NSW DEPARTMENT OF
PRIMARY INDUSTRIES

## SOILpak – southern dryland farmers - Readers' Note

This document is part of a larger publication. The remaining parts and full version of the publication can be found at:

http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides/soilpak/south-dryland

Updated versions of this document can also be found at the above web address.

# PART C. LOOKING AT YOUR SOIL

# C1. Examining the soil profile

**PURPOSE OF THIS CHAPTER**

To explain how to assess a soil

**CHAPTER CONTENTS**

This chapter deals with the soil surface, topsoil and subsoil. The main contents are:

- what to examine first
- 'Looking at your soil', a field version
- farm and paddock information
- surface soil
- soil features
- soil test results
- soil management options

**ASSOCIATED CHAPTERS**

You may need to refer to the following chapters:

- C2. Alternatives to the spade
- C3. Soil types and landscapes
- C5. Chemical soil tests
- D4. Maintaining and improving soil structure
- E1. Soil structure
- E2. Soil-structure rating system

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## EXAMINING THE SOIL PROFILE

**Why examine your soil?**

Examining your soil and assessing its condition enables you to make better decisions on the use of your paddocks, and protects your investment in the soil.

You will be able to make informed decisions on tillage, crop and pasture selection.

In the longer term, your whole-farm plan will reflect the changes in soil type across your property, making each paddock more uniform so it is easier to manage.

Soil properties are of two types: those that can be seen by visual examination and those that can be revealed only by laboratory testing.

It is very useful to record the results of your inspection on the soil description sheets in Appendix 4. This chapter, and the 'Looking at your soils' brochure, guide you through filling in the soil description sheets in a step-by-step way. At the end of the chapter there is a sample set of filled-in soil sheets.

## Visual examination

A good look at the soil can tell us lots about its physical condition.

The soil's physical condition is shown by its structure. Structure controls water and air movement into the soil and so affects ease of tillage, seedling emergence, root growth, waterlogging, and the potential for erosion.

## Laboratory testing

☞ *See Chapter C5 for more information on soil chemical tests that you send away for.*

☞ *See Chapter C4 for details on examining your plant roots to see how they are affected by physical and chemical properties.*

*Tip: Start with the easy examinations. You don't always have to examine everything.*

Laboratory testing of samples of your soil can yield enormous returns by ensuring that you apply the most profitable rates of fertiliser to your crop. Laboratory testing can sometimes help explain the causes of structural problems in your soil.

The following section covers physical tests that you can do in the paddock.

**What do you know already?**

A full examination of the soil is not necessary every time you examine a paddock. Some qualities change extremely slowly. For example, soil texture may not alter in a thousand years (unless erosion removes a layer).

However, qualities such as soil structure can change rapidly. For example, one pass of an implement through wet soil can create a plough pan immediately. Root growth may open up and improve a compacted soil significantly in as little as a few months. Because soil structure can alter so rapidly in response to management, assess the soil structure before making a management decision if you think the soil structure may have changed.

The pocket at the back of this manual contains blank soil description sheets. The sheet is a place to record what you find when you examine the soil. It also acts as a prompt for what to examine, and leads you towards appropriate management options.

Each section of this chapter contains an example of how you might enter notes in the relevant section of the soil description sheets.

### SECTION 1. FARM AND PADDOCK INFORMATION

Before you examine the soil profile, spend a little time describing the paddock. Such background information will help you to place in context the features that you find on and beneath the soil surface.

Here is an example of how you would fill in the details for section 1 of the sheet:

***Initial details:*** example

| | | |
|---|---|---|
| **Farmer:** Dave Brown | **Property:** Winterwood | **Paddock:** A3 |
| **Reasons:** poor growth & low yields | **Inspected by:** Greg Condon | **Date:** 12 January 1999 |

This information puts on file details of the year and the paddock (remember not to call the paddock e.g. wheat paddock, because next year it won't be wheat). If this is your property, this step may seem unnecessary, but an agronomist using the sheet may visit many farms and will need a record.

### Reason for inspection

Clarify why you are examining the soil. The reason for inspection often suggests a cause of the current condition of the paddock, and that in turn suggests which features to examine first. After examining those features, you can reassess your first impression.

### Sketch map

Make a sketch of the site as a record: you may want to go back to the same site and investigate further (Figure C1–1).

Remember not to dig near gates, fences, headlands or under trees, as they are not representative of the paddock. They may have had extra traffic or been used as stock camps, or higher amounts of fertiliser may have been applied to them.

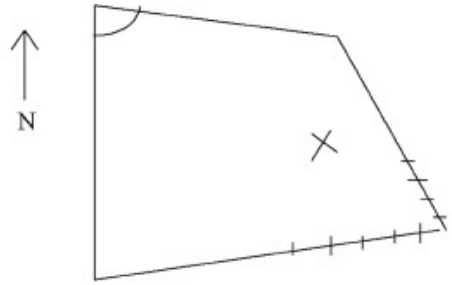



***Figure C1-1.*** *Example of a sketch map*

### Paddock history

Accurate and detailed records are a great help in determining the cause of poor crop growth. From your farm diary (if possible, for the last five years) note the following:

***Paddock history:*** *example*

| Year | Year | Crop/pasture | Lime (t/ha) | Gypsum (t/ha) | Stubble treatment (retain or burn) | Cultivation technique (number of workings, wide or narrow points) |
|---|---|---|---|---|---|---|
| This year | 1999 | wheat | — | — | retain | direct drilled—narrow points |
| 2 years ago | 1998 | lupins | — | — | retain | narrow points |
| 3 years ago | 1997 | wheat | — | — | retain | narrow points |
| 4 years ago | 1996 | canola | 2 | 2.5 | burn | harrows, scarify |
| previous 5 | 1995 | pasture | | | | |

Sometimes the first sign of a chemical imbalance or a soil structural problem is poor crop growth. Seedling emergence may be sparse, seedlings may be slower to emerge and develop, plants may be shorter than plants in other paddocks, or there may be a variation in plant height within one paddock. A crop may appear to run out of soil moisture because its roots cannot penetrate a hard or toxic layer to reach the moisture lower down. In wet weather, crops on compacted soil may appear yellow due to waterlogging.

Of course, poor growth may be caused by many factors; see a local agronomist if you are unsure.

Take into account the effect that the previous crop may have had on soil fertility. For example, a previous crop may have depleted the soil nitrogen. Did you apply enough fertiliser? How many cereal crops have there been since a legume phase? Was the soil moisture adequate? Was the ground compacted during harvest?

☞ *See Chapter B12 for more information on fertilising* soil.

## Anticipated management

Here you can record what management is anticipated for this paddock. Such information is useful in deciding which features to examine first. You might consider whether the soil is low in nitrogen, and, if so, whether it would benefit from a legume-based pasture phase. Pasture also benefits soil structure; it would be useful to examine the current soil structure with a view to its need for improvement by a pasture. Current structure also acts as a benchmark to assess the benefits gained by the pasture.

## Profile drawing

See Figure C1–2 for an example of a profile drawing and what to look for.

Pick back the soil surface, as using a spade or backhoe can seal the air pores. Mark and/or label everything you can see.

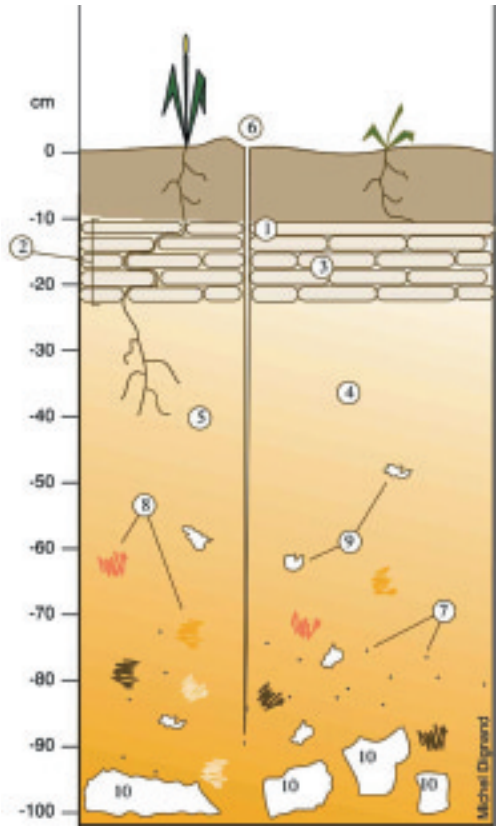



*Figure C1-2. Example of a profile drawing*
*What to look for:*

1. *plough pans*
2. *bleached zone: a very pale layer (nearly white)*
3. *compaction*
4. *texture change (including clay content)*
5. *roots: to what depth, size and number (new or old)*
6. *deep cracks: size and depth*
7. *buckshot (soft and red/black; see later in this chapter, 'Why is your soil that colour'*
8. *mottling: mixture of colours*
9. *lime concretions (battery acid test)*
10. *stones: indicate depth and size*

☞ See Chapter B15 for more information on soil moisture.

