Hydromulch – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	BFM Hydromulch alone provides little value for visual amenity or ecological outcomes. Good outcomes can be achieved if vegetation is established with the BFM Hydromulch, but will vary according to the Vegetation Type (see below).
Vegetation type	Cover crops, grasses, legumes, native ground covers, shrubs and trees.
Establishment time until erosion protection	BFM Hydromulch will provide erosion protection as soon as the mulch sets (24 - 48 hours), and offers a medium to high level of protection. Vegetation (if used) will provide further erosion protection once established.
Cost (at time of publication)	Moderate if suitable weed free topsoil is available in the immediate area: • $2.50 - $4.50/m^2 depending on location and area treated • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Soil scarification and amelioration of subsoil and topsoil.
Rate of vegetation establishment	Vegetation establishment is moderate to rapid.
Quality assurance and surveillance	Soil preparation; soil testing; soil amelioration; seed germination and purity; seed application rate; mulch type and application rate; application coverage by multiple passes in different directions; binder type and application rate; soil ameliorant application rate; soil surface cover.
Establishment and maintenance	Establishment and maintenance requirements are dependent on site conditions, and could include: • Reapplication if heavy rain or flow washes materials off the slope • Watering vegetation during dry periods • Maintenance application of ameliorants • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow (although BFM Hydromulch generally provides good weed suppression).

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 9

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Hydromulching – Hydrocompost

Hydraulic Mulch (Hydromulch) consists of various types of organic fibrous materials (eg – paper / wood pulp, wood fibre, straw fibre or milled cane fibre) mixed with water and sprayed onto the soil surface in slurry form that sets to provide a layer of temporary protection from wind and water erosion. There are three broad types of Hydromulching: Standard (Fact Sheet 7), Bonded fibre matrix (Fact Sheet 8) and Hydrocompost (this Fact Sheet).

Hydrocompost combines approximately 4,000kg / hectare of finely screened compost into the hydromulch slurry. Specified seed can also be added to the mix. Some proprietary products are available that combine these ingredients into a pre-packaged blend. Hydrocompost is particularly useful as an in-fill for three-dimensional batter surface stabilisation techniques, such as Turf reinforcement mats (see Fact Sheet 15).

Many Australian soils have extremely low organic carbon levels, which can limit vegetation establishment and growth in new stabilisation projects. However, when combined with other appropriate soil ameliorants, Hydrocompost can often improve the organic carbon levels and the soils biological properties enough to accelerate seed germination and growth and achieve an acceptable revegetation outcome. The heavy mulch and likely good revegetation outcomes can result in good weed suppression.

The compost used in hydrocompost is screened to remove particle sizes that would block the pumps in the hydromulching equipment. The quality of the compost is critical and it must comply with relevant specifications (eg – Australian Standard 4454: Compost, Soil conditions and Mulches). Poor quality compost can result in high nitrogen draw down, contain heavy metals, plastics and glass fragments and have elevated salinity.

Figure FS9a: Application of Hydrocompost on the Kempsey Bypass. (Source: Matthew Easton)

Figure FS9b: Vegetation establishment from Hydrocompost on the Kempsey Bypass. (Source: Matthew Easton)

