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A simple guide for describing soils

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Angela Stuart-Street, Nicolyn Short, Paul Galloway and Noel Schoknecht

Cover: Group of natural resource officers describing a soil pit in the northern wheatbelt (photo: A Stuart-Street)

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Disclaimer

Department of Primary Industries and Regional Development
3 Baron-Hay Court, South Perth WA 6151
Telephone: +61 (0)8 9368 3333
Email: enquiries@dpird.wa.gov.au
Website: dpird.wa.gov.au

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Introduction

Soils are enormously diverse and can be very confusing to understand and talk about. This simple guide for describing soils helps to identify the most important parts of a soil profile and provide an easy way to understand and explain what you see. It gives you a step-by-step guide of what soil properties to describe and how to describe them, along with the tools to make basic soil classifications. The soil descriptors help you to identify the soil type and aid in assigning a simple and standardised name to the soil. While this guide is designed to link with a simple classification system already in use for Western Australia — the Soil Groups of Western Australia — the soil description standards used here are applicable everywhere.

This guide is suitable for anyone who is interested in understanding the basics of soil morphology, characteristics and description. Experts in other scientific fields, industry consultants, students and interested lay readers will also benefit from using this guide as a stepping stone to a more advanced understanding of soil. Detailed soil descriptions and land surveys should always follow national standards described in the following documents:

- *Australian soil and land survey field handbook*, also called the 'yellow book' (National Committee on Soil and Terrain 2009)
- *Guidelines for surveying soil and land resources*, also called the 'blue book' (McKenzie et al 2008)
- *Soil chemical methods*, also called the 'green book' (Rayment &Lyons 2010)
- *Soil physical measurement and interpretation for land evaluation*, also called the 'brown book' (McKenzie et al 2002)
- *The Australian Soil Classification* (Isbell & National Committee on Soil and Terrain 2016).

We include in this guide the opportunity to provide the Department of Primary Industries and Regional Development (DPIRD) with your soil findings. This contribution can potentially help to refine the existing state soil data collections, if captured on the standardised brief soil description card (site card) included at the end of this guide.

We include bold terms throughout this guide to highlight important soil terms commonly used in profile descriptions, including specific codes or soil abbreviations. These codes or soil abbreviations are mainly for field recording to save space on the site card. Underlined words link to the glossary in this guide.

About soil

What is soil?

Soil is a dynamic, living environment that supports and feeds life. It is the 'earthy material' that plants grow in. Its lower limit is hard rock, permanent water or the lower limit of biological activity, which generally coincides with the rooting depth of native perennial plants. It is composed of a matrix of minerals, organic matter, air and water. Each component is important for supporting plant growth, microbial communities and chemical decomposition.

Why describe a soil?

Describing and naming a soil enables the simple communication of information, so that people can easily talk about their soil's character and management in a standard way.

A soil description helps us decide what can grow where, whether it is in the garden, the bush or on the farm. For example, knowing a paddock soil is a deep sand tells us it is probably good to grow lupins or carrots but not chick peas, or that we should be revegetating with banksias and not mallees.

It is also informative to have soils described as part of general environmental surveys or monitoring soil condition. For example, during a vegetation survey, describing the soil along with a plant specimen will give some idea of the plant's environment and requirements.

Describing a soil profile in the field

In the field, the soil profile is divided into layers (horizons) based on one or more of the key properties. Soil description is best conducted on an exposed profile, such as a soil pit or road cutting, so you can easily see the layers (Figure 1). Otherwise, a shovel, soil auger or coring device is usually adequate (Figure 2–4).

Figure 1 A soil profile exposed in a road cutting

Figure 2 Soil samples collected with an auger

Figure 3 Soil samples collected using a shovel

Figure 4 Soil samples being collected using a drill rig

Main soil properties used for describing soil

Numerous individual soil properties contribute to a soil's character. These properties are best examined and described in the field. The level of detail will depend on the level of information required and the time and funds available. Occasionally, being able to say that a soil has a sandy surface is enough, but usually a more detailed soil description is preferable.

The nine soil properties commonly examined are:

1. depth of profile or depth to (perceived) root-limiting layer
2. identifying and naming soil horizons
3. texture of each layer, including texture change through the soil profile
4. coarse fragments
5. colour
6. basic chemistry (pH and salinity)
7. calcareous (lime) layer/s
8. structure
9. water regime.

1 Depth of soil profile or depth to (perceived) root-limiting layer

The total depth of the soil described is the **soil profile**. The soil profile usually has its lower limit at hard rock, hardpan, permanent water or the lower limit of biological activity, and the depth these features are encountered should be recorded.

The soil profile depth can vary from a few centimetres (cm) — in the case of a thin soil over rock — to several metres. The soil profile should be examined from the surface to a depth of between 80cm and 150cm to adequately describe the soil for most agricultural purposes. For trees and perennial shrubs with roots that reach greater depths, deeper soil profile descriptions are needed.

2 Identifying and naming soil horizons

To better understand the characteristics of a soil profile, it is usually divided into one or more separate layers or **horizons**. The terms 'layer' and 'horizon' are often used interchangeably in describing soil profiles, but the term 'horizon' is generally used for more-technical soil profile descriptions. Each horizon contains a unique combination of soil properties, such as soil colour or texture, and is defined by an upper and lower depth. When they are all combined, these horizons or layers form the soil profile.

The depth of different horizons can be very important to understand a soil's characteristics. For example, a soil with a **shallow** sandy horizon (with upper depth from ground level to about 15cm deep) over a clayey horizon will perform differently to a soil with a **deep** sandy horizon (ground level to about 50cm deep) over a clayey horizon.

Using a letter or name for each horizon is a soil description standard. The surface layer/s of a soil is called the **topsoil** or **A horizon/s**. This layer is usually higher in organic matter, at least at the surface, and lower in clay than the deeper horizons (Figure 5).

The layer/s of soil below the topsoil are generally called the **subsoil** or **B horizon/s**. These are usually higher in clay and lower in organic matter than the topsoil.