### SECTION 2. SURFACE CONDITION

The soil surface is the soil and cover that you can see without digging. Surface cover (vegetation and plant residues) can be considered to be part of the soil surface, because surface cover influences the properties of the soil surface. You may need to separate the components of the soil surface by removing the surface cover to see the actual soil at the surface.

The surface soil includes the soil surface and the upper part of the soil profile that has a structure in common with the soil surface. 'Surface soil' and 'surface layer' mean the same. To examine the surface soil, you may need a screwdriver or blunt knife to prise out pieces.

Your surface soil can take a number of forms:

- tilled layer (recently cultivated)
- loose material
- compacted, crusted, slumping or hard-set.

## Learn from looking at your surface soil

All farmers look at the soil in their paddock before deciding when to cultivate and what implements to use. Examining the soil surface shows you whether the soil moisture content is optimal for tillage. You can also judge whether the soil tilth (cloddiness) is suitable for the seed size of the crop to be sown. Uniform depth of seed placement is crucial for good establishment.

Looking at the soil surface can also tell you about structural problems that may need attention, such as soil crusting or soil slumping.

**Surface condition**

When standing, look at an area about 1 m x 1 m. How much of the area is covered and how much is left bare? Below is an example of how you might record this information on the data sheets.

*Ground cover percentage*

**Significance of surface cover.** Surface cover reduces the impact of raindrops, thereby protecting the surface structure.

| **Surface condition:** *example* | **Poor area** | **Good area** |
|---|---|---|
| % ground cover | 40% | 85% |
| Pugging—a heavily compacted area that waterlogs | Yes | No |
| Crusting—bare soil that forms a hard surface about 0.5–1cm thick, reducing infiltration | Yes | No |
| Hardsetting—when the topsoil sets hard and cannot be penetrated | Yes | No |
| Cloddiness—lumps of soil brought to the surface by cultivation | No | No |
| Slumping—when the clod surface 'runs' together, forming a lumpy crust | No | No |

Cover also slows down water running over the surface, therefore increasing the intake of rain to the soil and reducing erosion. Large amounts of surface cover at sowing time can pose a problem to some sowing implements.

Note whether the surface is bare, or covered by a crop, pasture, weeds or stubble. Note whether stubble is standing or loose. Always indicate the percentage ground cover of the poor area and the good area in the paddock, as shown in the sample table.

***Figure C1-3.*** *Pugging*

*Pugging*

Pugging (Figure C1–3) is where the soft soil has been compacted and water now ponds. It is easily seen around dams where stock have been trampling.

*Soil crust (crusting)*

This is a thin (about 5 to 10 mm) layer on the soil surface overlying cloddier soil below (Figure C1–4). Crusts are formed by raindrops beating on to the surface of a weak-structured soil. Crusts are continuous when wet, but may break up into flat plates as they dry. When wet they restrict the entry of water and fresh air into the soil, reducing plant growth and increasing the erosion risk by increasing run-off. When dry they cause big problems for emerging seedlings.

***Figure C1-4.*** *Soil crusting*

*Hardsetting*

Once soil slumps and dries it gets cemented and is said to be hardsetting. Hardsetting soils tend to produce large clods unless tilled at the ideal moisture content.

*Cloddiness*

Cloddiness occurs when the hardset soil is cultivated and large dense clods are brought to the surface. They create an uneven surface, which can cause poor seedling emergence.

***Figure C1-5.*** *Soil slumping*

*Soil slumping*

Following rain cultivated soil tends to slump down into a continuous mass, losing the cloddy tilth produced by cultivation. Soils in the southern wheatbelt are very prone to this problem. This condition restricts water and air movement through the soil, reducing plant growth. These conditions favour the growth of toadrush, and this weed is an indicator of surface structural problems. As slumping occurs when the soil is very wet, it may indicate the presence of a water-impeding layer deeper in the soil (Figure C1–5).

## SECTION 3. SOIL FEATURES

### Depth

Enter the depths on the sheet for the zones in the soil profile that you identify as being distinctive. In the example below there are three zones: 0–10 cm, 10–20 cm and 20–40 cm. The identification of zones often entails assessing some texture features first.

**Soil features:** *example*

| | Depth (cm) | Texture | Colour | Aggregate size (cm) | Aggregate shape | Fabric consistency | Slaking and dispersion | pH (water) |
|---|---|---|---|---|---|---|---|---|
| Topsoil | 0–10 | loam | brown | 0.5–1 | polyhedral | rough | 1: slaking<br>0: no dispersion | 6 |
| Sub-surface | 10–20 | sandy loam | pale grey | 4 | platy | — | 3: slaking<br>0: no dispersion | 7 |
| Subsoil | 20–40 | medium clay | yellow | 2–3 | angular blocky | smooth | 2:slaking<br>2: dispersion | 7.5 |

### Texture

Soil texture is a measure of the behaviour of a small handful of soil when it is moistened and kneaded into a ball and then pressed out between thumb and forefinger. Texture depends mainly upon the proportions of gravel, coarse sand, fine sand, silt and clay in the soil. The table at right gives an indication of how to estimate texture.

### Why is your soil that colour?

Colour is the most obvious soil property that you see when you look into a pit. It is such a useful indicator of other soil properties that colour has an important role in all the scientific soil classifications.

Colour is a good indicator of soil aeration (the amount of oxygen circulating in the soil). A rich red colour indicates a well drained, well aerated soil capable of supporting good root growth. The red comes mainly from iron oxides (rust) deposited as a fine coat on the quartz sand grains of the soil. Yellows and greys warn us that the soil suffers periods when it is too wet to allow roots to grow. A pale yellow to white layer indicates an old weathered soil that is bleached.

When the soil is waterlogged and there is little oxygen available, some soil microbes attack the iron oxides to obtain the oxygen they need to sustain life. The iron is thus made more soluble and may be leached away in drainage water. This is seen in its most extreme form in the bleached layer often found at the bottom of the loamy surface layer of a texture contrast soil. The iron coatings also help to bind the soil particles together, so the lost iron equals lost strength, as anyone who has been bogged in these soils will know.

For soil colours see the pull-out ‘Looking at your soil’ field guide.

Toward the bottom of the pit you may find other colours of interest.

***Texture estimation*** (simplified texture classes)

**SANDS**

- The coherence of the soil ball is nil to slight.
- Single sand grains adhere to the fingers.
- As the clay content increases clay may stain your fingers.
- Minimal ribbon development when extruded between fingers and thumb.
- Clay content less than 10%.

**SANDY LOAM**

- Soil ball coherent but very sandy. In this region many of the topsoils are fine sandy loams.
- The sand in these soils cannot be easily seen with the naked eye but can be felt when rubbed between the fingers. A scratchy noise may be heard when the ball is manipulated between the fingers.
- Soil will form a ribbon 15-25 mm long when rubbed between fingers and thumb.
- Clay content 10%-20%.

**LOAM**

- Soil ball coherent and often spongy. May have a 'greasy' feeling if much organic matter is present.
- Soil will form a ribbon 25-40 mm long.
- Clay content 25%-30%.

**CLAY LOAM**

- Soil ball strongly coherent and plastic. Feels smooth.
- Soil will form a ribbon 40-50 mm long.
- Clay content 30%-35%.

**LIGHT/MEDIUM CLAY**

- Soil ball plastic. Slight-to-moderate resistance to shearing between the forefinger and thumb.
- Soil will form a ribbon 50-75 mm long.
- Clay content 35%-45%.

**MEDIUM/HEAVY CLAY**

- Smooth soil ball that handles like plasticine and can be moulded into rods without breaking.
- Soil has moderate-to-firm resistance to shearing.
- Soil can be rubbed between fingers and thumb to produce a ribbon 75 mm or more long.
- Clay content greater than 45%.

