Practical Guide to Soil Erosion

A guide to preventing, assessing, and treating soil erosion on your farm

Wendy Miller
An initiative of the Border Rivers-Gwydir Catchment Management Authority

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The information contained in this publication is based on knowledge and understanding at the time of writing (January 2008). However, because of advances in knowledge, users are reminded of the need to ensure information upon which they rely is up-to-date and to check the currency of the information with the appropriate staff at the Border Rivers-Gwydir Catchment Management Authority or the users independent adviser.

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New South Wales Government
Foreword

This booklet was produced by the Border Rivers-Gwydir Catchment Management Authority (herein referred to as the CMA), to help landholders manage their soils and natural resources. The need for such a book was identified by staff who have close contact with landholders, and also via a landholder survey conducted by the CMA.

The information contained in the booklet is aimed at providing basic but relevant information about how to recognise erosion problems, assess the extent of the problem, and ways to treat erosion. A major focus of the booklet is prevention. Therefore, land management practices that reduce the chances of erosion occurring are examined throughout the booklet.

**Most attention is focused on gully erosion**, but the ways to prevent all forms of erosion have a similar theme, which is catchment management. The options for treating erosion are also presented, focusing strongly on “soft” options such as vegetation and stock management. While “hard” options, such as engineering and earthworks are shown, they are only covered briefly to give an idea of the options available and the situations in which they may be utilised. Streambank erosion has not been included in the booklet as it is considered to be too large a subject to be represented in this small booklet.

The information contained in the booklet was current at the time of writing (January 2008). As our knowledge increases and technology changes there may be newer ways you can manage and treat erosion. To ensure you know all the options available to you be sure to talk to someone who is up-to-date with the latest methods.
Acknowledgements

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1. What is soil erosion?

Soil erosion is the movement of soil, via wind or water, from its original position in the landscape. While this is a dynamic process that is occurring naturally all the time on a small scale, the results of large-scale soil movement can be devastating to soil health and productivity. The acceleration of soil erosion is generally a symptom of human activities.

How it happens

Water movement is the main agent for soil erosion in Australia. On exposed soils, the impact of raindrops breaks up small soil aggregates which then clog up the pores in the soil surface. Subsequent rainfall lies on the soil surface and raindrops mobilise fine soil particles which are then carried away in the water flow.

Wind can also cause movement of soil under certain conditions and generally occurs when soil is exposed, dry and loose. Wind erosion is a complex interaction between wind speed, particle size, and duration of windy conditions. As more and more large soil particles are lifted and bounced along it has a cascading effect, with dust particles being lifted into suspension by these larger particles and carried away by the wind. The final destination of these particles depends on their weight, with larger particles dropping out the quickest.

What you can do

The amount of water and wind erosion that will occur on your property during a rainfall or wind event is related to the amount of stabilising vegetation present, topography, and soil types. In this guide an emphasis is placed on managing land within its capabilities to reduce the chances of erosion occurring and to help control existing eroded areas.
2. Back to basics

Soil and its properties
Although land management is the major factor that influences the chances of erosion occurring on your land, the type of soil you have is another factor that is important to take into account.

Soil formation is dependent on five soil-forming factors:
- parent material
- climate
- relief or topography
- organisms, including humans
- time.
(Murphy 2000)

Soil physical properties and behaviour
The way your soil is formed will influence its texture, structure and clay content. Differences in any of these factors will affect your soils physical properties, such as water retention, permeability, strength, and friability. This, in turn, influences the behaviour of soils and their susceptibility to erosion.

Clearly, some soils will be more prone to erosion than others. Furthermore, some soils will maintain a vegetative cover more readily than others. These two factors must be taken into account when managing your land and assessing erosion risk.
**Soil erodibility** is the susceptibility of soil to erosion either by water or wind. This susceptibility increases the risk of erosion, so you should be aware of the properties that make soil more erodible.

- **Cohesiveness** is a measure of how well soil material holds together under different moisture levels. The less cohesive a soil (e.g. sand), the higher the chances it will erode.

- **Soil texture** influences the cohesiveness of your soil. If a soil is fine textured, it will generally be more cohesive. However, if these fine particles are released they are more easily transported. Soils that are more erodible are usually soils that have a moderate silt or fine sand content and low clay content. The finer particles are easily eroded and the low clay content means there is generally less cohesion.

- **Aggregate size distribution** affects erodibility and transportation potential of soil. Aggregates are a group of peds held together to form a distinct unit. The larger the surface aggregates the lower the erosion risk as they are resistant to raindrop attachment, reduce surface runoff via their roughness, and are too heavy to transport long distances.

- **Aggregate stability and dispersion** determines how much aggregates will change character after rainfall. Some aggregates will disperse or slake easily in water while others remain stable (see Page 5). Soils high in sodium are more dispersible/erodible.

- **Permeability** or infiltration potential of a soil will affect its erodibility. If water can infiltrate a soil easily it is less likely to erode. Permeability is affected by structural degradation, crusting, presence of a plough pan, and the closure of soil cracks. Infiltration will also be slower when soil is already water-logged. (Reference: Geeves et al. 2000)
Back to basics, continued

Assessing erodibility
Based on the information on the previous page, it is possible to do a basic assessment of your soils to determine the risk of erosion. **Note that the following assessment is based purely on soil properties and does not include important considerations such as slope, ground cover or other factors.** These should also be taken into account when making management decisions.

<table>
<thead>
<tr>
<th>Erodibility</th>
<th>Topsoil</th>
<th>Subsoil</th>
</tr>
</thead>
</table>
| **Low**     | • High organic matter (>3%) (soils have a dark colour and feel greasy and spongy when textured).  
• High coarse sand (large grain size that is not easily moved by wind or water).  
• Well structured, non-dispersible clay loams and clays having aggregates that do not slake in water to particles less than 2mm. For example: red, smooth and rough ped earths, some structured loams and friable duplex soils. | • Cemented layers including silcrete, ortstein and laterite iron, manganese and silicon pans.  
• High coarse sand (large grain size that is not easily moved by wind or water). |
| **Medium**  | • Moderate organic matter (2-3%).  
• Moderate fine sand and silt, such as hard, pedal red duplex soils.  
• Well-structured clay-loams and clays that slake in water to particles less than 2mm such as Vertosols. | • Stable, non-dispersible loams and clay loams such as red and yellow massive earths.  
• Non-dispersible or slightly dispersible clays with particles that slake to finer than 2mm such as non-sodic red, brown and yellow duplex soils. |
| **High**    | • Low (1-2%) to very low (<1%) organic matter, such as soils with bleached A$_2$ horizons  
• High to very high silt and fine sand (>65% of soil particles are between 0.002 mm and 0.02 mm in size). | • Dispersable clays such as sodic, yellow and red soils. An ESP of 6% or higher indicates sodicity (see glossary).  
• Unstable, dispersable clayey sands and sandy clays, such as yellow and grey massive earths formed on sandstone and some granites. Unstable materials high in silt and fine sand, such as unconsolidated sediments and alluvial materials. |

(Source: Murphy 1984)
3. Testing soil slaking, dispersion, and salinity

• Testing slaking

What this test tells you
This test indicates whether you have sufficient organic matter in the soil to hold your soil together.