Below the B horizon is the parent material (e.g. decaying rock), which is called the **C horizon**. If encountered, it is important to describe some element of the parent material origins (e.g. granitic, sedimentary) in addition to describing the soil properties (Figure 6). For simple soil profile descriptions, two to four horizons are usually adequate.

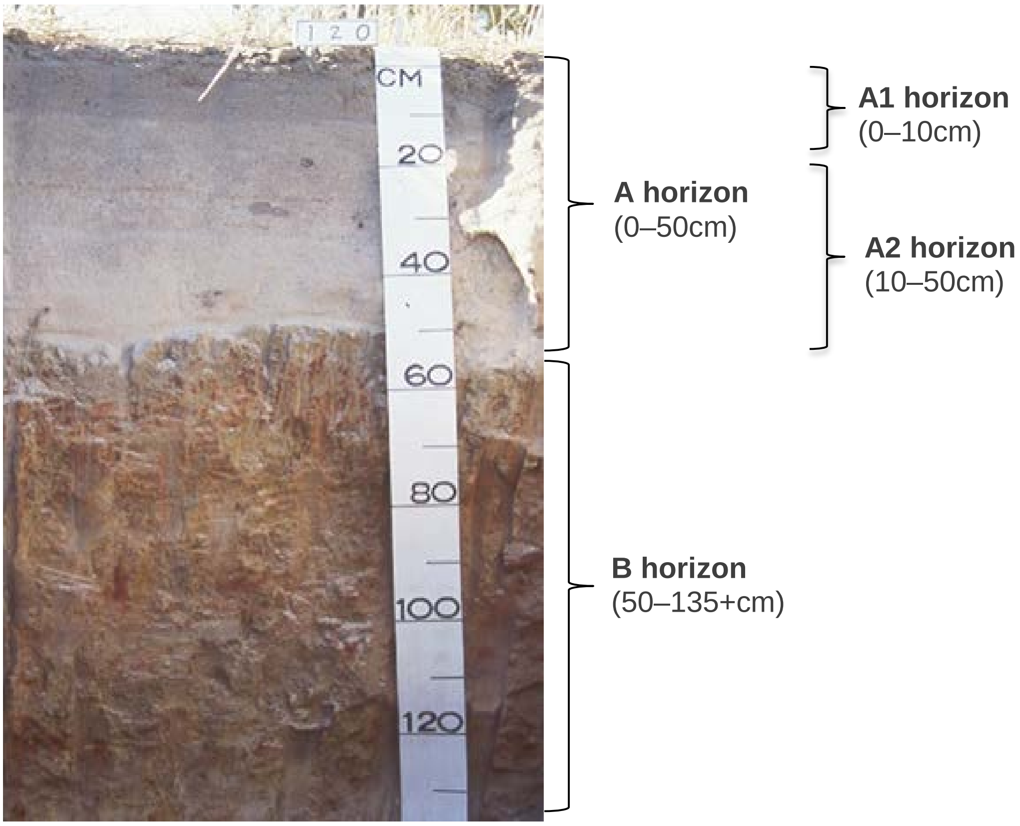


Figure 5 Soil profile showing an abrupt boundary at 50cm between the sandy A horizon and clayey B horizon. The A horizon could be subdivided into an A1 horizon (topsoil with some organic staining) and an A2 horizon (bleached)