***Explanation of terms used in the table at left***

**Coherence:** the ball of soil holds tightly together.

**Sandy:** feels gritty, and you can see coarser grains. Very fine sand grains (too small to see and feels a bit like silt) make a grating sound as you rub between your fingers.

**Spongy:** typical of loams; also, a high organic matter content creates a spongy feel.

**Silky:** the smooth, soapy, slippery feel of silt.

**Plastic:** the ball can be deformed and it holds its new shape strongly. Typical of clays.

**Resistance to shearing:** how firm the soil feels as you form a ribbon (place the ball between your thumb and forefinger and squeeze, sliding your thumb across the soil). The firmness is a good way to distinguish light, medium and heavy clays. A light clay is easier to shear; a medium clay is stiff; a heavy clay is very stiff and it usually takes two hands to form a ribbon.

☞ *Tip: Surface soil texture can be a good guide to the texture of the whole soil topsoil, especially if tillage has mixed the soil. An exception would be when a soil has experienced sheet erosion, where coarse sand may remain on the surface after finer material has washed away.*

Deeper in the soil the material leached (washed) from the surface tends to accumulate again. Here you will find hard reddish-black patches or small red-black 'buckshot' nodules. These are deposits of manganese and iron. They bind the soil together. There may also be lime present as white patches or soft white lumps as you look deeper in the soil. Test white spots for lime by dropping some dilute acid (battery acid) on them. Fizzing and bubbling will take place as the acid drives carbon dioxide off from the lime. This lime has been leached from the surface soil by hundreds of years of rain. The subsoil in your pit may also be mottled. Mottles are seen as small (5 to 10 mm) spots of varying colour in the soil. Grey to grey-blue mottles are another indication of impeded drainage. Look for

grey discolouration around old roots. Bacteria feeding on these dead roots can create strongly oxygen-deficient conditions, greying the nearby soil.

## Soil structural form

### Aggregate size

*Significance of aggregate size*

Small aggregates indicate a good tilth; large aggregates indicate cloddiness.

**How to assess aggregate size**. Break a lump of soil into smaller and smaller pieces, using moderate hand pressure. Take note of the size of the lump just before you begin tearing through the fabric of the soil, leaving a fine grainy surface. This is the point at which you are no longer breaking the soil along natural fracture planes: you are tearing the aggregate apart.

Note the most common size, or note size differences where you have aggregates of widely varying sizes. For example, in a cloddy tilled layer, some clods may be larger than 4 cm, with the remainder of the soil being made up of clods smaller than 1 cm or dust.

**Moderating factors.** When you are examining wet soil it can be difficult to determine the natural fracture plane between aggregates, and hence their size. Very dry soil can have high strength because of interlocking aggregates. Use enough force to expose natural faces; hitting a dry lump with an implement (a spade) may be the best technique.

### Aggregate shape

*Significance of aggregate shape*

The shape of aggregates depends upon the forces acting on the soil. Tillage and traffic can change the shape from what is considered 'natural'.

Soils that contain appreciable amounts of clay become plastic when moist or wet; they are particularly vulnerable to reshaping. Therefore, in clays and clay loams, aggregate shape is an excellent indicator of soil structural form. In other, less clayey soils, such as loams or silty or sandy soils, aggregate shape is less indicative of structural form.

*Natural shapes*

Shapes vary from many-faced, lens or wedge to cubed-with-rounded-corners (and cubed-with-square-corners if small and faces are shiny).

*Signs of damage*

In this case aggregates are platy, shell-shaped and massive (and cubed-with-square-corners if large and faces are dull).

*Many-faced aggregates* are a sign of good structure. They may be loosely joined as a thin, fragile crust (not usually strong enough to inhibit seedling emergence) or bound into very porous, crumbly aggregates.

*Platy aggregates* (Figure C1–6) show up as obvious horizontal layering in the soil profile, or may show in the way of a lump of soil parts. Prise a lump from the soil and

*Figure C1-6. Platy aggregates*

remember its orientation. Break it into smaller pieces by forcing in different directions. If it parts more easily along horizontal fractures than in other directions, and produces flat plates, it is platy. Platiness is a sign of poor soil structure. A thick platy layer is worse than a thin one. Platiness is common under wheel tracks and does not usually extend deeper than 30 cm below the surface.

*Massive aggregates* are dense and have a few pores. They appear dull. 'Featureless' would be an apt description. Massiveness is a sign of poor structure.

*Shell-shaped aggregates* are another sign of degradation in clays. You may find clods that separate along a cup-and-ball shaped fracture, suggesting that one clod has been pressed into another. This is a sign of poor soil structure. Shell-shaped is distinct from lens or wedge shaped: shell-shaped is tightly curved and has dull faces.

*Cube with square corners:* these aggregates occur naturally in non-self-mulching clays, but may also be the product of a massive block fractured by drying. Knowledge of similar soils in the area helps here look under trees or pasture to see if the soil type naturally has aggregates with square corners.

*Cube-with-rounded-corners:* these aggregates occur naturally, together with many-faced aggregates, below the surface. They may fit together in larger aggregates.

*Lens-shaped aggregates* also occur naturally in clay subsoils and are a sign of good structure. Such aggregates may be hard to find because often we see only part of a large lens-shaped aggregate. (Half a lens appears wedge-shaped.) Lens or wedge-shaped aggregates usually part into smaller aggregates. They occur at all angles in the soil, although larger aggregates typically have a face at $45^{o}$ to the horizontal.

## Fabric

Fabric describes the appearance of the soil material (under a 10 x hand lens). Differences in fabric are associated with the presence or absence of peds, the lustre (or lack of lustre) of the ped surface, and the size and shape of the ped and air pores in the soil.

**Smooth faced peds**

Peds form a relatively dense, tough, easily defined structural unit with a shiny surface. The shiny face indicates water washing over the surface. These soils are often seasonally waterlogged.

**Rough faced peds**

Peds are less dense, porous and friable. They lack any lustre and are not easily distinguished. They are well drained, with an uneven surface.

## Surface soil structure

**Significance of surface soil structure**

The structural form of surface soil influences water infiltration and run-off of water, and therefore soil erosion and seedling emergence.

Some soils can appear very well structured, but still have infiltration problems. This is why it is important to do slaking and dispersion tests, and to note whether the soil shrinks and swells. A soil that disperses is likely to form a surface crust and may also set hard on drying. A soil that slakes badly may do the same. A soil that shrinks and swells is able to repair its structure.

## Slaking and dispersion

This test is a measure of soil structural stability and shows the behaviour of dry soil when it is wet quickly. Slaking is the breakdown of a lump of soil into smaller fragments on wetting and is caused by the swelling of clay and the bursting out of entrapped air. Organic matter reduces slaking by binding mineral particles and by slowing the rate of wetting. Dispersion is a separation of soil particles. The clay particles mix with water and fill the soil pores.

**Significance of slaking**

Most cultivated soils in Australia are prone to slaking. The results can be either good or bad, depending on the size of the fragments produced.

Slaking is involved in the process of self-mulching, which occurs in many cracking clays. Self-mulching produces a loose surface layer of granular aggregates. Sometimes a thin, fragile crust caps the layer, but the crust is not strong enough to affect seedling emergence.

Dispersion (the separation of soil into single particles) is governed by soil texture, clay type, soil organic matter, soil salinity and the presence of exchangeable cations. A soil may disperse on wetting or after remoulding.

**Significance of dispersion on wetting**

A soil that disperses on wetting has a very unstable structure. It can form a surface crust or hard clods on drying. Pores below the surface can become blocked by dispersed soil particles. Dispersion of the surface soil slows down the intake of rain to the root zone, and therefore increases run-off.

**Significance of dispersion after remoulding**

Some problem soils do not disperse spontaneously on wetting, but do disperse when they are remoulded. Tillage when a soil is wetter than the plastic limit (see Appendix 3) causes remoulding. Also, raindrop impact may have a similar effect to remoulding.

## When to test for dispersion

This is a very simple test that gives you important information about your soil's behaviour. We suggest you do it routinely, and, particularly, the first time that you assess a soil.

Do this test if you are considering deep tillage. Tillage that brings up dispersive subsoil will create a dispersive soil surface, which may crust. Similarly, be cautious of operations that remove topsoil and expose the subsoil, such as when you are forming erosion control banks or laser-levelling. Carry out the test using a sample from the depth of the proposed tillage or earthworks.