1. Take a small lump of soil, about as big as a marble.
2. Place it carefully in a saucer of water.
3. Watch to see whether anything happens.
4. If small bubbles appear in the water, and the lump collapses, your soil has slaked. It has insufficient humus or decaying organic matter to hold the soil particles together.
5. When soil slakes, water rushes into the air spaces in the soil, forces the air out (as bubbles) and explodes the soil particles. Slaking occurs when soil is cultivated without any organic matter going into the soil.
6. If nothing happens to your soil lump, it has enough organic matter in it to hold it together. It has good structure.
Testing slaking, dispersion and salinity, continued

**Scoring and interpreting the slaking test**

**Score:**
- 0 = No slaking (the lump remains intact)
- 1 = The lump collapses around the edges but remains mainly intact
- 2 = The lump collapses into angular pieces about 2 mm or bigger
- 3 = The lump collapses into small (less than 2 mm) rounded pieces, forming a cone
- 4 = The lump collapses into single grains (if you can see the sand grains)

**What to do**

**Score 0 - 1** Means that your soil is stable to wetting, probably due to the presence of organic matter. Current management can continue as long as ground cover is maintained and soil is not over-cultivated.

**Score 2** This is a score typical of self-mulching soils. Use the dispersion test, and if it does not disperse then continue with the current management that has achieved this good condition.

**Score 3 - 4** This score may indicate you have low organic matter in your soil and it may also have a surface crust or be hard setting. This type of soil should support perennial pasture or be subject to no-till operations to increase organic matter in the soil.
Testing dispersion

What this test tells you
Dispersion is a measure of how your soil disintegrates into its individual components (clay, silt and sand) in water, and testing it is a very simple process. The results can give you an indication of how your soil will behave when wet, and its erosive potential. The following simple tests can be done by you on-farm.

1. Place some rain water or distilled water into a shallow dish (do not use town or treated water).
2. Place several lumps of dry soil (marble-sized) into the water and do not disturb for several hours.
3. Check after 10 minutes to see if the water around the soil has started to go cloudy. If it has, it means that the soil has started to disperse and it could indicate that your soil is sodic. Check again after 30 minutes and two hours to check for additional cloudiness.
4. Sodic soil has sodium attached to the clay and will attract a water shell around the soil and prevents the soil from joining together. The dispersed clay particles make the water look cloudy or muddy.

Modified from Department of Primary Industries (date unknown)
Interpreting and using the results of the dispersion test

Sodic soils
If the tests show you have sodic soils, then this can indicate that you will have a problem with erosion if you do not manage your land in an appropriate manner. Sodicity affects around a third of all soils in Australia and, along with the increased threat of erosion, can cause waterlogging, surface crusting and poor water infiltration. When interpreting soil laboratory tests, an Exchangeable Sodium Percentage (ESP) of 6% or greater indicates that you have sodic soils and could be at higher risk of erosion.

Sodic soils on sloping land are vulnerable to water erosion, which means your topsoil will be lost for production. When water follows small drainage lines in these areas it can cause rill erosion. In severe cases, gullies will develop. If the subsoil is sodic on sloping land, water flowing through the sodic layer will create tunnel erosion, leaving cavities which will eventually collapse and form gullies.

What to do
A calcium-containing substance like gypsum can be applied to the affected soil. The calcium replaces the sodium in the clay and makes it less likely to disperse into its individual particles. However, very large amounts of gypsum may be required to help even in the short term. In most cases, a property or sub-catchment approach to the management of sodic and other problem soils is the best way to manage your soils. Decisions based on an understanding of water movement and the distribution of soils on your farm will give a longer-term solution. Talk to the soils experts located at the CMA for more advice on how to manage sodic soils on your property.
• **Testing salinity**

**What this test tells you**
If you have an area on your property that lacks ground cover, it can potentially become eroded. A salinity test will tell you if the lack of ground cover is, at least partly, due to salts in your soil. This test involves measuring the electrical conductivity (EC$_{1:5}$) of the soil. EC$_{1:5}$ refers to the proportion of soil mixed with water to conduct the test. **Dry soil samples are collected and usually sent to a laboratory for testing, as it involves using special equipment.** The result of this test is then multiplied by a conversion factor based on the texture of the soil sample to give you EC$_e$ (see the factors on the facing page, and how to test your soil texture on the following pages).

**Where to sample**
You should sample in areas that you suspect there is a salinity problem, and also in adjoining areas for comparison. This may include areas that have indicators of salinity, such as indicator plants, and where stock congregate and lick the soil, or areas that do not support much ground cover. If you are unsure, talk to an expert such as your local salinity officer at the CMA, or your local agronomist. They may also be able to do salinity tests to give you an idea of the problem.

Take as many samples as possible (up to a maximum of twenty, depending on the size of the area), and do it in a pattern that you can repeat for future monitoring purposes. Take the samples at varying depths across the paddock to identify if you have subsoil salinity. Label the samples and keep each sample separate so that you can identify changes across the area. You should take enough soil to do the texture tests and at least another couple of handfuls of soil. **Send soil samples to an accredited laboratory.**
Testing slaking, dispersion and salinity, continued

What to do
If the test results indicate that you have saline soil, you should speak to your local salinity officer at the CMA or speak to other experienced people. In most instances, management of the saline area will need to be changed and should be different from the non-saline areas of your property. Fencing the area from stock and planting salt-tolerant pastures or trees, as well as mulching the soil, may help with short-term improvement of ground cover. The cause should be treated as well as the symptoms, so recharge and discharge areas should both be managed with strategic planting of perennial species (grasses, shrubs and trees).

The *Salinity Glove Box Guide, NSW Namoi, Border Rivers & Gwydir Catchments* details the causes, identification, and management options for saline sites and a copy is available from the CMA.

Conversion factors for soil texture groups
If you have access to a conductivity meter to do the EC_{1:5} test, the table below shows the conversion factors that you will need to use to multiply the result to get an accurate idea of how saline your site is. For example, if you get an EC_{1:5} of 0.3 dS/m and you have sandy loam soil the EC_{e} will be 0.3 x 14 = 4.2 dS/m.