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FACTOR	DETAIL
Slope	No limits. Hydrocompost is limited by the ability of the topsoil over which it is applied to hold on a slope. On steep slopes the Hydrocompost can be anchored or covered using a suitable supplementary stabilisation technique (eg – open weave organic erosion control blanket, turf re-enforcement mat) to increase likelihood of success.
Level of erosion protection	Raindrop splash erosion or sheet flow. May withstand concentrated flow if combined with a supplementary stabilisation technique (see above).
Growing media	Topsoil and sub-soil (assuming sufficient organic carbon can be applied to the sub-soil in the compost).
Soil amelioration	Moderate. Only a small quantity of ameliorants can be retained in the mulch.
Bioregion	Hydrocompost is bested suited to bioregions that can supply the required materials and will return the appropriate organics to the affected areas. As it can be used on steep slopes and often in conjunction with additional slope stabilisation techniques, it is suitable for forest and woodland environments and areas with regular heavy rain events.
Access	Installation – Access will be required for Hydromulch machines to apply the Hydrocompost (and seed, where used). Proximity will depend on the application distance of the specific machine – truck-mounted units are fixed and will need to be immediately adjacent to the batter, whereas machines fitted with hoses may be able to apply the material up to 100 metres from the access point. Maintenance – Access may be required for re-application, watering, applications of ameliorants or weed control.
Duration	Hydrocompost will remain effective for 6–12 months. Much longer stabilisation will be achieved if vegetation is established with the Hydrocompost –duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	Hydrocompost alone provides little value for visual amenity or ecological outcomes. Good outcomes can be achieved if vegetation is established with the Hydrocompost, but will vary according to the Vegetation Type (see below).
Vegetation type	Cover crops, grasses, legumes, native ground covers, shrubs and trees.
Establishment time until erosion protection	Hydrocompost will provide erosion protection as soon as the mulch sets (24–48 hours), and offers a medium to high level of protection. Vegetation (if used) will provide further erosion protection once established.
Cost (at time of publication)	Moderate if suitable weed free topsoil is available in the immediate area. Low if applied directly to subsoil and an acceptable vegetation outcome can be achieved. • $3.50 - $6.50/m^2 depending on location and area treated • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Soil scarification and amelioration of subsoil and topsoil.
Rate of vegetation establishment	Vegetation establishment is slow and variable.
Quality assurance and surveillance	Soil preparation; soil testing; seed germination and purity; seed application rate; mulch type and application rate; application coverage by multiple passes in different directions; compost quality and application rate; binder application rate; soil ameliorant application rate; soil surface cover.
Establishment and maintenance	Establishment and maintenance requirements are dependent on site conditions, and could include: • Reapplication if heavy rain or flow washes materials off the slope • Watering vegetation during dry periods • Maintenance application of ameliorants • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow (although Hydrocompost generally provides good weed suppression).

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 10

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Erosion control blanket – Organic fibre

Erosion control blankets (ECBs) are rolled erosion control products designed to protect the soil surface from various degrees of erosion.

They range from open meshes to thick dense mats, and can be manufactured from organic fibres (this fact sheet) or synthetic materials (Fact Sheet 11). There are many different Organic fibre ECBs available, so this fact sheet only describes general information.

Organic fibre ECBs are biodegradable and are suitable to be left in-situ if vegetation is also established. Organic fibre ECBs can be divided into two broad types:

- Grass promotion blankets – generally open meshes or thin mats and made of straw fibre, wood shavings or coir. Seed should be applied under the blanket to ensure intimate soil contact
- Weed suppression blankets – generally thick mats and made of jute or recycled fibre. Seedlings can be planted into the soil below the blanket using slits.

To function correctly and avoid being undermined, all ECBs require intensive soil preparation and correct installation. They must be adequately anchored at the top of the batter, pinned (stapled) and secured down the batter face (≤300mm spacing) to ensure intimate soil contact, and be overlapped the correct way (≥100mm, with each length over the top of the one below, like roof tiles). Installation should also achieve 100 percent coverage to ensure water cannot ingress and undermine the ECB.

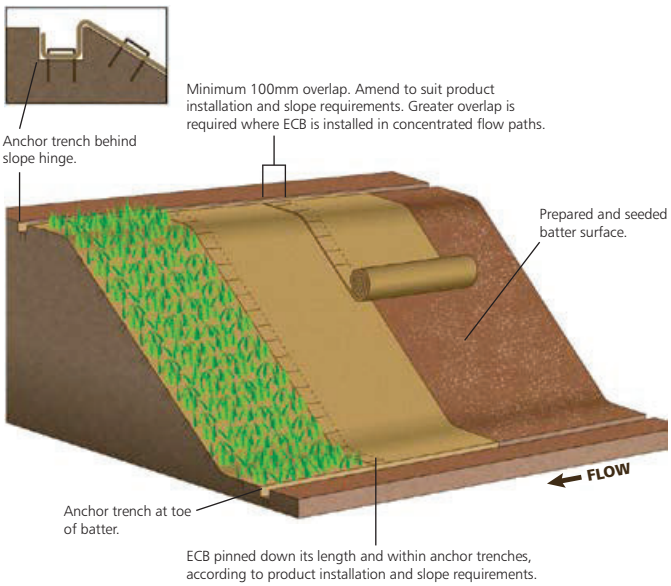

Figure FS10a: Correct ECB installation for a grass promotion blanket using seed. See Fact Sheet 11 for correct ECB installation for a weed suppression blanket using planting.