**How to assess slaking and dispersion**

This test requires air-dry crumbs of soil. If the soil is moist you cannot assess slaking, and dispersion occurs more rapidly. It is better to take a lump of soil and air-dry it (overnight) before testing.

***Caution: Do not dry the soil in an oven: this changes its properties.***

Take several small (3–5 mm) crumbs of dry soil and place them in a dish or saucer of rain water (or distilled water). Make sure the water is deep enough to cover the samples completely. Cover the dish to prevent wind from disturbing the water. Because dispersion takes some time to develop, start the tests and leave them while you examine something else.

☞ *Tip: For convenience when assessing slaking and dispersion, take a sample back from the paddock and do the test at home or in the shed.*

☞ *Tip: You may find it easier to assess slaking if the lumps are a litter larger (10-20 mm). However, this means doing two separate tests: the dispersion test requires small (3-5 mm) lumps of soil. As you gain experience, you will find it simpler and quicker to assess both slaking and dispersion on the same small lumps of soil.*

☞ *Caution: Do not disturb the dish or jar once the soil is in the water. Water movement will increase the rate of dispersion. Always put the water in first, then add the crumbs. Also, keep the test out of the wind: it is best done at home or in the shed on a stable surface.*

**Scoring slaking**

After five minutes, score slaking as follows:

Score 0 if the lump remains intact

Score 1 if the lump collapses around the edges but remains mainly intact.

Score 2 if the lump collapses into angular pieces.

Score 3 if the lump collapses into small (less than 2 mm) rounded pieces, forming a cone.

Score 4 if the lump collapses into single grains (if you can see sand grains).

**Decisions to make in relation to slaking**

A score of 0 or 1 means that the soil is stable to wetting. This is typical of pasture soils that are rich in organic matter. No action is needed.

A score of 2 is typical of self-mulching soils. They form a loose, granular surface layer with perhaps a thin, fragile crust. Do the dispersion test. (See below.) If the soil does not disperse, no action is needed.

A score of 3 or 4 suggests that the soil may crust or hard-set. It is not a good soil to cultivate and may be better suited to pasture.

**Scoring dispersion on wetting**

Figure C1–7 shows slaking and dispersion. Look for dispersion of the soil—where the soil breaks down to individual particles. A milky halo of clay particles around the remains of the soil crumb indicates dispersion.

Very unstable soils begin to show dispersion within about 10 minutes. Within two hours a very unstable soil may have dispersed completely into a cloudy suspension of single particles, with just sand grains remaining.

More stable (less dispersive) soil may show no milky halo or only a slight halo (hard to see) after two hours. Extremely stable soils will not show dispersion even by the next day.

Record the dispersion on wetting after 10 minutes and again after two hours as follows:

Score 0 for no dispersion.

Score 1 for slight dispersion, showing as slight milkiness of water near the clod.

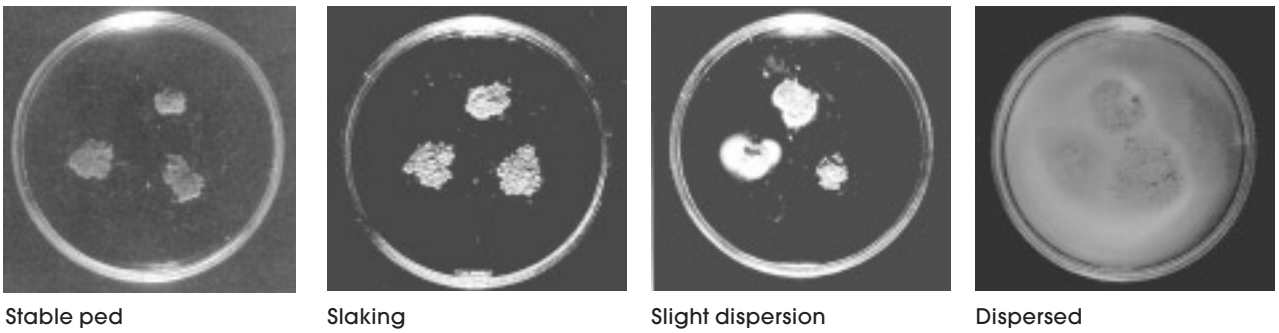



*Figure C1-7. Slaking and dispersion*

Score 2 for moderate dispersion with obvious milkiness.

Score 3 for strong dispersion with considerable milkiness, with about half the original volume of soil dispersed outwards.

Score 4 for complete dispersion, leaving only sand grains in a cloud of clay.

Add the 10-minute and two-hour scores together; this gives a possible range of values between 0 and 8.

For those soils that scored 0, determine the dispersion after remoulding. Take some more soil and mix it with rainwater or distilled water to a plastic consistency. Remould it with a knife for one minute and form it into small balls. Place the balls into a dish of rainwater or distilled water.

☞ *Tip: In the dispersion test, if the score is 4 after 10 minutes, it will be 4 after two hours (it is already fully dispersed). In this case there is no need to wait the two hours; the score is 8.*

Score dispersion as for the 'dispersion on wetting' test, after 10 minutes and again after two hours. Add both these scores together, giving a possible range of values between 0 and 8.

For those crumbs that dispersed on wetting, assume that they would disperse rapidly and completely after remoulding, and score 8. Therefore add 8 to their total score. This gives them a possible range of values between 9 and 16.

☞ *See Chapter D3 for more information on adding gypsum.*

**Decisions to make in relation to dispersion**

Consider the following:

- A score of 0 or 1 indicates a negligible risk of dispersion. However, it is wise to maintain ground cover to protect the soil surface from raindrops and overland flow.
- A score of 2 to 6 indicates a moderate risk of dispersion. There may be a need for gypsum: investigate further with laboratory testing. Avoid tilling this soil when it is moist. Maintain ground cover to protect the soil surface from raindrops and overland flow. Increase the organic matter content.
- A score of 7 to 16 indicates a serious risk of dispersion. Such soils are likely to respond to gypsum. Avoid tilling this soil when moist. Maintain ground cover to protect the soil surface from raindrops and overland flow. Increase the organic matter content.

Adding gypsum, or in some circumstances a mixture of gypsum and lime, will reduce clay dispersion and improve the surface soil structure. Investigate further with laboratory testing to determine how much gypsum or lime is required.

The dispersion test is a good in-field or in-shed test that points to the likely need to add gypsum to prevent surface dispersion. Repeat the test with additional samples of soil from other areas of the paddock to confirm the results—don't assume that one crumb of soil is typical of a whole paddock! It is a good practice to try test strips of gypsum (see Chapter B8) before treating the whole paddock. If you do decide to treat a whole paddock, leave an untreated strip to show the benefits.

## SECTION 4. CHEMICAL TESTS

The following table is an example of test results.
Transfer these results (for 0–10 cm) into the table on the soil description sheet by ticking the relevant box, so that the table looks like this:

***Chemical test results:*** example

| Depth(cm) | pH $CaCl_2$ | Aluminimum % | Organic Matter % | Soil nitrate $NO_3^-$ | Salt $EC_e$ dS/m | Sodium ESP % | Ca:Mg ratio | Other |
|---|---|---|---|---|---|---|---|---|
| 0–10 | 5 | 1 | 2 | – | 0.2 | 1 | 5:1 | – |
| 10–20 | 6 | 0 | 0.6 | – | 0 | 3 | 2:1 | – |
| 20–40 | 6.6 | 0 | 0.2 | – | 0 | 11 | 1.5:1 | – |

See Chapters C1 to C5 for help in filling out the soil test results table and understanding how to make use of this information.

***Topsoil 0–10 cm:*** example

| | | | |
|---|---|---|---|
| pH | ✓ acidic < 5 | ☐ neutral 7 | ☐ alkaline > 8 |
| Al | ✓ < 5% | ☐ 5–15% | ☐ > 15% high |
| OM | ☐ low < 1% | ✓ moderate 1–2% | ☐ high > 2% |
| $EC_e$ | ✓ low < 2ds/m | ☐ moderate 2–8 dS/m | ☐ high > 8 dS/m |
| ESP | ✓ low < 6 | ☐ moderate 6–15 (apply gypsum) | ☐ high > 15 |
| Ca:Mg | ☐ poor < 1 | ☐ low 1–2 | ✓ satisfactory > 2 |

Other comments:

Both of these tables should help to indicate whether a soil test result is low, medium or high. Use the above two tables to look at management options. Your local agronomist will know more details for the area.