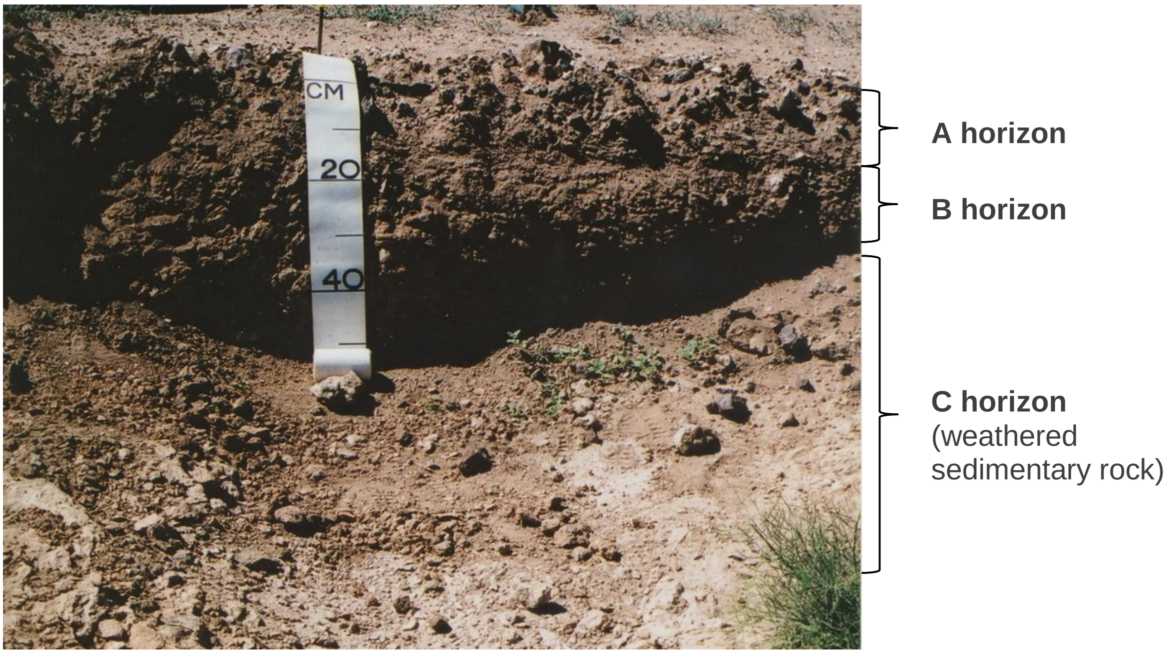


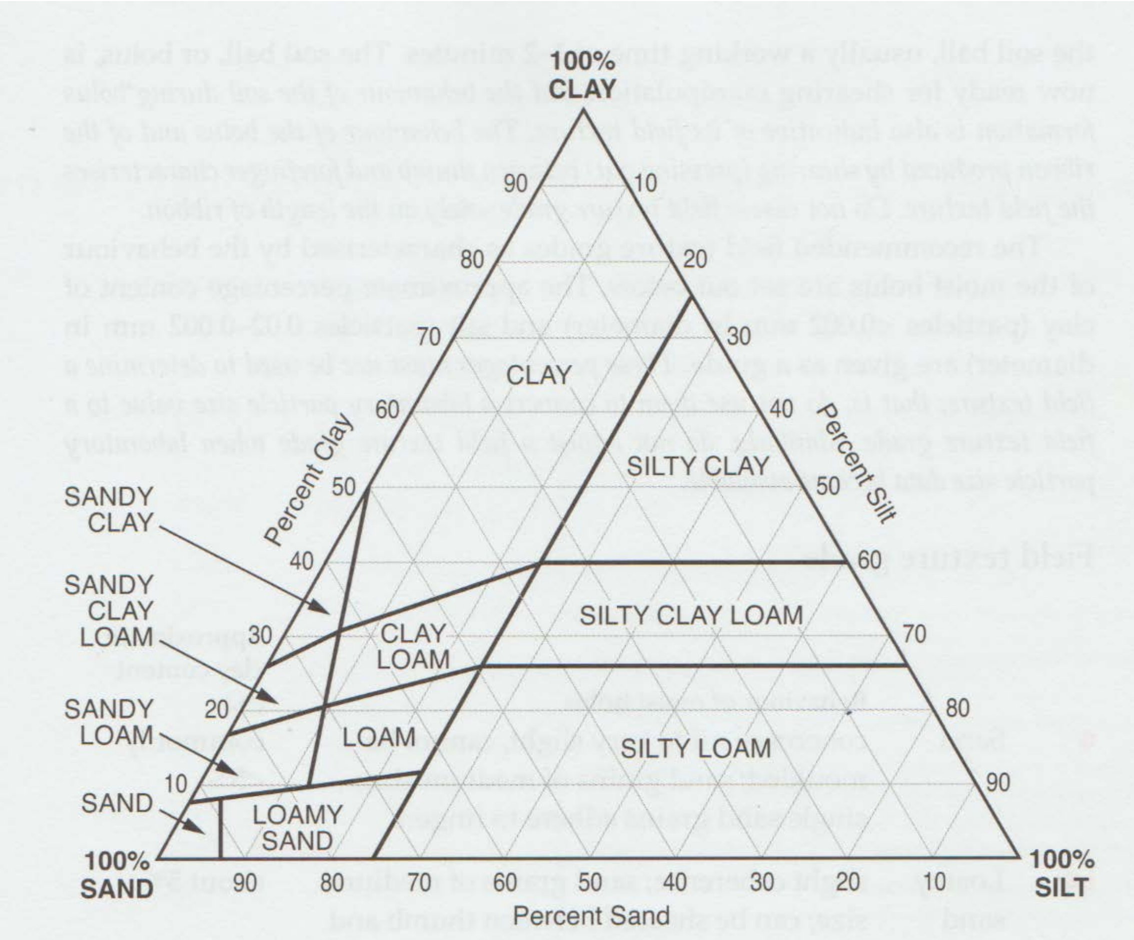
Figure 6 Soil profile showing a shallow loamy soil over weathered rock parent material

3 Texture

Almost every soil contains a range of different particle sizes and it is their combined proportions that contribute to assigning an overall texture. Soil texture and change of soil texture down the profile is an important factor contributing to a diverse range of soil properties, including hydraulic conductivity (water storage and water infiltration), soil fertility, soil chemical and mechanical properties, agricultural workability and trafficability, and erosivity.

Soil texture can be identified by laboratory analysis of the range of particle sizes present in the mineral fraction of the soil, and in the field by hand 'texturing the soil'.

The laboratory method uses the results from a particle size analysis. The proportions of sand, silt and clay are transcribed onto a standard texture triangle to determine a soil texture grade (Figure 7).



Source: National Committee on Soil and Terrain (2009)

Figure 7 Australian standard texture triangle

For example, a soil with a particle size analysis of 70% sand, 15% silt and 15% clay would return a texture grade of 'loam'. Figure 8 is a worked illustration of this example.