<table>
<thead>
<tr>
<th>SOIL TEXTURE GROUP</th>
<th>CONVERSION FACTOR (MULTIPLY BY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SANDS</td>
<td>17</td>
</tr>
<tr>
<td>SANDY LOAMS</td>
<td>14</td>
</tr>
<tr>
<td>LOAMS</td>
<td>9.5</td>
</tr>
<tr>
<td>CLAY LOAMS &amp; LIGHT CLAYS</td>
<td>8.6</td>
</tr>
<tr>
<td>MEDIUM AND HEAVY CLAYS</td>
<td>6.7</td>
</tr>
</tbody>
</table>
4. Testing soil texture

What this test tells you
Soil texture tests give an indication of the proportions of sand, silt and clay in your soil sample. Differing proportions of these three mineral particles in your soil will give it different physical properties. In particular, it influences the cohesiveness of your soil. The higher the clay content the more cohesive your soil will be. Clay soils are less likely to become eroded. However, this cohesiveness may cause other land management problems such as difficulty in cultivation when too wet or too dry.

1. Take a small handful of soil.
2. Add enough water to make a ball. If you can’t make a ball then your soil is very sandy.
3. Feel the ball to see if it is gritty (sand), silky (silt) or plastic/sticky (clay).
4. Re-roll the ball and, with your thumb, press it out over your forefinger to form a hanging ribbon of soil.
5. The longer the ribbon the more clay you have in your soil. Measure the ribbon length (ruler on the rear of book) and refer to the table to assess your soil texture.
### Testing soil texture, continued

The following table shows how to interpret your soil texture test. (Source: Evans, 2001)

<table>
<thead>
<tr>
<th>Ribbon length (mm)</th>
<th>Coherence (way ball holds together)</th>
<th>Approx. clay %</th>
<th>Texture class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>Nil</td>
<td>Less than 5%</td>
<td>Sand (S)</td>
</tr>
<tr>
<td>5</td>
<td>Very slight</td>
<td>5-10%</td>
<td>Loamy sand (LS)</td>
</tr>
<tr>
<td>5-15</td>
<td>Slight</td>
<td>5-10%</td>
<td>Clayey sand (CS)</td>
</tr>
<tr>
<td>15-20</td>
<td>Slight to just firm</td>
<td>10-20%</td>
<td>Sandy loam (SL)</td>
</tr>
<tr>
<td>15-25</td>
<td>Just firm</td>
<td>10-20%</td>
<td>Fine sandy loam (FSL)</td>
</tr>
<tr>
<td>About 25</td>
<td>Spongy to firm</td>
<td>About 25%</td>
<td>Loam (L)</td>
</tr>
<tr>
<td>About 25</td>
<td>Firm</td>
<td>25%</td>
<td>Silty loam (SiL)</td>
</tr>
<tr>
<td>25-40</td>
<td>Strong</td>
<td>20-30%</td>
<td>Sandy Clay Loam (SCL)</td>
</tr>
<tr>
<td>40-50</td>
<td>Firm</td>
<td>30-35%</td>
<td>Fine sandy clay loam (FSCL)</td>
</tr>
<tr>
<td>40-50</td>
<td>Firm</td>
<td>30-35%</td>
<td>Silty Clay Loam (SiCL)</td>
</tr>
<tr>
<td>40-50</td>
<td>Strong</td>
<td>30-35%</td>
<td>Clay loam (CL)</td>
</tr>
<tr>
<td>50-75</td>
<td>Firm</td>
<td>35-40%</td>
<td>Sandy clay (SC) Silty Clay (SiC)</td>
</tr>
<tr>
<td>50-75</td>
<td>Firm to strong</td>
<td>35-40%</td>
<td>Light clay (LC)</td>
</tr>
<tr>
<td>75-85</td>
<td>Strong</td>
<td>40-45%</td>
<td>Light medium clay (LMC)</td>
</tr>
<tr>
<td>85-100</td>
<td>Strong</td>
<td>45-55%</td>
<td>Medium clay (MC)</td>
</tr>
<tr>
<td>More than 100 mm</td>
<td>Very strong</td>
<td>More than 55%</td>
<td>Heavy clay (HC)</td>
</tr>
</tbody>
</table>
5. Land capability and management

Soil testing will give you some idea of what type of land use you should consider for different portions of your property.

The term land capability refers to “the ability of land to sustain a type of land use without causing it permanent damage” (Property Management Planning Training Course, BRG CMA). In New South Wales there are eight classes within the land capability assessment system, and these are classified according to soil type, slope and erosion risk (see the following page). These factors influence how you manage your land and the production techniques you use.

The link between the risk of erosion and land capability is clear. Farming beyond the limitations of your land, by over-grazing or cultivating on inappropriate areas, can leave your soil vulnerable to erosion. So it is important for you to identify the different land classes on your property and manage them within their limitations. This will reduce the risk of erosion occurring on your farm.

Severe erosion on a farm near Glen Innes caused by cultivating on a slope without soil erosion control works in place. Note the fence inundated with soil in the foreground.

Sedimentation on a farm near North Star, caused by runoff from a cultivated paddock. This paddock should have soil contour banks in place or be sown permanently to pasture.

Gully and tunnel erosion at Wallangarra.
### Land class

<table>
<thead>
<tr>
<th>Land class</th>
<th>Soil conservation practices</th>
<th>Brief description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>No special soil conservation works or practices required.</td>
<td>Usually flat land that is suitable for a wide variety of uses. When it is fertile it can be used for almost anything including fruit and vegetables, sugar cane, cereal crops and other grain crops.</td>
</tr>
<tr>
<td>II</td>
<td>Soil conservation practices such as strip cropping, minimum tillage and crop rotation.</td>
<td>Gently sloping land suitable for many agricultural uses. Good cropping land on fertile soils. Low erosion potential.</td>
</tr>
<tr>
<td>III</td>
<td>Structural soil conservation works required, conservation tillage techniques and crop rotation.</td>
<td>Sloping country that is likely to wash and erode when cultivated. The land is quite fertile and adequate for cropping as long as soil conservation practices such as contour banks are used.</td>
</tr>
<tr>
<td>IV</td>
<td>Soil conservation practices such as pasture improvement, stock management, fertiliser application and minimal cultivation for pasture establishment and maintenance.</td>
<td>Good grazing country but not suitable for the practices listed in I to III. Main limitations are slope, rockiness, soil fertility, and susceptibility to soil structure decline. Maintenance of good ground cover is essential.</td>
</tr>
<tr>
<td>V</td>
<td>As above, as well as absorption banks, diversion banks and contour ripping.</td>
<td>Not suitable for cultivation on a regular basis owing to slope gradient, soil erosion, shallowness or rockiness, climate, or a combination of all of these factors. Soil erosion problems are often severe.</td>
</tr>
<tr>
<td>VI</td>
<td>Limitation of stock, aerial spreading of seed and fertiliser. May include some isolated structural earthworks.</td>
<td>Comprises the less productive grazing lands that should not be cultivated because of soils, slope, wind or water erosion hazard. Requires sound grazing management and pasture improvement.</td>
</tr>
<tr>
<td>VII</td>
<td>Land best protected by woody, native vegetation or undisturbed ground cover.</td>
<td>Too fragile for grazing.</td>
</tr>
<tr>
<td>VIII</td>
<td>Unsuitable for agricultural production.</td>
<td>Cliffs, lakes or swamps etc. Not capable of sustaining agriculture.</td>
</tr>
</tbody>
</table>