## SECTION 5. MANAGEMENT

### Compaction

Compaction layers can restrict root development and plant growth, and limit infiltration. It is important to note the depth

of a compaction layer to see if biological ripping, mechanical ripping or gypsum is needed.

A compaction layer needs to be removed before conservation farming practices can be beneficial.

On the description sheet fill out the following information on your compaction layer:

| | | |
|---|---|---|
| Compaction layer | ☑ | Present: at what depth? 10–20 cm |
| | ☐ | Absent |

## BROAD SOIL TYPES

When you fill in the data sheet tick the relevant soil type box, for example:

Broad soil type:

- ☐ Texture contrast: red, brown or yellow (non-sodic)
- ☑ (Texture contrast: grey or white (sodic)
- ☐ Earth: red or yellow
- ☐ Heavy clay

### Significance of broad soil types

The soil type determines the overall soil management strategy for a paddock. There is no need to be a soil classification expert—the aim is to fit the soil into a broad type only.

To determine your broad soil type, you will need to have completed the description sheets so that you know as much as you can about the soil. The sample soil description sheets at the end of this chapter illustrate the procedure used to determine a broad soil type.

Soil texture and soil colour are the main observations to make in determining your soil type. Together with surface slaking and surface soil structure, they will allow you to assign a soil to a broad soil type.

*Texture*

The first feature to consider is soil texture. From Section 3 of the soil description sheet, note the surface soil texture and the various depths of the soil profile. In the sample soil description sheets given at the end of this chapter the soil has a texture of medium clay all the way down the profile.

☞ *See Chapter C3 for more information on soil types and landscapes.*

*Colour*

From Section 3 of the soil description sheet, note the colour of the surface soil and down the profile.

In the sample data sheets given at the end of this chapter the soil colour is yellow. The texture and colour information takes us to the texture contrast soils group.

### Characteristics of the broad soil groups

*Texture-contrast non-sodic soils*

Texture-contrast non-sodic soils include red-brown earths, and red and yellow podzolic soils. Their light textures promote acidity and their low organic matter makes them highly erodable. They will benefit from conservation farming

techniques to increase organic matter. They are generally low in fertility and may need applications of phosphorus.

*Texture-contrast sodic soils*
Texture contrast sodic soils include the solodised solonetz and solodics. They are prone to crusting or hardsetting under cultivation, but are more stable under pasture. They need conservation farming practices to increase their organic matter content. Maintain a minimum ground cover of 70%, as the high sodium levels cause dispersion and crusting.

*Earths*
Red and yellow earths are well structured soils. They are prone to hardsetting and surface crusting under cultivation, but are more stable under pastures. Some earths have deficiencies in phosphorus and nitrogen.

*Heavy clays*
Heavy cracking clays are prone to compaction, smearing and remoulding. However, they can restore and maintain good structure under wetting and drying. The surface of these soils are usually self-mulching; if not, the surface may be dispersive and gypsum may be required.

☞ *See Part D, Practical Soil Management, for further information on soil management, or see your local agronomist.*

## Management options

Any of these broad soil types can have other features, such as compaction, that require management attention. The different soil types require different management approaches.

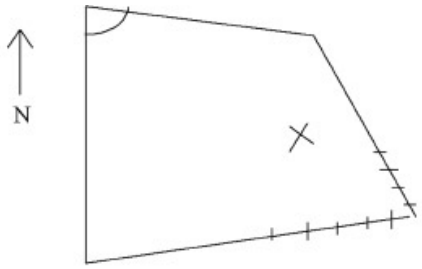
# Looking at your soils: Sample soil description sheets

## 1. FARM AND PADDOCK INFORMATION

**Farmer Details:**

| | | | |
|---|---|---|---|
| **Farmer:** | Dave Brown | **Property:** | Winterwood |
| **Paddock:** | A3 | **Reasons:** | poor growth & low yields |
| **Inspected by:** | Greg Condon | **Date:** | 12 January 1999 |

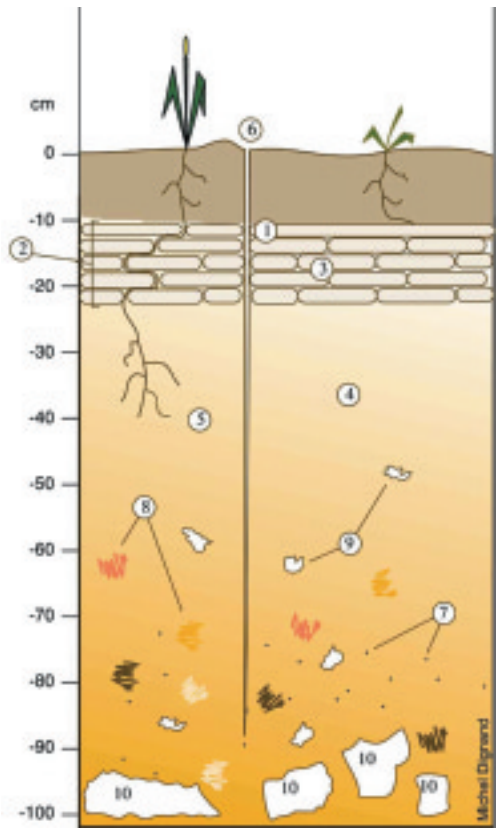
**Sketch site:**




### Paddock history

| | Year | Crop or pasture | Lime (t/ha) | Gypsum (t/ha) | Stubble treatment (retain or burn) | Cultivation technique (number of workings,wide or narrow points) |
|---|---|---|---|---|---|---|
| This year | 1999 | wheat | — | — | retain | direct drilled—narrow points |
| last year (2) | 1998 | lupins | — | — | retain | narrow points |
| previous (3) | 1997 | wheat | — | — | retain | narrow points |
| previous (4) | 1996 | canola | 2 | 2.5 | burn | harrows, scarify |
| previous (5) | 1995 | pasture | — | — | — | — |

### Profile




## 2. SURFACE CONDITION

| | Poor area | Good area |
|---|---|---|
| **% ground cover** | 40% | 85% |
| **Pugging:** a heavily compacted area that waterlogs | yes | no |
| **Crusting:** bare soil that forms a hard surface about 1 cm thick, reducing infiltration | yes | no |
| **Hardsetting:** when the topsoil sets hard and cannot be penetrated | yes | no |
| **Cloddiness:** lumps of soil brought to the surface by cultivation | no | no |
| **Slumping:** when the clod surface 'runs' together, forming a lumpy crust | no | no |

**Profile**
Pick back the soil surface with a knife, as using the spade or backhoe can seal air pores.

**What to look for:**
1. plough pans
2. bleached zone: a very pale layer (nearly white)
3. compaction
4. texture change (including clay content)
5. roots: to what depth, size and number
6. deep cracks: size and depth
7. buckshot (soft and red/black)
8. mottling: mixture of colours
9. lime concretions (a drop of battery acid causes lime particles to fizz)
10. stones: indicate the depth and size

### 3. SOIL FEATURES

| | Depth (cm) | Texture | Colour | Aggregate size (cm) | Aggregate shape | Fabric consistency | Slaking and dispersion | pH (water) |
|---|---|---|---|---|---|---|---|---|
| Topsoil | 0–10 | loam | brown | 0.5–1 | polyhedral | rough | 1: slaking<br>0: no dispersion | 6 |
| Sub-surface | 10–20 | sandy loam | pale grey | 4 | platy | — | 3: slaking<br>0: no dispersion | 7 |
| Subsoil | 20–40 | medium clay | yellow | 2–3 | angular blocky | smooth | 2:slaking<br>2: dispersion | 7.5 |

### 4. CHEMICAL TESTS (see Chapter C5)

| Depth(cm) | pH $CaCl_2$ | Aluminium % | Organic Matter % | Soil nitrate $NO_3^-$ | Salt $EC_e$ dS/m | Sodium ESP % | Ca:Mg ratio | Other |
|---|---|---|---|---|---|---|---|---|
| 0–10 | 5 | 1 | 2 | — | 0.2 | 1 | 5:1 | — |
| 10–20 | 6 | 0 | 0.6 | — | 0 | 3 | 2:1 | — |
| 20–40 | 6.6 | 0 | 0.2 | — | 0 | 11 | 1.5:1 | — |