Figure FS10b: ECB failure due to poor surface preparation and water ingress through tree planting cuts. (Source: Landloch Pty Ltd)

FACTOR	DETAIL
Slope	There is no limit to the slope that Organic fibre ECBs can be applied to, as they are anchored to the slope surface with pins. They will be limited by the ability of the topsoil below to hold on the slope.
Level of erosion protection	Raindrop splash impact and sheet flow.
Growing media	Topsoil.
Soil amelioration	Organic fibre ECBs provide no soil amelioration. If vegetation is to be established through the ECB, soil amelioration might need to be undertaken prior to installation to provide suitable conditions for the desired vegetation type.
Bioregion	Organic fibre ECBs are suitable for use in all NSW bioregions, but the climate and level of exposure to weather (especially wetting and drying cycles) will affect the longevity and integrity of the material.
Access	Installation – intensive slope preparation and anchoring is required and access is needed down the entire batter. On steep slopes where safety is an issue, this may require the use of a cherry picker and/or other machinery. Maintenance – Access may be required for watering vegetation, anchoring repairs, replacing any damaged ECB and weed control.
Duration	Organic fibre ECBs will last up to 12 months before biodegrading - thickness and density are the biggest factors influencing duration. Much longer stabilisation will be achieved if vegetation is established with the ECB – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	Organic fibre ECBs are made from natural materials that provide minimal visual impact, but alone they provide little ecological value. The establishment of vegetation will improve the visual amenity and has the potential to improve ecological outcomes.
Vegetation type	Grass promotion blankets – cover crops, grasses and legumes. Weed suppression blankets – native ground covers, shrubs and trees.
Establishment time until erosion protection	Erosion protection is provided immediately upon installation. This will be enhanced if vegetation is established with the ECB.
Cost (at time of publication)	High: • $5 - $10/m^2 for materials, plus intensive soil preparation and labour costs • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for plants, watering in dry conditions and weed suppression (where necessary).
Preparation	Soil amelioration and intensive soil preparation to provide a uniform surface free of obstructions, tree stumps or rubble and create intimate contact between the ECB and soil surface. Preliminary weed control is essential before laying the material. If using a grass promotion blanket, seed should be applied before laying the material.
Rate of vegetation establishment	Vegetation establishment is generally slow.
Quality assurance and surveillance	Soil testing; soil amelioration; soil preparation; seed germination and purity; seed application rate; mulch type and application rate; compost quality and application rate; binder application rate; soil ameliorant application rate; soil surface cover.
Establishment and maintenance	Establishment and maintenance requirements are generally low to moderate, and could include: • Reapplication if heavy rain or flow washes materials off the slope • Watering vegetation during dry periods • Maintenance application of ameliorants • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 11

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Erosion control blanket – Synthetic

Erosion control blankets (ECBs) are rolled erosion control products designed to protect the soil surface from various degrees of erosion. They range from open meshes to thick dense mats, and can be manufactured from organic fibres (Fact Sheet 10) or synthetic materials (this fact sheet). There are many different Synthetic ECBs available, so this fact sheet only describes general information.

Figure FS11a: Erosion control blanket with cuttings for plantings. (Source: Geofabrics Australasia Pty Ltd)

Synthetic ECBs are manufactured from a variety of polymers and are not biodegradable. As such, they can generate a waste problem and must be removed and appropriately disposed of once they are no longer required for stabilisation. Synthetic ECBs can be divided into two broad types:

- Grass promotion blankets - generally open meshes or thin mats. Seed should be applied under the blanket to ensure intimate soil contact
- Weed suppression blankets – generally thick mats. Seedlings can be planted into the soil below the blanket using small slits (see Figure FS11a).

To function correctly and avoid being undermined, all ECBs require intensive soil preparation and correct installation. They must be adequately anchored at the top of the batter, stapled and secured down the batter face (≤300mm spacing) to ensure intimate soil contact, and be overlapped the correct way (≥100mm, with each length over the top of the one below, like roof tiles). Installation should also achieve 100 percent coverage to ensure water cannot ingress and undermine the ECB.