(Table modified from Emery (date unknown))

(All photographs on this page from Bruce Peasely)
6. Land management and erosion risk

From the description of land classes on the previous page, it is clear there is a link between those classifications and erosion risk. All land classes of Class III and above are at some risk of erosion if land management practices are not tailored to work within their limitations. To decide what class, or classes, your farm fits into you need to have a good idea about the soil types on your farm. For this reason it is advisable to do some basic soil tests.

Land management practices targeted at reducing erosion risk are generally also good for overall soil health. Maintaining or establishing well vegetated paddocks will lead to better soil structure, and plant water availability (see Section 7 on ground cover). These improvements will ultimately lead to better productivity, resulting in a win/win situation - reduced erosion and increased productivity.

However, there are some soils that have characteristics that may make it difficult for you to establish and maintain vegetation (e.g. sodic or saline soils), and it is these areas that are often more prone to erosion especially if there is some degree of slope. Therefore, it is important to know what land management classes you have on your farm so that you can divide your farm into units that have a similar management need. This will allow you to apply different management practices to land more prone to erosion.

▲ This Class VII land is vulnerable to severe degradation and the native vegetation should be retained.
Erosion resulting from Class VII land being cleared.

This erosion has resulted in the loss of top soil and continued erosion, in mined areas of a property.

Vehicle and stock tracks can initiate and worsen erosion.

Other ways to reduce erosion

Apart from the land management options already discussed, there are other ways to reduce the chances of erosion occurring:

- **Watering points** - cattle and sheep tracks leading from troughs can initiate erosion. Ensure troughs are not located downhill from a stock camp. Locate troughs on level ground and place rocks and cobbles around the trough to limit pugging and saturation should the trough overflow or need to be drained.

- **Fences and other infrastructure** - aside from locating fences that divide your farm into similar management units, i.e. land capability, you should also place fences on the contour or up and down the slope. Locate gates in well-drained positions.

- **Farm tracks** - These should be positioned so they are running across the slope or, preferably, on top of ridges. Tracks should cross drainage lines at right angles to limit diversion of flow.
What role does ground cover play in reducing erosion?
Bare soil is vulnerable to wind and water erosion. Cover on the soil surface reduces the impact of wind, raindrops and overland water flow on your soil. Having a well-vegetated soil is the best way to prevent or halt erosion.

What is ground cover?
The term ground cover is used to describe material, such as actively growing plants, dead plants and plant litter that cover the ground surface. Crops (including stubble), grasses in pasture, dead leaves and stems from plants, broadleaf plants and so on are all considered a part of ground cover (Lowien & McGufficke, 2006).

The effect of rainfall on bare and vegetated soil surfaces

Ground cover for reducing erosion risk
When a raindrop hits bare topsoil it hits with enough impact to break up the peds (groups of soil particles) into smaller fragments. These particles are then washed into the spaces between the peds, sealing the soil surface. Further rain on the sealed surface frees some of the fine particles and they are then washed away in overland flow. The heavier and longer the duration of rain, the more soil is washed away. If you have good ground cover the impact of the raindrops is reduced when it hits the plants and litter. It also slows overland flow, which will reduce the time of concentration and peak discharge, i.e. the speed and erosion power of water.
How much ground cover is enough?
Although you should aim for maintaining 100% ground cover, research has shown that the critical cut-off point for a minimum amount of ground cover is 70% (Lang & McDonald, 2005). This figure relates only to gently sloping land. If you are on steeper country the amount of ground cover you need to maintain stability increases.

Other factors, such as rainfall amount, duration, and intensity, soil moisture, and slope length also need to be taken into account. If your soil is unprotected you may lose up to 10 tonnes/ha of topsoil in a year (this equals only one millimetre depth of soil over one hectare). In Australia, average soil loss occurs at a rate of 60 times that of soil formation. So, if water running off your land looks coloured in any way by sediment, then you are losing soil quicker than it is forming. By maintaining adequate levels of ground cover you will also be using rainfall more efficiently for plant growth. Instead of rainfall running off and increasing erosive power, more of it will remain within your soil and near plant roots.

Ground cover on ‘problem’ soils
Some soils on your farm may not support a high level of ground cover, such as areas that suffer from salinity or are very low in nutrients. Ideally, these areas should be fenced and managed differently from your other land. Stock exclusion (either permanently or strategically) is one of the first management changes you should make.
Maintaining ground cover is important in all areas of the catchment and, like ground cover, soil conservation methods are targeted at reducing runoff and erosion. Where the land is capable of supporting cropping, simple actions such as cultivating along contours instead of down slope, can reduce erosion rates. Minimum tillage cropping can also greatly reduce the risk of you losing your precious topsoil. Both of these practices are designed to slow or halt runoff, and if used in conjunction with erosion control banks and channels they can be instrumental in controlling sheet and rill erosion.

**Erosion control banks**

When cultivating on sloping land, it is necessary to have erosion control banks constructed to slow runoff. Most farmers have recognised the benefits of having such controls in place to retain their soil. Erosion control banks work in two ways. Firstly, they divide the slope into smaller segments, effectively slowing the rate of water runoff. Secondly, they safely divert the runoff onto vegetated areas beside the cultivation. Grassed waterways should not be used as roads or tracks.

The number of erosion control banks required in a paddock will depend on how much your land slopes, land use, local climatic factors, and soil type. Cultivation management between the banks, such as contour cultivation and stubble retention, is necessary for them to be effective.