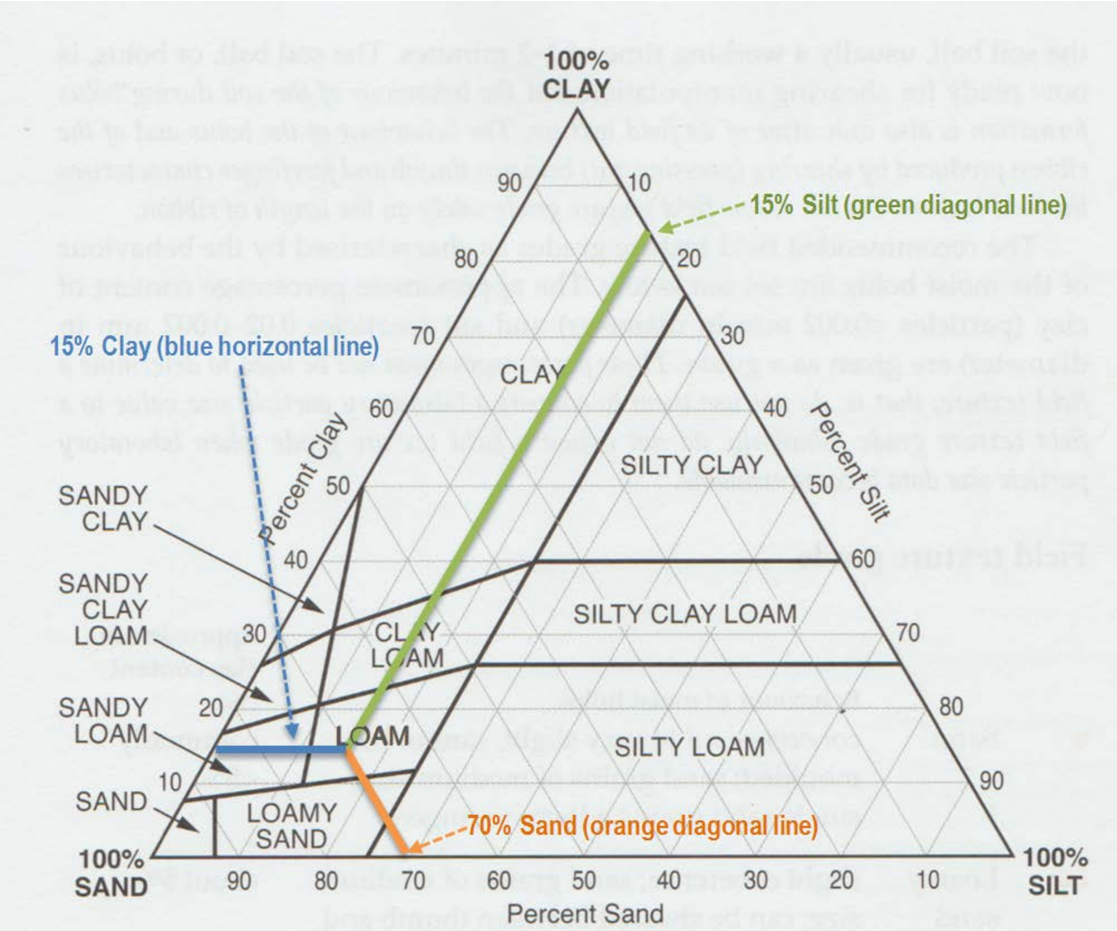


Figure 8 A worked example determining a soil texture grade (loam) from laboratory-measured particle size data showing 70% sand, 15% silt and 15% clay

The field ‘hand texture’ method approximates the particle size distribution and is a useful measure in its own right (see the step-by-step guide to soil field texturing on page 8. **Field texture** identifies how the soil feels, reacts and sounds when a small handful of soil is moistened and kneaded into a ball (or bolus) which is influenced by the proportions of **sand**, **silt** and **clay** that make up the soil. Clay is the smallest or finest of the soil particles in a bolus, sand is the largest or coarsest, and silt is between the two.

Recognising the role that different particle sizes (excluding gravels and stones which are larger than 2 millimetres [mm]) contribute to soil texture helps to understand how a moist bolus of soil material feels to touch and mould in your hand.

Particle size

Soil particles vary from fine clay to rocks. By convention, the particles larger than 2mm are **coarse fragments** (gravels and stones) and all the particles 2mm and smaller are called the **fine earth**. Most field texture descriptions are of the fine earth fraction, including the mineral soil and organic matter. As mentioned above, this mineral soil is divided into three main size groups:

- Sand particles are 0.02 to 2mm in size. When texturing the soil, sand particles feel gritty and individual sand grains can be easily seen.
- Silt particles are 0.002 to 0.02mm in size. When texturing the soil, silt particles are fine and feel silky, a bit like custard powder.

- Clay particles are less than 0.002mm in size. When texturing the soil, clay particles are very fine, and give the soil a sticky feel when moist.

In most WA soils, sand and clay particle sizes dominate. A few soils have significant silt and organic matter in their particle size fraction, but they are generally not widespread, and are often water- or wind-deposited soils near rivers or on dunes surrounding salt lakes. These soils can be called silty, but their texture description is not elaborated on in this guide.

Texture groups and texture grade

After estimating the proportion of particle sizes in your moistened bolus of soil and observed how it behaves when squeezed out into a ribbon between your thumb and forefinger — see the soil field texture guide on page 8 — the next step is to work out the **texture group** your sample belongs in.

As described above, the names sand, silt and clay each represent a particle size range. However, — and confusingly for people new to soil description — the phrases sand, silt and clay, along with the term '**loam**', are also used to describe the overall texture group of the layer being described. For example, soil with a sand-dominated fine earth fraction and only a small proportion of silt and clay is known as 'sandy' soil. Soil with a significant content of organic and silt fine earth fraction is known as 'silty' soil. Soil with a large proportion of clay (or very fine) particles is known as 'clayey' soil. Soils with more mixed proportions of sand, silt and clay fall somewhere in between these particle size 'extremes'. These are known as 'loamy' soils.

However, there is greater variation than just these three groups. **Texture grade** is a subdivision of texture groups to more accurately express the range of particle sizes present in a soil layer and it is largely determined by the feel and behaviour of manipulated moist soil.

The composition of the soil material, including the organic matter and various particle size fractions — the proportion of sand, silt or clay particles that you estimate from a sample — largely determines the **texture grade**. Table 1 shows a basic subdivision of texture groups into texture grades.

Table 1 The texture grades in the texture groups

Texture group	Texture grades
Sands	sand, loamy sand, clayey sand
Loams	sandy loam, loam, sandy clay loam, clay loam
Clays	sandy clay, light clay, medium clay, heavy clay

The last name of the grade defines the texture group and the first name is a qualification. For example, a clayey sand is a 'sand' with 5–10% clay, whereas a sandy clay is a 'clay' (more than 35% clay) with a proportion of sand.

Depending on the requirements of the soil describer, soil field texture can be assigned to the three texture groups, or to the 11 texture grades, or to the more defined national soil texture standards described in *The Australian soil and land survey handbook*, the yellow book (National Committee on Soil and Terrain [NCST] 2009).

Soil field texture guide

The hand texture of a soil is a measure of the different particle sizes: it reflects its proportions of sand, silt and clay. The feel and behaviour of the soil as you moisten and knead it will help you to identify its texture.

Before you start

It is a good idea to sieve your soil using a 2mm sieve before determining its texture. This removes any stones and gravel, and breaks down lumps in the soil, making it easier to work with. If you do not have a sieve, or if your soil is wet, manually removing most of the coarse fragments may be easier.