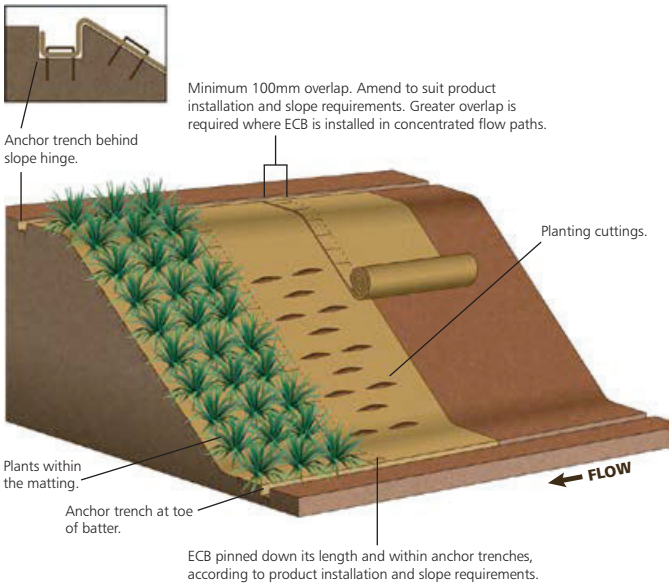

Figure FS11b: Correct ECB installation for a weed suppression blanket using planting. See Fact Sheet 10 for correct ECB installation for a grass promotion blanket using seeding.

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FACTOR	DETAIL
Slope	There is no limit to the slope that synthetic ECBs can be applied too, as they are anchored to the slope surface with staples. They will be limited by the ability of the topsoil below to hold on the slope.
Level of erosion protection	Synthetic erosion control blankets are designed to withstand sheet flow up to ~1.5 metres / second.
Growing media	Topsoil.
Soil amelioration	Synthetic ECBs provide no soil amelioration. If vegetation is to be established through the ECB, soil amelioration might need to be undertaken prior to installation to provide suitable conditions for the desired vegetation type.
Bioregion	Synthetic ECBs are suitable for use in all bioregions, but the should consider aspect and temperature. If left uncovered or unshaded, synthetic ECBs may increase the soil temperature in the upper root zone for newly germinated plants, which can inhibit vegetative establishment. Ensure that the ECB is UV-stable for use in exposed areas.
Access	Installation – intensive slope preparation and anchoring is required and access is needed down the entire batter. On steep slopes where safety is an issue, this may require the use of a cherry picker and/ or other machinery. Maintenance – Access may be required for watering vegetation, anchoring repairs, replacing any damaged ECB and weed control.
Duration	Synthetic ECBs will last up to 2 years before starting to break down - thickness and density are the biggest factors influencing duration. Much longer stabilisation will be achieved if vegetation is established with the ECB – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	Synthetic ECBs are often neutral colours that provide minimal visual impact, but alone they provide little ecological value. The establishment of vegetation will improve the visual amenity and has the potential to improve ecological outcomes.
Vegetation type	Grass promotion blankets – cover crops, grasses and legumes. Weed suppression blankets – native ground covers, shrubs and trees.
Establishment time until erosion protection	Erosion protection is provided immediately upon installation. This will be enhanced if vegetation is established with the ECB.
Cost (at time of publication)	Very high: • $5 - $10/m^2 for materials, plus intensive soil preparation and labour costs • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for plants, watering in dry conditions and weed suppression (where necessary).
Preparation	Soil amelioration and intensive soil preparation to provide a uniform surface free of obstructions, tree stumps or rubble and create intimate contact between the ECB and soil surface. Preliminary weed control is essential before laying the material. If using a grass promotion blanket, seed should be applied before laying the material.
Rate of vegetation establishment	Vegetation establishment is generally slow.
Quality assurance and surveillance	Soil testing, soil amelioration, soil preparation; seed germination and purity; seed application rate; seed application method; mulch type and application rate; binder application rate; soil ameliorant application rate; soil surface cover.
Establishment and maintenance	Establishment and maintenance requirements are generally low to moderate, and could include: • Reapplication if heavy rain or flow washes materials off the slope • Watering vegetation during dry periods • Maintenance application of ameliorants • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 12

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Cellular confinement systems

Cellular confinement systems are either a permanent or biodegradable product with the primary purpose to uniformly contain soil and other materials over an area and provide geotechnical strength with low strength materials and/or environments. The permanent cellular confinement systems are constructed from HDPE and the biodegradable ones from coconut fibre.

Cellular confinement systems were originally designed to contain material for temporary or permanent low cost, load-bearing access tracks over soft or unstable ground such as sand dunes, river beds and water logged areas. They can be effective for some batter surface stabilisation situations, where they confine fill material to resist flows, minimise erosion and prevent the downward migration of the materials. They are also suitable as a channel liner in some low velocity situations.

For batter surface stabilisation and the establishment of vegetation, they can be filled with topsoil or compost. Seed can either be applied with the growing media, or as a secondary application on top of the growing media. To protect seeds and assist with germination and establishment, compost blankets or bonded fibre matrix Hydromulch products can be used in conjunction with the cellular confinement system.