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**8. Reducing sheet and rill erosion in cropping land**

▲ **General method for cultivating between erosion control banks, working from the top** (modified from NSW Agriculture Northern Wheat-belt SOILpak (1994)).
Maintenance of erosion control banks
Continued maintenance of erosion control banks is needed to ensure they do not deteriorate and, in some cases, cause greater erosion problems. The banks will decrease in height due to the soil settling, and if they are cultivated incorrectly they will rapidly reduce in height. Stock tracks along and across banks can also initiate erosion of the banks and their subsequent break down. Burrowing animals, such as rabbits, will cause weaknesses in the banks and then subsidence. In areas of black clay soil, cracks may occur that are the depth of the entire bank. When this occurs it is likely to cause a breach during moderate rain fall events.

The grassed waterways, designed to carry runoff away from the paddocks, must also be maintained. If these become filled with sediment, their ability to retain water reduces and it is likely to overflow across the paddock. A vegetated cover, or mulching, must be maintained in the waterway, or erosion of the channel may occur. Particular care must be taken at the point where water runs off the bank into the waterway. Scouring can occur in this area as it is the lowest point of the bank.

Conservation farming to control erosion
Continued cultivation of soil breaks down its structure, makes it less permeable to water and, without protection, is likely to erode easily. Reduced tillage farming uses fewer tillage operations each season and is usually associated with stubble retention and alternative weed control methods (i.e. herbicides and grazing instead of cultivation). Reduced tillage can reduce soil erosion and also conserve soil moisture, maintain soil structure, and save time and money.
Reduced tillage systems
- **Reduced tillage** - involves grazing the crop following harvest to remove stubble and control weeds. This is followed by seedbed preparation and involves fewer tillage operations than a conventional system. Perhaps only one cultivation needs to be done followed by the application of a contact herbicide.
- **Minimum tillage** - Involves retaining stubble with only one primary cultivation. Weed control is achieved with herbicides during the fallow and following cultivation. This method is applicable to cropping areas in the Border Rivers and Gwydir catchments.
- **No tillage** - involves the retention of all stubble and no cultivation at all during the fallow between crops. All weed control is done using herbicides and the next crop is sown directly into undisturbed soil through the stubble and weed materials.
- **Direct drilling** - involves no tillage with sowing of the next crop into undisturbed soil. Stubble and weeds are removed by grazing during the fallow. The fallow is sprayed with herbicide prior to sowing.

Benefits of conservation farming methods that reduce tillage
Reduced tillage helps to reduce soil erosion by: reducing raindrop impact where stubble is retained, stopping soil structure breakdown, slowing the decline of organic matter (organic carbon) and soil moisture levels, reducing the chances of the formation of plough pans, reducing surface runoff, and decreasing wind erosion.
9. Wind erosion

Wind erosion
Like water erosion, wind erosion is likely to occur if the soil surface is exposed. If there are few plants to absorb wind energy, then soil particles will be lifted and moved if the energy is great enough. The risk and occurrence of wind erosion is greatest in dryland farming areas that receive low amounts of rainfall (less than 375 mm per year). In these areas, where stubble retention is not practiced, or where ground cover is not maintained, the likelihood of wind erosion occurring increases greatly.

Wind erosion occurs when wind energy is greater than the gravitational and cohesive forces of the soil. Therefore, loose, dry and finely granulated soils, with little ground cover, are the most at risk of being eroded by wind (Rosewell et al 2000). Most nutrients are held in this fraction of the soil, so not only do you lose the soil but you lose the fertile portions of the soil.

Soils that are more prone to wind erosion
Sands and loamy sands are more susceptible to wind erosion (Rosewell et al, 2000), while clay loams and clay are more resistant. Lack of ground cover makes soils more susceptible to erosion, and the amount of rainfall while the soil is bare will also influence the risk of wind erosion (soil is less likely to erode when wet).

Reducing the risk of wind erosion
The ways to reduce wind erosion are similar to those of water erosion. Maintain as much ground cover as conditions will allow. This includes using soil conservation practices that reduce the number of cultivations and leave stubble between harvesting and planting the next crop. Windbreaks planted along paddocks to dissipate the energy of the prevailing winds, and to intercept dust before it is transported off-farm, are also beneficial.
Scalds

Scalds are areas where the topsoil has been worn away by water or wind, causing exposure of a clayey subsoil. This layer is usually impermeable to water. Duplex soils in arid or semi-arid areas are the most likely to suffer from scalding.

Erosion is likely to continue because of the lack of topsoil, waterlogging, and (sometimes) saline surface. Maintaining a vegetated surface in these areas is a challenge. Some scalds are initiated by the presence of saline water and subsequent lack of vegetation.

Remediation of scald areas

Before attempting remediation, you should ask a soil expert to inspect the site and give advice. Some of the options that you could be given may include fencing off the area from stock, and/or mulching the area. Mulching involves spreading hay or straw across the area, and perhaps spreading pasture seed at the same time. Some landholders have successfully placed baled straw or hay in lines across the scald instead of spreading it out. This may also be useful to slow water flow across the area and reduce some erosion.

A Scald on hard-setting alluvial soil next to the Dumaresq River near Yetman.
What is a gully?
A gully is a channel that is greater than 30 cm in depth that has been caused by erosion of the surface and subsurface soil. Gullies are often steep-sided and typically have a headward eroding point.

How are gullies formed?
A gully is initiated when a previously minor drainage line begins to erode more actively due to increased discharge, i.e. runoff from contributing catchment or decreased soil resistance, such as a reduction in ground cover. Once this occurs, it is often difficult to control erosive forces and early intervention is the best way to halt gully erosion. However, more management effort is required to control the erosion than to maintain the previously stable system.

Influences on gully erosion rates
Once started, gully erosion continues during heavy rainfall and runoff. The amount of erosion and the speed at which a gully will erode is influenced by catchment size (the area of land ‘upstream’ of the gully), ground cover, erodibility of soils, and the volume and frequency of runoff. Runoff is influenced by rainfall intensity and duration, slope, catchment size, ground cover, grazing pressure, rockiness and so on.
Assessing gully erosion

Assessing gully erosion - how active is your gully?
Some gullies may become stable after many years of continual erosion. Similarly, many gullies continue to erode for many years and can cover hectares of once-productive land. You need to visually assess all parts of your gullies to assess their stability. Ideally, you would want to treat the entire gully, especially the head of the gully. If you don’t you are most likely to have continued erosion. The three components of a gully that you need to look at to assess stability are the: gully head, gully floor and sidewalls.

A gully erosion classification system can be used to decide what management actions you may need to perform once you have assessed your gully. It is designed for you to easily assess the current stability of your gully, which will allow you to make a decision on the most suitable erosion control options.

Basics of assessing gully stability
Gully stability can be assessed by looking at the individual parts of the gully. Gullies erode in a ‘headwards’ direction, so assessment should start at the head. The level of stability of each part of your gully is indicated by the presence, or lack of, actively-growing vegetation as well as the amount of fresh sediment deposits present.