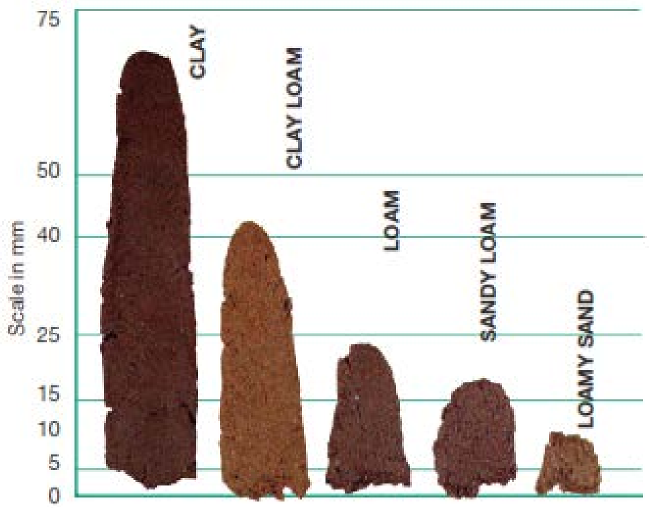
Hand texturing

Step 1 Take a small handful of soil (about the size of an egg) that will fit comfortably in the palm of your hand.

Step 2 Add enough water to make a bolus. Knead the ball for 1–2 minutes, adding more water or soil until it just stops sticking to your fingers. Note how the soil feels when kneading it: gritty (sandy), silky (silty) or plastic/sticky (clay). If you cannot make a ball, the soil is very sandy.

Step 3 Gently press out the soil between your thumb and index finger to form a hanging ribbon. The ribbon should only be 2–3mm thick. The more clay you have in your soil, the longer your ribbon will be (Figure 9, Table 2).

The behaviour of the soil bolus and the ribbon determines the field texture. Do not determine soil texture solely on the length of the ribbon. Use the additional information in Table 2 to help identify your soil's texture.



Source: Top Crop Australia soil field texture card

Figure 9 Example of soil ribbons for different textures

Table 2 Guide to common soil field texture grades

Texture group	Texture grade & code	Ribbon length (mm)	How the soil behaves or feels	Clay content (%)
Sand	Sand (S)	Nil	Coherence is nil to very slight; soil cannot be moulded into a bolus; sand grains stick to fingers.	<5
	Loamy sand (LS)	5	Slight coherence; sand grains of medium size can be pressed out (sheared) between thumb and forefinger.	5–10
	Clayey sand (CS)	5–15	Slight coherence; sticky when wet; sand grains stick to fingers, discolours fingers; little or no organic matter.	5–10
Loam	Sandy loam (SL)	15–25	Coherent bolus but feels very sandy; dominant sand grains are medium sized and easy to see.	10–20
	Loam (L)	About 25	Loams may form a thick ribbon; soil bolus is easy to manipulate and has a smooth, spongy feel with no obvious sandiness; feels greasy if organic matter present.	About 25
	Sandy clay loam (SCL)	25–40	Strongly coherent bolus; feels sandy; medium-sized sand grains can be seen in a finer matrix.	20–30
	Clay loam (CL)	40–50	Strongly coherent and plastic bolus; smooth to manipulate.	30–35
Clay	Sandy clay (SC)	50–75	Plastic bolus; sand grains can be seen and felt.	35–40
	Light clay (LC)	50–75	Plastic behaviour is evident; feels smooth; easily worked, moulded and rolled into a rod that can form a ring without cracking.	35–40
	Medium clay (MC)	>75	Smooth plastic bolus; handles like plasticine; can be moulded into rods and form a ring without cracking; resistant to shearing.	45–55
	Heavy clay (HC)	>75	Smooth, very plastic bolus; strongly coherent; feels very sticky; handles like stiff plasticine; will mould into rods and form a ring without cracking; firm resistance to shearing.	>50

Texture change through the soil profile

Soil texture often changes with depth. Usually the texture becomes ‘heavier’ with depth — that is, there is an increase in the clay content, often described as an increase in texture — and sometimes it is quite dramatic. Understanding this change down the profile helps to explain how different soils behave. This is why it is important to investigate below the topsoil, deeper into the environment where roots grow.

The importance of texture change through the soil profile is reflected in soil classifications worldwide. The texture changes in three main ways with depth:

- there may be little or no change in texture with depth and this is called a **uniform soil**
- there may be a gradual increase in texture (becomes more clayey) and this is called a **gradational soil**
- there may be an abrupt or sharp increase in texture and this is called a **duplex soil**.

When the field texture of a soil remains within the one texture group throughout the profile described — for example, sandy clay at surface, becoming heavy clay at depth — the soil texture profile is termed a **uniform soil**. Figure 10 and Figure 11 show examples of uniform soil profiles.

Figure 10 Profile of a uniform soil, with sandy textures down the profile

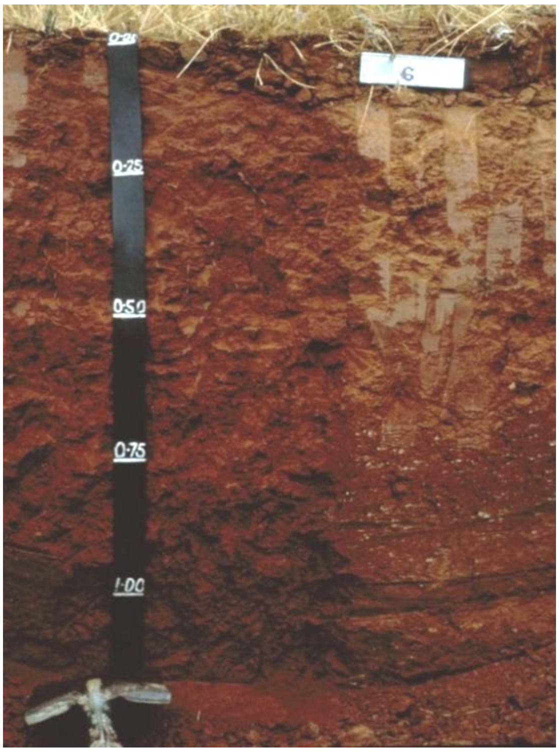


Figure 11 Profile of a uniform soil, with clayey textures down the profile

A **gradational soil** has a gradual increase in texture (becomes more clayey) down the soil profile. Typical examples are where the sandy surface soil **grades to** a loamy subsoil — sand to loamy sand to sandy loam — and where a loamy surface soil grades to a clayey subsoil. The term ‘grades to’ indicates that changes in texture occur over at least 10cm. Figure 12 and Figure 13 show examples of gradational soil profiles.