Cellular confinement systems require intensive slope preparation and fastening, and the edges of the system should be installed at or below ground level to minimise scouring at the edges by run on stormwater. Incorrect installation can result in dramatic failures, as one weak point can drag the entire batter down the slope.

Figure FS12a: Installation of cellular confinement system – backfilling with unbound granular material beneath the pavement and imported topsoil on the batter slope. (Source: Queensland Department of Transport and Main Roads)

Figure FS12b: Cellular confinement that has been installed and planted out on an extremely steep slope, and begun to slump due to insufficient anchoring.

FACTOR	DETAIL
Slope	≤1h:1v
Level of erosion protection	Raindrop splash erosion, sheet flow and low velocity concentrated flow.
Growing media	Topsoil or compost.
Soil amelioration	Soil amelioration is completely dependent on the material used to fill the cellular confinement system. If topsoil is used, it should be tested and ameliorated (if necessary) to ensure it is appropriate for any vegetation that is to be established. If compost is used, it can provide good soil amelioration for the existing topsoil / subsoil below.
Bioregion	Cellular confinement systems are generally able to be used in all NSW bioregions, but their effectiveness and installation depends on the geotechnical conditions. Avoid using cellular confinement systems in vegetation systems with buttressing roots that can "heave" the system off the ground surface. Cellular confinement systems made with thick synthetic materials may also absorb extra heat in exposed aspects.
Access	Installation – intensive slope preparation and anchoring is required and access is needed down the entire slope. On steep slopes where safety is an issue, this may require the use of a cherry picker and/or other machinery. Maintenance – Access may be required for watering, re-application of seed, anchoring repairs and weed control.
Duration	HDPE cellular confinement systems can be installed as permanent fixtures. Coconut fibre cellular confinement systems will last up to 4 years.
Visual amenity and ecological outcome	HDPE cellular confinement systems can be visually obtrusive and provide little ecological value. Coconut fibre cellular confinement systems can also be visually obtrusive, but provide a more natural appearance, but still provide little ecological value. The establishment of vegetation will improve the visual amenity of both products and has the potential to improve ecological outcomes.
Vegetation type	Cover crops, grasses, legumes, native ground covers, shrubs and trees. The cell size (ranges from ~200–400mm diameter) will limit the growth of trees and should be considered when selecting species so as not to cause ring-barking.
Establishment time until erosion protection	Erosion protection is immediate once appropriately installed, and will improve as vegetation (if used) establishes. Cellular confinement systems should not be used on dispersive soils unless suitably ameliorated with gypsum.
Cost (at time of publication)	Very high: • $20 - $30/m^2 for supply of cellular confinement system and installation • Additional cost for soil anchors (eg – duck billed anchors, soil nails) • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for seed, watering in dry conditions and weed suppression (where necessary).
Preparation	Soil amelioration may be required when topsoil is used. Intensive soil preparation is required to provide intimate contact between the cellular confinement system and the soil surface. If vegetation is to be established, seeding will be required.
Rate of vegetation establishment	Vegetation establishment will be variable if topsoil alone is used. Vegetation establishment will be rapid if installation is combined with compost, a compost blanket or topsoil with BFM hydromulch.
Quality assurance and surveillance	Soil testing and amelioration; cellular confinement system type and installation; soil preparation; seed germination and purity; seed application rate; seed application method; mulch type.
Establishment and maintenance	Establishment and maintenance requirements can be intensive and long-term, and could include: • Watering in dry conditions and re-seeding any failed areas • Long term maintenance of slopes with plastic matrix in place • Long term observations of tree establishment to ensure they are not strangled by cells • Ongoing observations of anchoring • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 13

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Compost blanket

A compost blanket consists of high quality compost, organic tackifiers (normally Guar), biological stimulants (bacteria and fungi foods), wetting agents, soil ameliorants and (usually) a seed mix, that is applied to the surface of the batter. They have many potential applications, but can be particularly useful when slopes are too steep for topsoil application, there is insufficient topsoil, the topsoil is of poor quality (including weed infested), or the topsoil is inaccessible for amelioration.

The compost production process results in a stable growing media that is high in organic carbon, has low potential for viable weed seeds (due to pasteurisation) and will not result in nitrogen drawdown. The compost provides slow release nutrients for vegetation establishment, has good water holding capacity and can be used on compacted and dispersible (with amelioration) soils. To ensure the quality of the compost, it is normally recommended that it be produced according to Australian Standard 4454.