*Topsoil 0–10 cm*

| | | | |
|---|---|---|---|
| pH | ☑ acidic <5 | ☐ neutral 7 | ☐ alkaline > 8 |
| Al | ☑ <5% satisfactory | ☐ 5–15% | ☐ > 15% high |
| OM | ☐ low < 1% | ☑ moderate 1–2% | ☐ high > 2% |
| $EC_e$ | ☑ low < 2dS/m | ☐ moderate 2–8 dS/m | ☐ high > 8 dS/m |
| ESP | ☑ low < 6 | ☐ moderate 6–15 (apply gypsum) | ☐ high > 15 |
| Ca:Mg | ☐ poor < 1 | ☐ low 1–2 | ☑ satisfactory > 2 |

Other comments:

### 5. MANAGEMENT

**Compaction layer:**

☑ Present: at what depth? ☐ Absent

**Broad soil type:** ☐ Cracking clay ☐ Earth

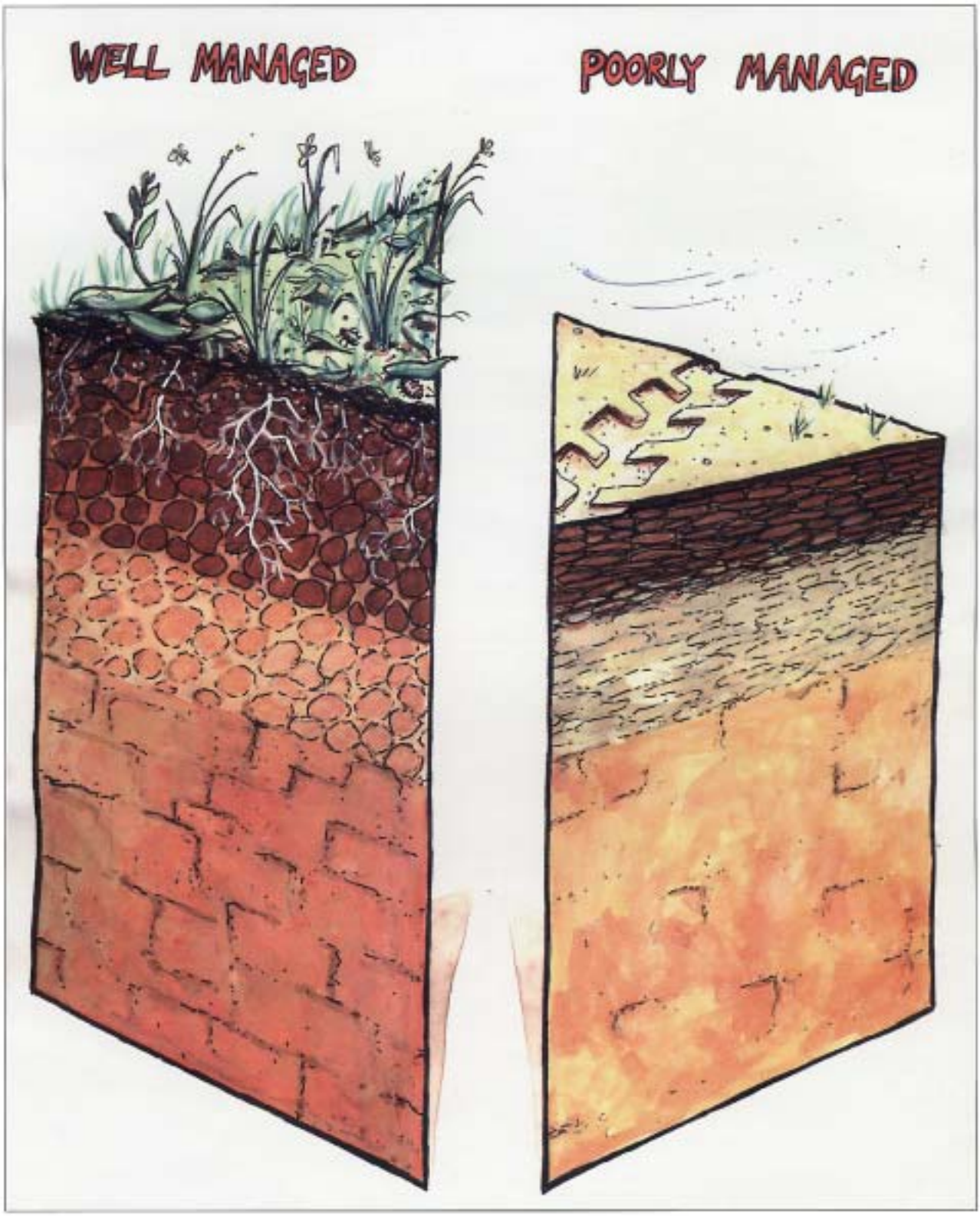
☐ Texture contrast red or bright yellow

☑ Texture contrast yellow, grey or white

**Management options:** (consult your SOILpak or speak to an agonomist or catchment manager)

# Looking at Your Soils

This 8-page colour supplement to Chapter C1 is designed to be pulled out and used in the field. It helps you to fill in the soil description data sheets step by step.




by Nathalie Brown, NSW Agriculture
and Tom Green, CSIRO

## THE BASICS

The easiest way to read your soil is by examining a slab of soil. Dig a hole about 30 cm square and 30–40 cm deep. Insert your spade about 15 cm behind one side of the hole and lever out a slab. It helps to slice the sides of the slab first. Clay slabs are easier to dig than slabs from sandy soils.

Lever out the slab carefully from the hole and lie it on the grass. Use a blunt knife to pick the soil surface back so that you can see details such as plant roots.

## Farm details

| | | | |
|---|---|---|---|
| **Farmer:** | Dave Brown | **Property:** | Winterwood |
| **Paddock:** | A3 | **Reasons:** | poor growth & low yields |
| **Inspected by:** | Greg Condon | **Date:** | 12 January 1999 |

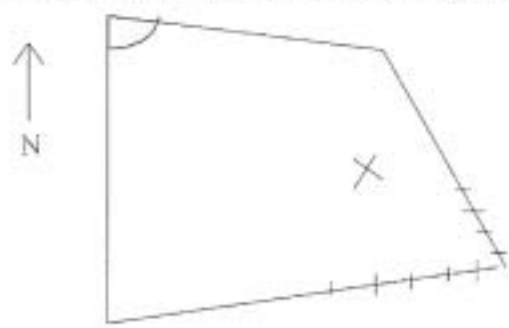
This information gives details for you to file, indicating which year, paddock etc. (Remember not to call a paddock, for example, 'wheat paddock', because next year it won't be wheat.) If this is your property, this information may seem unnecessary, but an agronomist using the sheet may visit many farms and will need a record.

## Paddock history: example

| | Year | Crop or pasture | Lime (t/ha) | Gypsum (t/ha) | Stubble treatment (retain or burn) | Cultivation technique (number of workings, wide or narrow points) |
|---|---|---|---|---|---|---|
| This year | 1999 | wheat | — | — | retain | direct drilled–narrow points |
| last year (2) | 1998 | lupins | — | — | retain | narrow points |
| previous (3) | 1997 | wheat | — | — | retain | narrow points |
| previous (4) | 1996 | canola | 2 | 2.5 | burn | harrows, scarify |
| previous (5) | 1995 | pasture | — | — | — | — |

## Sketch site: *example*

Remember not to dig near gates, fences, headlands or under trees, as they are not representative of the paddock. They may have had extra traffic or been used as stock camps, or higher amounts of fertiliser may have been applied.