Figure 12 Profile of a gradational soil, with sandy loam topsoil grading to sandy light clay subsoil

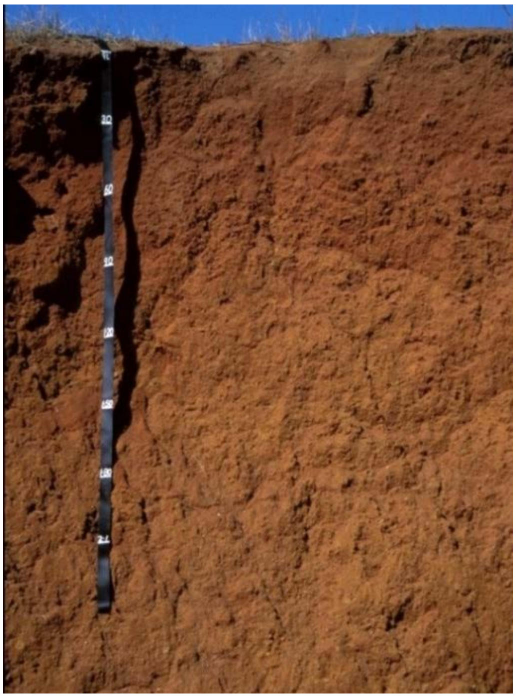


Figure 13 Profile of a gradational soil, with clayey sand topsoil grading to sandy clay loam subsoil

A **duplex soil** has a **texture contrast** where there is a significant increase in soil texture (becomes more clayey) over a short vertical distance — a sharp or abrupt increase in less than 5cm. A typical example of a duplex soil or layered soil is sand **over** clay, as in Figure 14 and Figure 15. The term 'over' indicates this rapid change in texture with depth, although sometimes, as in Figure 15, the change is harder to see.

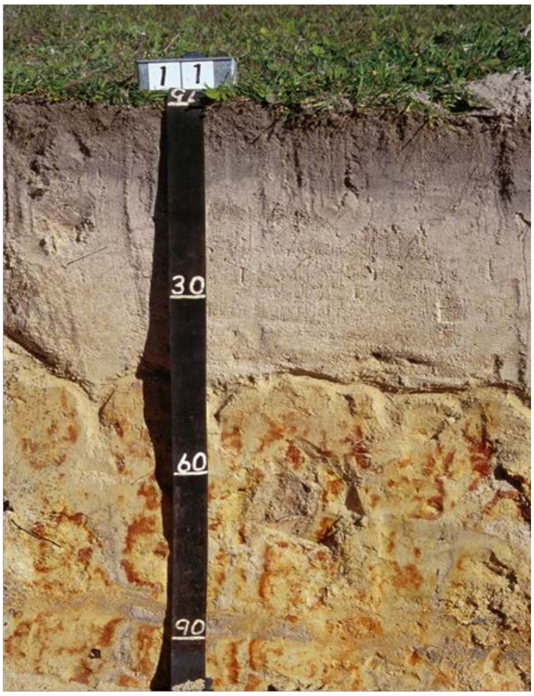


Figure 14 Profile of a duplex soil, with a sandy A horizon over a clayey B horizon at 45cm

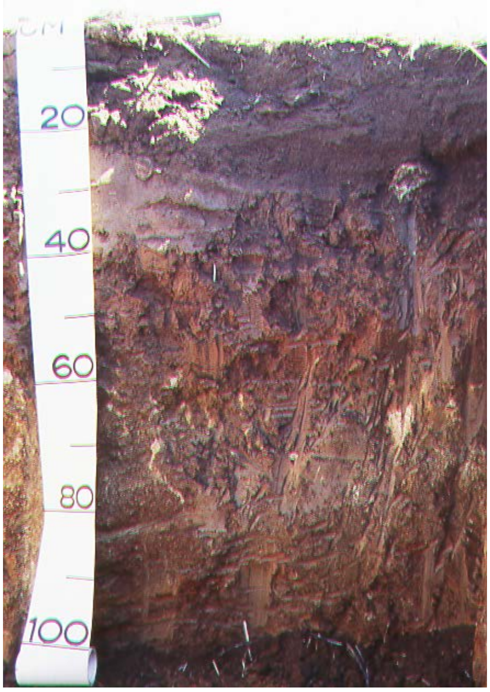


Figure 15 Profile of a duplex soil with a loamy A horizon over a clayey B horizon at 35cm

4 Coarse fragments

Coarse fragments in the soil are the particles bigger than 2mm and they are generally estimated by sieving the soil sample to separate them from the fine earth soil component (Figure 16). Coarse fragments may be gravels (2–20mm), coarse gravels (20–60mm), cobbles (60–200mm), stones (200–600mm) or even boulders (>600mm). Significant amounts of coarse fragments can affect soil properties, such as effective rooting volume and amount of plant available water in the profile.

Coarse fragments are normally recorded by type and abundance. In WA, the main types of coarse fragments are:

- ironstone gravels (code FE) ─ ferruginous hard concretions or nodules (Figure 17, Figure 18)
- calcareous gravels (code CA) ─ calcareous hard concretions or nodules (see Section 7 Calcareous layer/s)
- rock fragments (code RF)
- siliceous fragments (code SI) ─ siliceous hard segregations or quartz rock fragments.

Ironstone gravels are common in WA and calcareous gravels are very common in drier regions of WA. Both of these gravel types can have properties that contribute to plant nutrition and an increase in plant available water over what would be expected if the coarse fragments were inert and unreactive, as is assumed for quartz and crystalline rock fragments.