Compost blankets are usually applied with pneumatic blowers at thicknesses ranging from 25 - 100 millimetres depending on slope conditions and desired vegetation outcome. Thin compost blankets are normally used for grass establishment and/or low rainfall environments and thick compost blankets are normally used for native vegetation establishment and/or high rainfall environments. The installation must achieve 100 percent soil surface cover with a uniform thickness, and must extend over the top of the batter to ensure water does not undermine the blanket.

Figure FS13a: Application of a compost blanket on a steep batter. This application also included the addition of woodchip to provide additional erosion protection. (Source: Leighton Contractors)

Figure FS13 b: Watering of compost blanket after application. (Source: The Hills Bark Blower)

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FACTOR	DETAIL
Slope	≤ 2h:1v ≤ 1h:1v if used with a supplementary stabilisation technique (eg – open weave organic blanket, turf re-enforcement mat).
Level of erosion protection	Raindrop splash erosion and sheet flow. May withstand low velocity concentrated flow if combined with a supplementary stabilisation technique (see above).
Growing media	The compost is supplied as the growing media, and is best applied over subsoils and where topsoil does not exist (eg – over rock).
Soil amelioration	The compost blanket provides medium-long term, slow release amelioration to the soil over which it is placed. However the compost itself normally provides all of the required properties to establish the desired vegetation.
Bioregion	Compost is appropriate for use in any NSW bioregion.
Access	Installation – Access requirements will depend on the application method. If applied by earthmoving machinery, the machines will need suitable access to the batter itself. Truck-mounted pneumatic blowers can apply compost up to 100 metres from the truck access point. Maintenance – Access may be required for watering and re-application in any failed areas.
Duration	The compost blanket itself will remain effective for 6 – 12 months. Much longer stabilisation will be achieved if vegetation is established with the compost blanket – duration will be dependent on the Vegetation Type (see below).
Visual amenity and ecological outcome	The compost blanket itself provides little visual amenity or ecological outcomes. However the vegetation, once established, can provide significant outcomes – this will be dependent on the vegetation type (see below).
Vegetation type	Cover crops, grasses, legumes, native ground covers, shrubs and trees.
Establishment time until erosion protection	Compost blankets will provide a medium to high level of erosion protection as soon as the tackifier sets (24-48 hours). Vegetation (if used) will provide further erosion protection once established.
Cost (at time of publication)	High upfront cost: • $3.50-$12/m^2 – depending on distance from suitable compost supply, area to be treated, depth of application and additives (eg – seed, ameliorants) required • However topsoil is not required, and maintenance costs are often minimal, so lifecycle costs should be considered.
Preparation	The batter surface (soil or rock) must be contour scarified and all loose rocks, roots, clods, stumps and debris over 50mm in diameter must be removed. Ameliorants must be applied to dispersive soils.
Rate of vegetation establishment	Vegetation establishment is usually rapid.
Quality assurance and surveillance	Soil preparation; soil testing; soil ameliorant application rate; seed germination and purity; seed application rate; application coverage by multiple passes in different directions; tackifier type and application rate; compost quality and application rate; soil surface cover.
Establishment and maintenance	Establishment and maintenance requirements are usually low, but could include: • Initial watering and in dry conditions • Replacing any washed out areas (must be done immediately) • Weed control if weeds are adjacent to the area.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 14

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Placed turf

Turf refers to growing grass, root and soil material that is harvested from the field in rolls. The rolls are placed on the ground providing immediate erosion protection from wind, raindrops and light surface flow.

Freshly laid turf is susceptible to lifting by strong sheet flows, and should be laid perpendicular to the path of flow to prevent scouring between rolls and pinned into place. The spacing and depth of anchor pins depends on the slope gradient and estimated surface water flow. Turf is easily cut to shape at junctions, around drains and culverts.

All turf requires mowing, but different turf species will grow at different speeds, have a variety of grass blade lengths, and a range of microclimate tolerances. Slow-growing, low maintenance turfs may be intolerant to wear or high flows, whereas fast-growing turfs may be more tolerant to wear or high flows but will require more frequent mowing or slashing.

Figure FS14a: Turf strip at top of seeded batter to spread sheet flow, Kempsey Bypass.

Figure FS14b: Turf placed on variable slopes, Bega Bypass.