Gully assessment involves looking at three parts of the gully - the head, walls and floor. Although this photograph focuses on the head of the gully, it illustrates the other areas that you need to assess for stability.
The different components of your gully should be assessed according to the steps shown above. Starting at the gully head, decide whether each part of your gully is actively eroding or is stable. You may find your gully shows different levels of stability as you move along it. This means you may have to think about using different assessment and management options for each of these sections. You should also walk along the entire length of the gully, as good conditions at the top of the gully may deteriorate into large scale problems along its length.
Step 1 Assessing the gully head - examples of inactive and active heads

Gully head that is presently inactive with plenty of vegetation and with no signs of recent erosion. Changes in grazing management or vegetation condition could trigger further erosion if ground cover decreases. Note: this gully also has a small contributing catchment.

Active gully head showing signs of recent, continuing erosion. A plunge pool at the head of the gully is an indication the head is active.
Step 2 Assessing the gully walls - examples of active and inactive walls

The walls on this gully are **inactive and stable**. Good grass cover on the walls and in the surrounding catchment means that there is very little erosion occurring. Note the rock basket weir across the gully.

The walls of this gully in black soil are **actively eroding**, indicated by the low amount of vegetative cover on the walls and the signs of recent erosion. Note: black soil gullies such as this one have a different character to gullies in other soil types.
**Step 3 Assessing the gully floor - examples of active and inactive floors**

Good grass cover on the floor of the gully indicates that there is **very little**, if any, **active erosion** occurring at this point of the gully. The wire weir and the presence of good ground cover in the gully catchment will increase the chances of the gully becoming stable.

The walls and floor of this gully are still **actively eroding**. Fresh sediment deposits indicate this gully is still eroding. Undercutting is also occurring and it is likely this will slump as it continues to be undermined.
Classifying your gully and what to do with the results

The classifications that you have worked out from the assessment guide give an indication of your options for management of your gully. **Class 1** gullies are the least stable and **Class 8** are the most stable. In general, Classes 5 to 8 are the most easily managed as they have a stable gully head. This only indicates the gully is relatively stable at this point in time, and changes in groundcover or overland flow may initiate more erosion from that point. It is important to maintain or improve current management practices so this doesn’t occur. Fencing the area, ensuring a good buffer zone, and keeping livestock away from the gully is a good starting point.

If your gully classification falls into Classes 1 to 4, you may require earthworks to stabilise the gully. This may involve constructing diversion banks or installing a gully control structure such as a dam or flume. **Recommendations for management of your gully are made on the following pages.**

▲ Stock tracks and stock pressure can increase erosion problems. Try and keep stock away from sensitive areas.

▶ Actively eroding gully head. Diversion of water and establishment of good groundcover are some of the steps that can be taken to reduce the likelihood of erosion continuing.
11. Managing gully erosion - options

The following options are listed according to which part/s of your gully are actively eroding. Each option for managing these parts of your gully are explained more fully in the following sections regarding non-earthworks (fencing and revegetation) and engineered options.

<table>
<thead>
<tr>
<th>Gully head</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active</strong> (Classes 1, 2, 3, 4)</td>
<td></td>
<td>- Divert any water running into the gully or use a gully control structure. Depending on the amount of water to be diverted, this may involve either simple diversion banks or extensive earthworks.</td>
</tr>
<tr>
<td><strong>Inactive</strong> (Classes 5, 6, 7, 8)</td>
<td></td>
<td>- Manage ground cover in the catchment to maintain stability in the area.</td>
</tr>
</tbody>
</table>

**There may be multiple gully heads along the length of the gully, so although the upper-most head may be stable you should check the entire gully system for active areas**

<table>
<thead>
<tr>
<th>Gully floor</th>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Unstable</strong> (Classes 1, 2, 5, 6)</td>
<td></td>
<td>- Once the head is stabilised, the gully floor should quickly become inactive. The only exception to this will be if the erosion is being caused by lateral movement of sub-surface water. Special structures will need to be installed if this is the case. Low-cost wire weirs can also be installed. If the floor is stable and re-vegetation does not occur naturally, introduce appropriate vegetation (i.e. grasses) to speed up the process.</td>
</tr>
<tr>
<td><strong>Stable</strong> (Classes 3, 4, 7, 8)</td>
<td></td>
<td>- Manage ground cover in the catchment to maintain stability in the area.</td>
</tr>
</tbody>
</table>
Managing gully erosion - options, continued

### Side walls

**Eroding**  (Classes 1, 3, 5, 7)
- Divert any runoff water away from the walls, and control stock by fencing them out. In some cases it may be necessary to shape or batter the walls to allow vegetation to re-establish.

**Stable**  (Classes 2, 4, 6, 8)
- Manage ground cover in the catchment to maintain stability in the area.

### Points to remember

- Don’t do earthworks if they **are not** needed
- Don’t just fence and revegetate if earthworks **are** needed
- Always establish grass on exposed soils following earthworks
- Consider applying mulch to side walls to establish vegetation
- Don’t reshape a gully just because it ‘looks bad’. You may increase its instability and your money could be better invested elsewhere.
Factors to take into account when planning gully management

- Rainfall – intensity, frequency & duration.
- Catchment area - the larger the catchment, the larger the problem will be (i.e. more water running onto the site).
- Soil type.
- Slope – grade & length.
- Catchment land use – ground cover, soil structure, livestock and vehicular tracking and so on.

Soil erosion is a symptom of broader land management issues, so soil conservation works (engineered or otherwise) at the site of gully erosion generally do not address the underlying cause of the problem. Management of the land in the catchment contributing to runoff is critical to improve catchment water movement and reduce the erosive power of water running onto the site.

Before you can decide the best management options for your gully erosion you should identify the cause of the erosion and what the effects are (i.e. continued erosion of your gully). Some causes may include lack of groundcover (sometimes caused by ‘problem’ soils such as sodic, saline or ‘poor’ soils), diversion of overflows from dams, livestock tracks channelling water to sensitive areas and so on.

Once you have identified the cause, you should take steps to stabilise the site (i.e. address the effect) and then take action to manage the cause. This may include increasing ground cover in the catchment with perennial pastures, fencing the gully off from stock, and planting trees to utilise water before it gets to the gully (particularly if there is sub-surface erosion occurring).
12. Managing gully erosion - fencing and revegetation

Revegetation and/or fencing

- Suitable where the gully head is inactive and run-on water is not a significant, destabilising influence
- An option for Classes 5 to 8 or in conjunction with earthworks for Classes 1 to 4.