The **abundance** of coarse fragments is visually estimated in the field and recorded as a percentage of the soil volume ─ how much of the sieved sample is fine earth and how much is coarse fragments (Figure 16, Figure 17, Figure 18). Record the actual percentage of coarse fragments or use these common groupings (the bold letter shows the typical recording code):

- **N**one = nil
- **V**ery few = <2%
- **F**ew = 2–10%
- **C**ommon = 10–20%
- **M**any = 20–50%
- **A**bundant = 50–90%
- **T** very abundant = >90%.

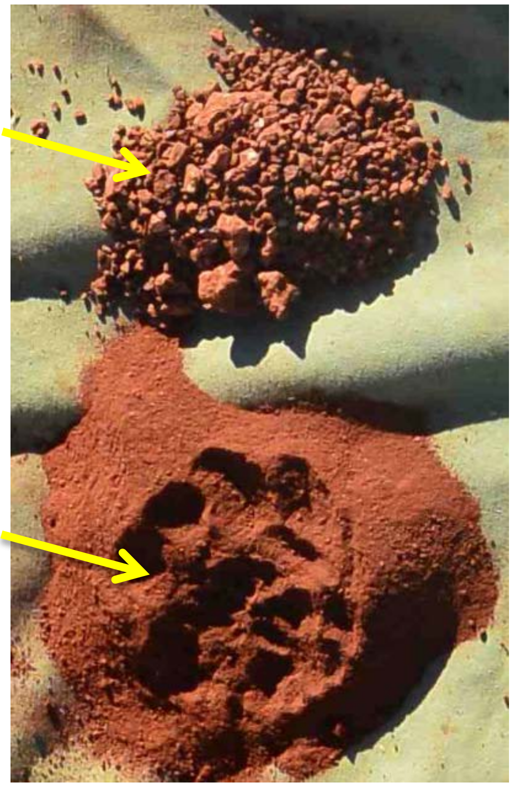


Figure 16 Example of a sieved soil sample showing coarse fragment (above) and fine earth (below) proportions

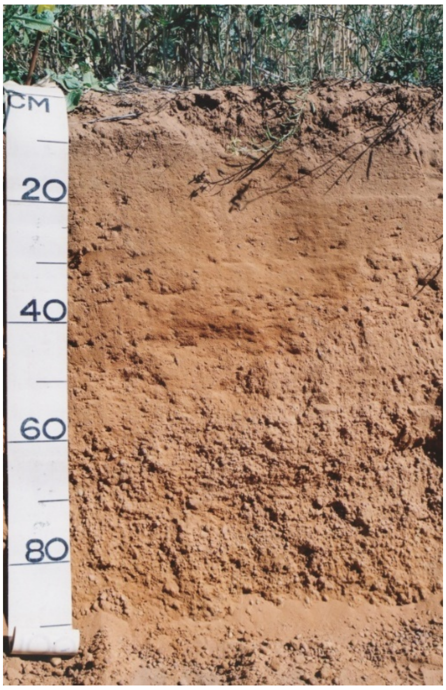


Figure 17 Profile of a brown deep sand with ironstone gravel coarse fragments; gravel estimate is few (or 5%) in the upper horizon (0–55cm) and many (or 40%) in the lower horizon (55–90cm)

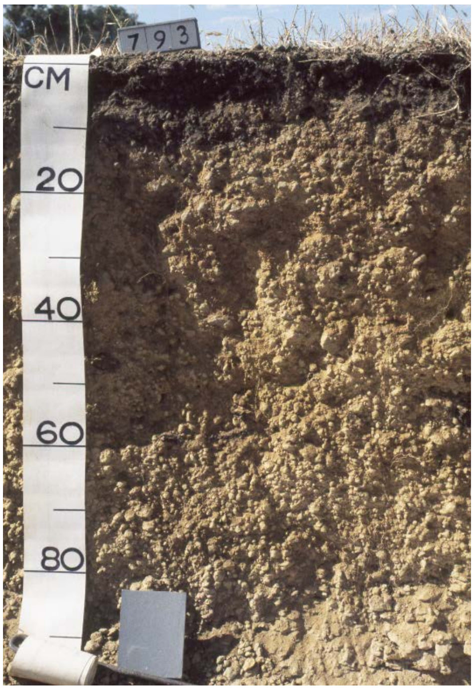


Figure 18 Profile of a deep sandy gravel, with abundant ironstone gravels throughout

5 Colour

Colour can help predict some important soil properties, such as drainage. It is described on moist soil before hand texturing because soil is a lighter colour when dry and moulding the soil may modify the colour, particularly if **mottles** are present.

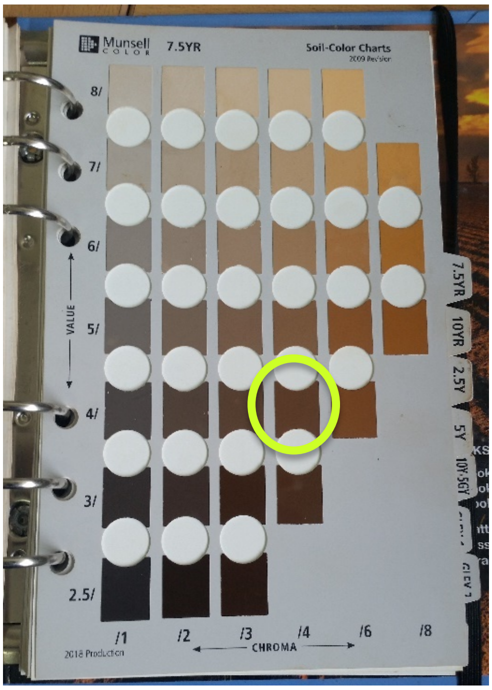


Figure 19 Colour range of hue 7.5YR in the Munsell soil colour chart

Soil colour is best described using the soil colour standard (a bit like a paint colour chart) known as the Munsell soil colour chart (Munsell Color Company 2000; Figure 19).

To determine the colour, hold a sample of unmoulded, moist soil against the colours in the chart to find the best match (shown circled on Figure 19).