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FACTOR	DETAIL
Slope	Although turf can thrive on very steep slopes, it is usually limited by the angle of access of mowing or slashing, which is ≤ 3h:1v.
Level of erosion protection	Raindrop splash erosion, sheet flow and concentrated flow.
Growing media	Turf should be laid on 50 – 150mm of sandy loam over cultivated subsoil for fastest root establishment. Turf may be pinned directly onto heavily cultivated subsoil to prevent eroding of growing media prior to establishment, but the quality and evenness of turf cover will be poorer.
Soil amelioration	Turf will grow in all soils except those with high acid or alkaline levels. Turf responds quickly to ameliorated growing media.
Bioregion	Turf is best suited to warmer climates for rapid growth and coverage. Most turfs are resistant to light frosts. Few turfs are drought tolerant, however dead turf will provide erosion control for a limited period if undisturbed.
Access	Installation – Turf rolling machinery can only access slopes ≤ 1v:4h. Turf can be laid by hand, so installation will only be limited by the ability to safely access the slope. Maintenance – machines to mow or slash the turf can only operated on slopes ≤ 1v:3h. Access may be required for watering, application of fertiliser and re-application in any failed areas.
Duration	If an appropriate turf variety is selected for the bioregion and it is not subject to excessive climate differentials, wear or compaction, turf can provide permanent stabilisation. Some cultivar turfs have sterile seed, so if the turf is worn or patchy, it will not recover.
Visual amenity and ecological outcome	Turf provides reasonable visual amenity outcomes, with a neat, uniform batter surface cover. Turf is excellent for late-finishing works and provides instant effect. Most turf grasses are exotic and low-growing, with little ecological benefit. There are significant environmental benefits in using turf to reduce ground surface heat, provide a temporary access surface and to keep areas open for sightlines or hazard clearance.
Vegetation type	Turf. Some grass species can be left to grow wild or managed as turf. There are some native turfs that are slow growing and will not require regular mowing, but these can be sensitive to frosts and frequent inundation.
Establishment time until erosion protection	Erosion protection from wind, raindrop and low sheet flow is immediate. Protection from concentrated flows will be provided after root establishment in 1-6 weeks, depending on bioregion, season and turf variety. Most turfs are much slower to establish in cold seasons and climates.
Cost (at time of publication)	High: • $4 - $12/m^2, depending on location and availability of turf • Additional $3 - $5/m^2 to strip, ameliorate and respread topsoil if required • Additional cost allowances should be made for watering in dry conditions and weed suppression (where necessary).
Preparation	Soil amelioration may be required when topsoil is used and cultivation of subsoil will be required to ensure it is free-draining. Intensive soil preparation is required to provide a level and uniform surface free of obstructions, debris and materials that prevent intimate contact between the turf roots and the soil surface.
Rate of vegetation establishment	Turf is installed as a mature product, and only requires the roots to establish in the sites growing media. Rate of vegetation establishment is dependant on the species, quality of bed preparation, climate and watering, but is generally rapid. Warm weather, frequent watering and preventing use or access over the new turf will increase the rate of establishment.
Quality assurance and surveillance	Turf type and installation; soil testing and amelioration; soil preparation; soil ameliorant application rate; soil surface cover; watering.
Establishment and maintenance	Establishment and maintenance requirements are generally moderate, but can be high for exotic turfs laid in peak warm seasons, and could include: • Watering in dry conditions and re-application in any failed areas • Mowing (~every 8 - 12 weeks after initial establishment) • Weed control if growing media is poor or weeds are adjacent to the area.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

Fact Sheet 15

Guideline for Batter Surface Stabilisation using vegetation

Roads & Maritime

Turf reinforcement mats

Turf Reinforcements Mats (TRMs) are primarily used as an alternative to hard armours in channel lining situations. In slope stabilisation situations TRMs are used when overland flows are present or the slope gradients are too steep to hold topsoil or compost.

TRMs are two- or three-dimensional rolled mats made from a dense mesh of synthetic polymers (ie – not biodegradable) that are placed on the soil surface to protect it from medium to high velocity flows.

Two-dimensional non-soil filled TRMs are flat and are used in situations where suitable topsoil exists but an overland flow could erode it. The topsoil is seeded prior to the application of the TRM. Once established, the plant stems intertwine with the TRM to form a strong surface that withstands flow.

Soil filled TRMs are up to 10mm thick and are considered the most appropriate for slope stabilisation solutions. They can be used where the slope is too steep to hold topsoil or compost. Following installation of the TRM, topsoil or compost is applied using a slinger or blower truck to fill the voids in the three-dimensional mat. Seed is either mixed in with the growing media or applied on top of it. The mat then assists to hold the soil and seed in place while the plants establish and intertwine with the TRM to form a strong surface that withstands flow. Other stabilisation techniques (eg – BFM Hydromulch) can be applied over the surface of TRMs to provide an additional level of erosion protection for critical sites.