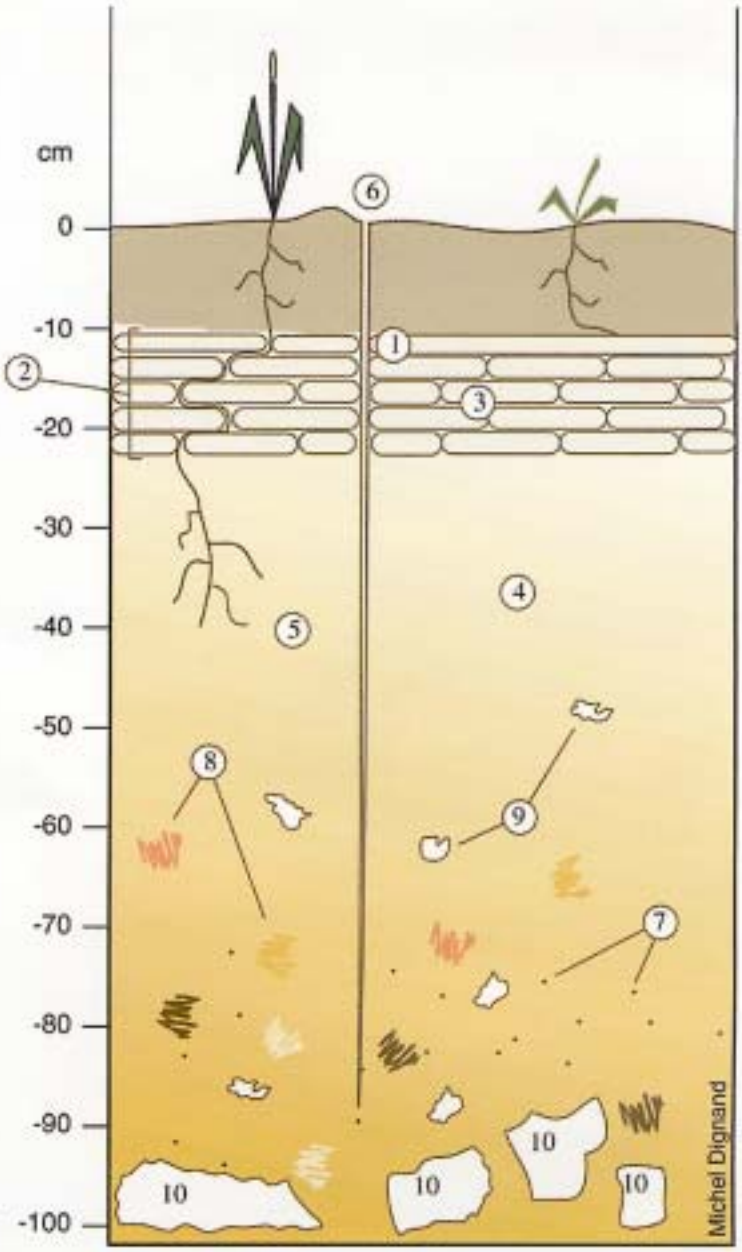


## Profile

Pick back the soil surface with a knife, as using the spade or backhoe can seal air pores.

**What to look for:**

1. plough pans
2. bleached zone: a very pale layer (nearly white)
3. compaction
4. texture change (including clay content)
5. roots: to what depth, size and number
6. deep cracks: size and depth
7. buckshot (soft and red/black)
8. mottling: mixture of colours
9. lime concretions (a drop of battery acid causes lime particles to fizz)
10. stones: indicate the depth and size




## Surface condition

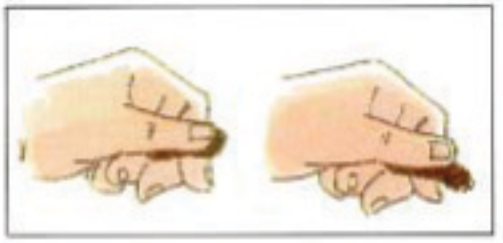
When standing, look at an area about 1 m x 1 m. What proportion is covered (good), and what area is left bare (poor)?

| Surface condition | Poor area | Good area |
|---|---|---|
| % ground cover | 40% | 85% |
| **Pugging:** a heavily compacted area that waterlogs | Yes | No |
| **Crusting:** bare soil that forms a hard surface about 0.5–1cm thick, reducing infiltration | Yes | No |
| **Hardsetting:** when the topsoil sets hard and cannot be penetrated | Yes | No |
| **Cloddiness:** lumps of soil brought to the surface by cultivation | No | No |
| **Slumping:** when the clod surface 'runs' together, forming a lumpy crust | No | No |

## SOIL FEATURES

### Soil texture

A simple field test can be used to determine texture. Work a handful of soil with a little water and try to form a ball. If you can form a ball, try to ribbon the ball between your thumb and forefinger. The ribbon length will be determined by the clay content. Sand can be heard as you work the ball—it will feel gritty. Silt has a soft, silky feeling. The texture influences the structural development of the soil and the retention of water and nutrients.



***Determine the soil texture class from a ribbon length:***

| Ribbon (cm) | Description | Texture |
|---|---|---|
| < 1 | Difficulty in forming a ball | Sand |
| 1.5–2.5 | Forms a ball, sandy, slight stickiness | Sandy loam |
| 2.5–4 | Forms a smooth, spongy ball, some stickiness | Loam |
| 4–5 | Forms a smooth 'plastic' ball, sticky | Clay loam |
| 5–7 | Forms a smooth very 'plastic' ball, very sticky | Light clay |
| > 7 | Forms extremely 'plastic' ball, extremely sticky | Medium to heavy clay |

(simplified textural classes)

### Colour

Colour is a soil feature that is easily observable. It can tell you about factors that influence plant growth.

| | |
|---|---|
| Black: | • organic matter—on the soil surface from plant or animal litter<br>• iron/manganese—released during periodic waterlogging (gravelly/buckshot appearance). |
| Red: | • rust colour—'dry' conditions<br>• well aerated<br>• soil is freely draining |
| Red/yellow: | • presence of iron minerals |
| Yellow: | • 'moist' conditions<br>• soil is seasonally/intermittently wet |
| Grey: | • indicates poor drainage<br>• permanently wet (low oxygen)<br>• in severe waterlogging—grey with a bluish/green tint |
| White: | • removal of organic matter and iron minerals |
| Mottled: | • red/yellow in grey background<br>• seasonal/intermittent waterlogging (indicates a fluctuating watertable) |

See the soil-type photos on the last page of this booklet for more information.

## SOIL STRUCTURE

The structure of a soil is defined by the arrangement of sand, silt, clay and organic matter, and the size and shape of gaps or channels between these materials. These gaps or channels are called pores. The pores carry air and water to plant roots and allow these roots to grow into the soil.

### Aggregate size

It is best for aggregates to be less than 1 cm in diameter. Small aggregates have a larger surface area for other aggregates to attach to, and also allow more cracks for roots and water.

### Aggregate shape

**Massive:** Dense soil in which pore spaces are filled by soil particles, so that on drying the soil surface forms clods.

**Platy:** Aggregates are two to three times longer than they are wide, indicating that they have been squashed and compacted. They become very dense and do not hold water.

**Polyhedral:** The presence of many-sided aggregates indicates that the structure is all right.

**Angular blocky:** Aggregates fit tightly together with minimum air space—usually found in the lower layers of clay soils.

**Sub-angular blocky:** Aggregates are more rounded, allowing more air pockets—usually found in the lower layers of clay soils.

### Aggregate fabric

**Rough:** Aggregate surface is porous and uneven, indicating that the soil is well drained.

**Smooth:** Aggregate surface is shiny, indicating that water has been washing over it. Often seasonally waterlogged.

### Wet and dry soils

When soil is wet it is swollen, and cracks may be hard to see. Moisture often makes a poorly structured soil look good and often easier to compact.

Dry soils can be very strong, even when they are well structured. Poorly structured soils can be easily broken down into dust.

### Consistence

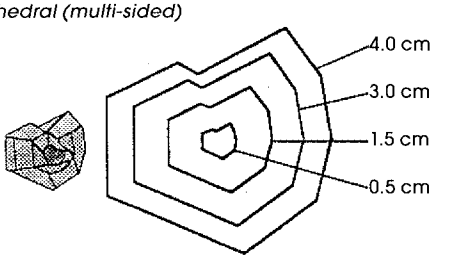
Consistence is the resistance of the soil to breaking. To determine the breaking resistance, take a 30 mm cube of dry or moist soil (friable) between forefinger and thumb. How easily does the soil cube break under force?

**Soft:** If only slight force is needed, then this soil will not restrict roots. However, it may slow water movement.

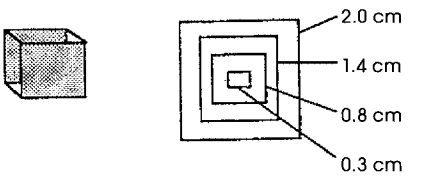
**Firm:** If moderate to strong force is needed, the soil has the potential for waterlogging.

**Very hard:** The soil is hard to break with the hands but may crush underfoot. This soil gives restricted root growth and water flow and is most likely to be waterlogged.