Ensure a good buffer zone between the gully and fences. Fencing a gully and excluding stock can be a management technique in itself, but must usually be combined with treating the cause of erosion at a catchment level, i.e. increasing groundcover, diverting flow and so on.

Maintaining good ground cover, planting trees, and fencing from stock are all good non-engineering options for gully erosion control, especially if the causes of erosion in the entire gully catchment have been addressed. These actions can also be combined with engineering options.
Guidelines for fencing and revegetating a gully

- Ensure there is a good buffer zone to allow for further slumping and for space to plant trees. Allow room for vehicular access and also for stock access if needed for a feed gap or shelter.
- Do not cause additional problems by placing a fence in an area that stock are likely to walk up and down (i.e. between watering points). This may initiate channelling of water and a new gully!
- Incorporate new fences into a whole farm plan where all other farm infrastructure, such as watering points, gates and tracks are incorporated into your management.
- Select species that are suitable for your soil type and climate, as well as species that are recommended for stabilising gully areas (e.g. Spiny-headed mat-rush, *Lomandra longifolia*; Black sally, *Eucalyptus stellulata*; Graceful wattle, *Acacia decora*). Grass (ground cover) is the most important vegetation around the gully and in its catchment. Ask your plant supplier what plants are suitable and look at nearby native vegetation to try and select the same species.

**WHY USE VEGETATION TO STABILISE GULLIES?**

- Groundcover and trees reduce the initial impact of rain, wind and water on the soil.
- Vegetation traps sediment and reduces its movement across the landscape.
- Vegetation has multiple benefits, including attracting wildlife and providing shelter for stock.
- Where it is suitable, it is a low-cost alternative to engineered solutions.
- Maintenance of vegetated areas is lower cost than replacing failed engineered options such as flumes.
- Trees can protect the ground layer from frost, harsh sunlight, and add litter to the soil surface.

*Lomandra longifolia* is a good stabilising plant for gullies in many areas.
**Herringbone ripping (combined with revegetation)**

Ground preparation for tree planting using herringbone ripping involves ripping tree planting lines at an angle, down and away from the gully. This type of ripping is preferred for revegetation works as it reduces the risk of slumping and tunnel initiation. The ripline is angled away from the gully, because if ripping is done parallel to the gully, i.e. downslope, the rip line may become a gully itself.

Herringbone ripping is appropriate for revegetation in most erosion-prone soils. However, for some gully and soil types it may be too high risk to rip at all. **Speak to someone that has expertise in this method before going ahead with any works.**

▲ Rip lines next to a gully prior to vegetation planting. Ripping is angled enough to slow and divert water, but not enough for it to initiate new gullying.
13. Managing gully erosion - engineering options

The following information regarding earthworks for gully control is meant as a guide only. **You must get expert advice when planning any earthworks.** The Soil Conservation Service, private contractors or consultants with specialist experience should be approached before planning any work. They will firstly be able to tell you whether earthworks are necessary, and if they are, they can then advise you on the extent of the work required.

**When might earthworks or other structural work be necessary?**
If your assessment shows that your gully falls into **Classes 1 to 4** it means the gully head is active and you may need to actively retain or divert water away from your gully, and simply increasing vegetation may not be enough. This is particularly important if the gully has a large catchment area and/or run-on water is a problem.

**What type of structural works are suitable?**
This depends on the extent of the gully erosion, as well as catchment size and what the underlying cause of the erosion is (i.e. sodic soils along with lack of ground cover, or runoff water from upstream structures such as dams).
The aims of engineered or structural erosion control methods are to either slow catchment runoff or to divert run-on water to a more stable point.

### Broad categories of engineered/earthworks methods

<table>
<thead>
<tr>
<th><strong>Dams and gully control structures</strong> (e.g. weirs)</th>
<th><strong>Drop structures</strong> (e.g. pipes &amp; flumes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduce flows below a dam through storage of runoff</td>
<td>• Provide a mechanism for water to be directed over the side of a gully without causing erosion – part of a spillway for a dam or outlet for diversion bank</td>
</tr>
<tr>
<td>• Provide a trap for sediment</td>
<td>• Stabilising the head of an active gully.</td>
</tr>
<tr>
<td>• Block water flow for diversion in a bank to a stable outlet area</td>
<td></td>
</tr>
<tr>
<td>• Inundate an active gully head with stored runoff water.</td>
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</tbody>
</table>

**Banks and waterways**

- Banks can divert flows away to a stable outlet area
- Banks can increase the length of flow line for runoff and decrease time of concentration
- Waterways carry runoff downhill without causing erosion.

**Filling and shaping**

- Re-shaping the batters and filling the gully, creating a smooth, stable drainage line
- Shaping is not suitable where concentrated flows drop over the side of a gully
- Can only be applied if the cause of the problem has been addressed (catchment management).
Examples of structural options for gully erosion

Dams and weirs

Filling and shaping

Pipes and flumes
Wire weirs

Wire weirs represent a low-cost way in which you can increase stability on your gully floor. Wire weirs are steel post, mesh, and netting ‘fences’ that are constructed across the gully. Their function is to trap sediment that is eroding and to slow the flow of water through the gully. The sediment that is trapped forms a fan across the floor of the gully until it reaches the gully wall. Eventually this soil will become vegetated and stable. With multiple weirs placed across the gully, the level of the entire gully floor may eventually be raised and vegetated, slowing the water flow along the gully. Once water flow has been slowed this will reduce its erosive power higher up in the gully. You should get expert advice on how to construct these weirs. The description below is given to illustrate their application. Log weirs and rock basket weirs are other methods for slowing water flow through the gully.

Brief guide to building wire weirs

1. Steel star posts, reinforcing mesh, plain wire, and fence netting (at least 90 cm wide) are required.
2. Determine a level for the end points, which should be 50-60 cm above the gully floor in the deepest part of the gully.
3. Drive posts into gully floor to the proposed height of fence, about a metre apart.
4. Thread plain wire through top holes and twist at each post. Place lengths of wire netting flat on the gully floor on both sides of the posts. Tie together and pin down to the floor and side walls.
5. Cut reinforcing mesh to fit the shape of the gully and stand against posts on the upstream side and tie on.
6. Cover mesh with wire netting on the upstream side ensuring that it extends at least 20 cm upstream on the floor of the gully.
14. The final word on erosion

CATCHMENT MANAGEMENT IS THE KEY TO PREVENTING AND CONTROLLING EROSION

- **Maximise groundcover** - maintain at least 70% groundcover on slopes and plains (more on hillier country) to ensure that soil is stable and rainfall use is maximised. Erosion will be decreased and vegetation will benefit from retained moisture.