Like other rolled batter surface stabilisation techniques (eg – erosion control blanket, cellular confinement systems), correct installation of TRMs is critical to ensure success. It requires a smooth and uniform soil surface to ensure intimate soil contact, sufficient anchoring at the top of the batter, stapling down its length (≤300mm spacing) and sufficient overlapping (≥100mm).

Figure FS15a: Soil-filled turf reinforcement mat. (Source: Wally Butman – Profile Products)

Figure FS15b: Non-soil filled turf reinforcement mat.

FACTOR	DETAIL
Slope	TRMs can be applied on slopes ≤ 3h:1v. It may be possible to apply a TRM to slopes <1h:1v if a complementary measure (eg – BFM Hydromulch) is used to help stabilise the slope.
Level of erosion protection	Raindrop splash erosion, sheet flow and concentrated flow.
Growing media	The growing media is dependent on the type of TRM that is used. Two-dimensional TRMs are laid on the slope surface and rely on an existing growing media. Three-dimensional TRMs are laid on the slope surface and topsoil (existing or imported) or compost is then applied to fill the voids in the matting.
Soil amelioration	No soil amelioration is provided when two-dimensional TRMs are applied over existing topsoil. Soil amelioration can be provided when imported topsoil (variable and reliant on quality of source material) or compost (usually high levels of amelioration) are applied to three-dimensional TRM's. Both topsoil and compost can be artificially ameliorated prior to application. If BFM Hydromulch is used with a TRM it can provide moderate additional levels of amelioration.
Bioregion	TRMs are appropriate for use in any NSW bioregion. If made with thick synthetic materials they may also absorb extra heat in exposed aspects.
Access	Installation – intensive slope preparation and anchoring is required and access is needed down the entire slope. On steep slopes where safety is an issue, this may require the use of a cherry picker and/or other machinery. Maintenance – Access may be required for watering, re-application of seed, anchoring repairs and weed control.
Duration	TRMs are designed as a permanent stabilisation technique. Each product will eventually break down (longevity is dependent on the materials used), however established vegetation will continue to provide some level of stabilisation.
Visual amenity and ecological outcome	TRMs are often a natural or unobtrusive colour that provides minimal visual impact, but alone they provide little ecological value. The establishment of vegetation will improve the visual amenity of both products and has the potential to improve ecological outcomes.
Vegetation type	TRM's can be used with either temporary or permanent vegetation, however the cost will likely limit the application of TRM's for temporary solutions. Vegetation type will be limited by the pore size of the given TRM, and will be restricted to cover crops, grasses, legumes and possibly some small native ground covers.
Establishment time until erosion protection	The erosion protection provided by a two-dimensional TRM is limited until vegetation establishes, as the soil underneath is not held in place. The erosion protection provided by a three-dimensional TRM is instant, and will be enhanced when vegetation establishes.
Cost (at time of publication)	Very high: • $12 - $35/m^2 to supply and install • For three-dimensional TRMs, additional costs should be allowed to either strip, ameliorate and re-apply topsoil, or import, ameliorate and apply topsoil or compost.
Preparation	Intensive soil preparation is required to ensure a smooth and uniform surface (free of obstructions, tree stumps, clods and rubble) and intimate contact between the TRM and slope surface. Soil amelioration may also be required to ensure the growing media (existing or imported) is suitable for the vegetation that is to be established with the TRM. Preliminary weed control is essential before laying the TRM.
Rate of vegetation establishment	Vegetation establishment is dependent on the vegetation type and the quality of the growing media. Rate of establishment with topsoil is extremely variable, but will generally be rapid if compost is used. The use of BFM Hydromulch with any growing media will generally speed up the rate of establishment, by shielding seed from rain drop impact and regulating soil temperature and moisture levels.
Quality assurance and surveillance	TRM type and installation; soil testing and amelioration; compost quality; soil preparation; seed germination and purity; seed application rate; seed application method; mulch type.
Establishment and maintenance	Establishment and maintenance requirements are usually low, but could include: • Watering in dry conditions and re-seeding any failed areas • Ongoing observations of anchoring and repair where necessary • Weed control if topsoil is poor, weeds are adjacent to the area or vegetation establishment is slow.

This fact sheet has been prepared to be complementary to Section 3, Factors to consider, of the Guideline for Batter Surface Stabilisation using vegetation.

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