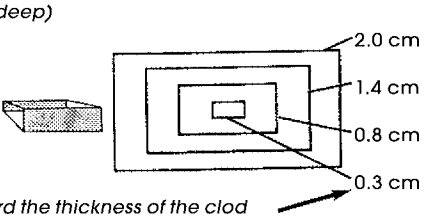
*Polyhedral (multi-sided)*




*Angular blocky (approximately cube-shaped, square corners)*

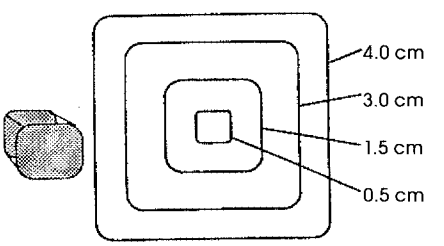



*Platy (2–3 times longer and/or wider than deep)*

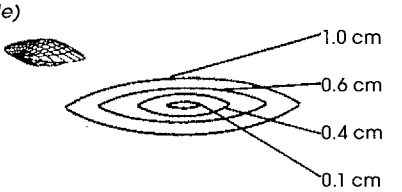



*Record the thickness of the clod ie: through its thinnest dimension*

*Sub-angular blocky (approximately cube-shaped, rounded corners)*




*Lenticular (lens-shaped, 2 sided, thicker in the middle)*




*Concoidal (ball and cup), generally larger than 1 cm*

☞ *Tip: If you dig up your plants and the roots are growing sideways, you may have a compaction layer or an acid layer. Check your pH and see a local agronomist.*

## Management

To improve your structure you will need to:

- reduce disturbance
- retain a ground cover
- encourage root growth
- use biological ripping (that is, with plant roots)
- sacrifice paddocks for stock in wet weather to reduce compaction.

Soils with good structure have a high proportion of small crumbs and many visible holes or pores from worm and root channels. A variety of air pore sizes is needed in the soil. Large pores allow for drainage of water from the soil, while medium-sized pores supply water to plants.

## SLAKING AND DISPERSING

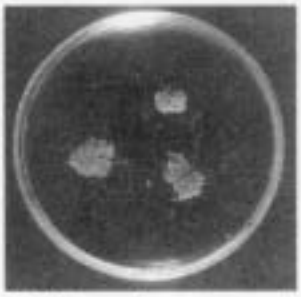
The same test is used for both slaking and dispersion. Drop a few pea-sized, dry aggregates into a dish or jar of distilled water or rainwater. Observe for five minutes for slaking results, and for 10 minutes and two hours for dispersion results.

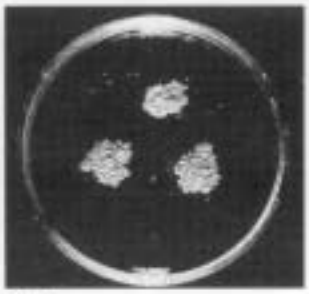
**Caution:** Do not disturb the dish or jar once the soil is in the water. Water movement will make the dispersion rise. Always put the water in first, then add the crumbs. Also keep the test out of the wind. This test is best done at home or in the shed on a stable surface.

Slaking is most important in the topsoil. Dispersion is important in the root zone. Sample at different points down the profile, as dispersion changes with depth.

***Comparison of slaking and dispersion***

| Slaking | Dispersion |
|---|---|
| A measure of soil strength. If the soil slakes this is usually due to a lack of organic matter, which is needed to bind the soil. This soil can be easily eroded; it forms a surface crust and is hardsetting. | A measure of the chemical stability of the soil. If the soil disperses this is due to an imbalance of the cations in the soil (for example, excessive sodium), or an excessive magnesium to calcium ratio. Dispersed clay will clog the soil pores, causing poor water infiltration and restricting the root growth. |
| After five minutes, score slaking as follows:<br>• Score 0 if the lump remains intact.<br>• Score 1 if the lump collapses around the edges but remains mainly intact.<br>• Score 2 if the lump collapses into angular pieces.<br>• Score 3 if the lump collapses into small (less than 2 mm) rounded pieces, forming a cone.<br>• Score 4 if the lump collapses into single grains (that is, if you can see sand grains). | Record dispersion on wetting as follows:<br>• Score 0 for no dispersion within two hours.<br>• Score 1 for slight dispersion within two hours.<br>• Score 2 for slight dispersion within 10 minutes or strong dispersion within two hours.<br>• Score 3 for strong dispersion within 10 minutes or complete dispersion within two hours.<br>• Score 4 for complete dispersion within 10 minutes. |
| Slaking can be reduced by adding organic matter.<br>• Score 0 or 1 indicates that the soil is in excellent condition.<br>• Score 2 is typical of clay soils. Check for dispersion.<br>• Score 3 soil may form a crust. It will need to be managed according to conservation farming methods. See Chapter D6 of Dryland SOILpak.<br>• Score 4 soil will crust and hard set. Take urgent action to increase organic matter levels through good pasture management and conservation farming. | • Score 0 indicates healthy soil.<br>• Score 1 indicates that further chemical laboratory tests are needed.<br>• Score 2 indicates a probable need for gypsum. Seek further chemical laboratory tests.<br>• Score 3 or 4 suggests that gypsum is most likely to improve the soil.<br>Dispersion on wetting is a good field test which points to the likely need for gypsum to prevent surface dispersion. Repeat the test in other areas of the paddock to confirm your results. Don't assume that one test is typical of the whole paddock. Try a test strip of gypsum. |


Stable ped


Slaking


Slight dispersion


Dispersed

## SOIL TESTING FOR FURTHER INFORMATION

### Soil testing do's and don'ts

Your soil tests are only as good as the sampling procedure you use. It will save you money if you sample correctly.

### Do's

- Know what you are sampling for.
- Sample at least three months after liming and two months after the last fertiliser application.
- Take 30 samples of the major soil type in the paddock.
- Take samples randomly.
- Take samples of the topsoil (0–10 cm) and where possible the subsoil (10–60 cm).
- Remove excess plant material before sampling.
- Mix sample well.
- Collect a sub-sample of about 0.5 to 1 kg of soil.
- Send for analysis on day of sampling, or air-dry the soil on newspaper.
- If testing for nitrogen, place in the fridge and send by express delivery as soon as possible.
- Label the outside of the bag immediately using permanent ink. Include your name, address and paddock name or number.
- Take samples at 10 to 60 cm when measuring nitrogen. It is essential to keep the sample cold or to air-dry it. If the sample is left in warm, moist conditions, the bacteria will start breaking down the nitrogen, which is then lost into the air, giving you an inaccurate result.
- Be careful not to get any topsoil in the 10 to 60 cm sample.

### Dont's

- Avoid sampling along fence lines, in headlands, stock camps, gateways, wet areas, troughs, fertiliser dumps and tracks, under trees, near buildings and in areas where timber has been stacked and burnt. The fertility of these areas will be different to that of most of the paddock and will influence your results.
- Avoid areas of poor growth or excessively good growth, for example urine and dung patches.

- Avoid leaving samples in a hot car, in plastic bags or in the back of a ute.
- Avoid handling soil; perspiration from hands can affect the sodium and potassium levels.

You can measure pH with a simple pH test kit or with a pH meter, which must be calibrated accurately. Both are available from nurseries or farm centres.

A laboratory test is a more accurate measure of what is happening in your soil. If you have a major problem in the paddock, lab tests give you an idea about the nutrients available to plants. It is best to take samples from 0 to 10 cm and 10 to 20 cm, and deeper if economically feasible.

***Soil Types:***

***Red earth — NJ34***


*0.00–0.10 5yr 2.5/1*

*0.10–0.20 5yr 3/2*

*0.20–0.35 5yr 3/3*

*0.35–0.50 2.5yr 3/4*

*0.50–0.80 2.5yr 3/6*

***Heavy clay — VC02***


*0.00–0.05 10yr 4/2*

*0.05–0.25 10yr 4/2*

*0.25–0.60 10yr 4/2*

*0.60–End 10yr 5/2*

***Yellow solodic — Holding***


*0.00–0.10 10yr 6/1*

*0.10–0.40 2.5yr 6/4*

*0.40–End 2.5yr 7/6*

***Red brown earth — NJ06***


*0.00–0.08 5yr 3/2*

*0.08–0.15 5yr 3/3*

*0.15–0.40 2.5yr 3/6*

*0.40–0.60 2.5yr 4/6*

*0.60–End 5yr 4/6*