- **Manage your land to its capability** - ensure you know the limitations of your land, and by managing it within its capability it will be easier to maintain ground cover and reduce erosion risks.

- **Increase the amount of perennial pastures and trees** on your property so rainfall is used where it falls and water movement across your property is reduced.

- **Plan** where you want to put farm infrastructure such as roads, fences, gates and watering points to ensure that stock and vehicle movement, and their tracks, will not initiate erosion.
15. Glossary

A, A1, A2 horizon: See: Soil profile.

Aggregate: a soil unit consisting of a group of peds. The peds are held together by cohesive forces or by secondary soil materials such as iron oxides, silica or organic matter.

Alluvial soil: a soil consisting of recently deposited particles that have been deposited by water and have not been through a soil forming process. Layers in this type of soil are successive depositions and not soil horizons.

B horizon: see: Soil profile.

C horizon: see: Soil profile.

Clay: soil particles smaller than 0.002 millimetres and are involved in swelling and shrinking of soils; they hold water and exchangeable cations. “Clay” soils refer to any soils that have 35% clay content and have clay behaviour.

Clay mineralogy: the composition of the clay portion of a soil. Differences in effective surface area and charge density of particles can vary widely.

Compaction: compression of soil into a smaller volume.

Conventional tillage: traditional methods of cultivation using machinery in seedbed preparation and weed control, normally involving 3 to 6 tillage operations.

Crusting: occurs when the soil sets hard and becomes impermeable following wetting. If only the first 10mm are affected it is called crusting; if deeper (perhaps affecting the entire top soil) it is referred to as hard-setting.

Deep tillage: any tillage deeper than that needed to produce loose soil for a seedbed. Usually done to loosen a hard subsoil.
Deposition: movement of particles to their present location by wind and water.
Discharge: the volume of water flowing in a stream or through an aquifer past a point over a given period of time.
Dispersion: disintegration of micro-aggregates into individual clay, silt and sand grains; it is the opposite of flocculation.
Duplex soil: a soil which shows a sharp change in texture between the A and B horizons.
Exchangeable cations: positively charged ions held loosely on negatively charged soil particles that are easily exchanged with other ions in soil solution.

Exchangeable Sodium Percentage (ESP): proportion of cation exchange capacity occupied by sodium ions. In Australia, sodic soils are categorised by an ESP of 6-14%, strongly sodic >15%.

Gypsum: Calcium sulphate, used to reduce dispersion. It is a naturally occurring substance and also a by-product of fertiliser production.

Hard-setting: a layer of soil that ‘melts together’ when wet and sets hard and impermeable when dry.

Horizon: a layer of soil in the soil profile that differs from layers above and below. It can differ in colour, texture and/or structure.

Infiltration: movement of water into soil.

Leaching: carrying dissolved material downwards.
<table>
<thead>
<tr>
<th>Glossary continued</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Massive earth:</strong> coherent or solid mass of soil devoid of natural lines of weakness.</td>
</tr>
<tr>
<td><strong>Minimum tillage:</strong> describes a farming practice which reduces the number of tillage operations compared with conventional tillage.</td>
</tr>
<tr>
<td><strong>No-tillage:</strong> a form of conservation farming that involves no mechanical soil disturbance other than when planting.</td>
</tr>
<tr>
<td><strong>Organic matter:</strong> plant and animal material, living and dead.</td>
</tr>
<tr>
<td><strong>Parent material:</strong> geologic material from which the soil profile develops, such as bedrock, alluvium etc.</td>
</tr>
<tr>
<td><strong>Peak discharge:</strong> the maximum discharge resulting from a catchment and is based on a number of hydrological conditions (e.g. rainfall intensity, catchment area, storm duration etc.)</td>
</tr>
<tr>
<td><strong>Ped:</strong> an individual natural soil aggregate consisting of a cluster of primary particles and separated from adjoining clusters by surfaces of weakness that are recognisable as being natural.</td>
</tr>
<tr>
<td><strong>Permeability:</strong> ability of a soil to transmit water and gases.</td>
</tr>
<tr>
<td><strong>Pore:</strong> channel or cavity in soil.</td>
</tr>
<tr>
<td><strong>Porosity:</strong> the degree to which a soil is permeated with pores.</td>
</tr>
<tr>
<td><strong>Red brown earths:</strong> red coloured soils with hard setting topsoils over clay-rich subsoils.</td>
</tr>
</tbody>
</table>
Rill erosion: the removal of soil by concentrated water running along natural depressions and drainage lines, where there is not enough ground cover to maintain the soil surface.

Salinity: an excess of water-soluble salts (usually sodium chloride in Australia) that restricts plant growth.

Sand: soil particles between 0.02 mm and 2 mm in diameter. Fine sand is 0.02 – 0.2 mm and coarse sand is 0.2-2 mm.

Sediments: particles of clay, silt and sand carried by wind and water and deposited.

Self-mulching: refers to cracking clay surfaces that develop a shallow layer of loose, small aggregates after wetting and drying.

Sheet erosion: removal of the top layer of soil by raindrops and/or water flow.

Silt: soil particles between 0.002 mm and 0.02 mm in size, intermediate between sand and clay.

Slaking: collapse of aggregates to microaggregates in water due to the swelling of clay and expulsion of air.

Sodic: an excess of exchangeable sodium (ESP greater than 5) and low salinity, making a soil prone to dispersion.

Soil profile: the vertical sequence of layers in a soil, the three main horizons are A (generally referred to as topsoil), B (generally referred to as subsoil) and C (the parent rock).

Continued on following page
Soil profile cont.: The A horizon may consist of an A1 and A2 horizon, with the A1 being higher in organic matter and biological activity and A2 often being poorer in structure, lower in clay content and less fertile. The A2 horizon does not always occur.

The B horizon is the zone of accumulation of materials from above: clay, iron, aluminium and organic matter. Structure is different from that of A or C horizons and colour is typically stronger.

The C horizon consists of weathered rock, little affected by soil forming processes. Alluvial soils do not have a C horizon as the rock below is not related to the soil. This would be referred to as a D horizon.

Structure: the form in which soil is arranged into larger units and the stability of that arrangement.

Stubble mulching: the use of tillage machinery that leaves more crop stubble on the soil surface.

Texture: the behaviour of a small handful of soil when moistened and formed into a small ball and then pressed out between thumb and forefinger. Soil texture depends mainly upon the proportions of gravel, coarse sand, fine sand, silt and clay in the soil.

Time of concentration: the shortest time necessary for all points on a catchment area to contribute simultaneously to flow past a specified point.

Vertosol: a soil which ‘turns’ (tills) itself as surface soil falls down cracks and eventually returns to the surface after many cycles of wetting and drying.
16. References and further reading