Record the Munsell hue (the number and letters at the top of the Munsell colour page) that best matches your sample; in Figure 19 it is 7.5YR. Then the Munsell value, the vertical scale on the left of the chart, which in this case is 4. Then the Munsell chroma, the horizontal scale at the bottom of the chart, which in this case is 4. The colour is then recorded as 7.5YR 4/4.

If no Munsell colour chart is available, a general description using the five main soil colours — red, brown, yellow, grey (including white) and black — is acceptable. Figure 20 shows examples of these colours.

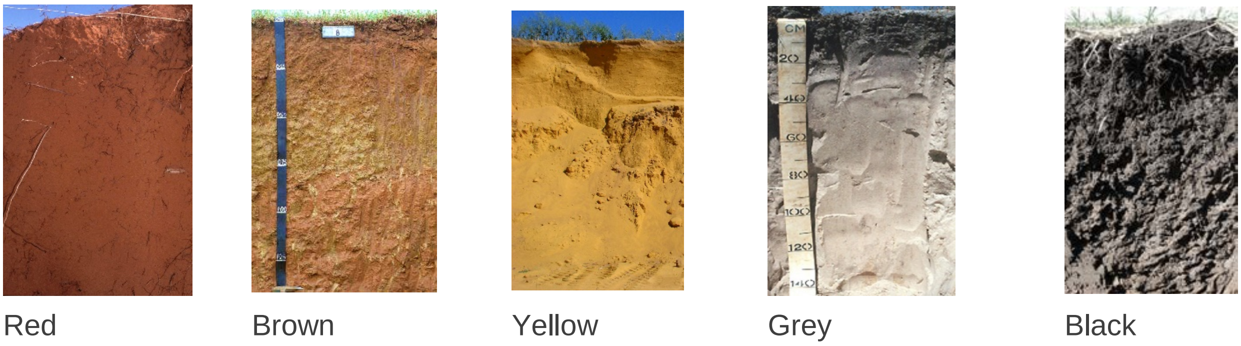
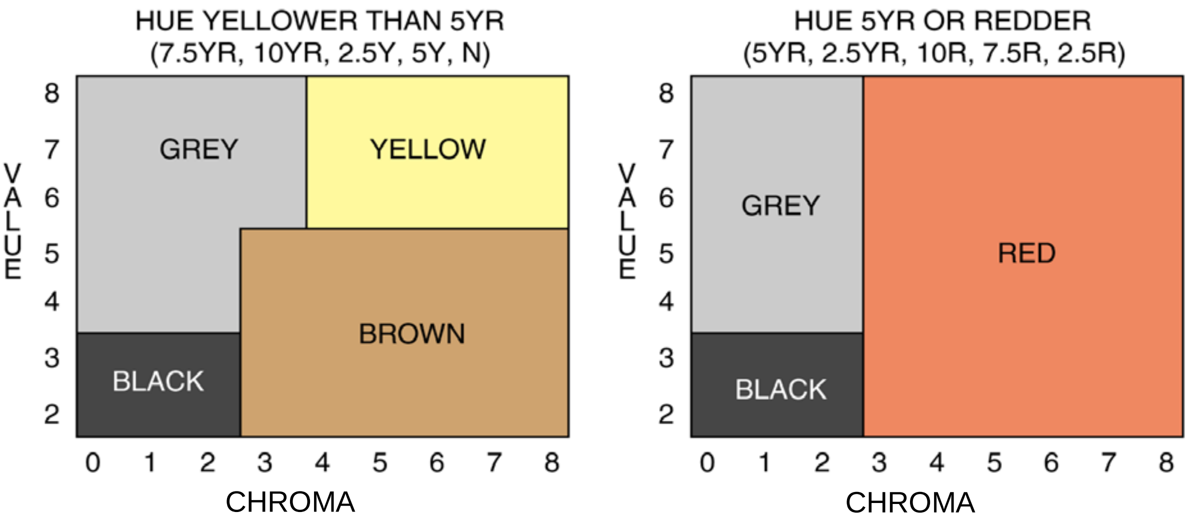


Figure 20 Five soil profiles showing the main colour groups

These main colours relate to the Munsell hue, value and chroma, as shown in Figure 21. The Munsell soil colour chart provides descriptions of colours using these classes and is the preferred method of summarising soil colour because it improves objectivity and consistency.



Source: *The Australian Soil Classification* (Isbell & the National Committee on Soil and Terrain 2016)

Figure 21 The Munsell hue, value and chroma

Occasionally, if soil has been exposed to long periods of wetness, it can be blueish or greenish in colour, known as gleying.

Other common colour descriptors for soils include:

- pale yellow
- yellow–brown
- grey–brown
- red–brown
- white (bleached layers)
- dark grey.

Some soil horizons have a mixture of colours, generally called mottles (see below). These can indicate soil characteristics, such as waterlogging.

Mottles

Mottles are spots, blotches or streaks of colours different to the main soil matrix. They are commonly seen in clayey subsoils, but may also occur along root lines in topsoils. Where mottles are obvious, they may indicate a very old soil feature or soil characteristics, such as waterlogging, and should be recorded as being present.

For simple soil profile descriptions, identify the dominant mottle colour — use the Munsell soil colour chart or just give a basic colour description. For example, you can describe the colour of a soil profile with mottles as yellow with red mottles (Figure 22), or grey with pale-yellow mottles (Figure 23). In detailed soil descriptions, mottles are recorded by size, colour and abundance.

In some soils, there may be many mottle colours and these should all be described if possible.

Figure 22 Example of a mottled clay subsoil, where the main soil colour is yellow, with a strong rust-red mottle

Figure 23 Example of a mottled clay subsoil, where the main soil colour is grey, with a pale-yellow mottle

6 Basic chemistry

Soil pH

pH is an important characteristic of soil chemistry because it affects the availability of plant nutrients and toxic elements.

Soil pH is a measure of how acidic or basic (alkaline) the soil solute (soil water) is, and is a function of the concentration of hydrogen ions (H^+) in the solution. It is expressed as a unit-less value on a logarithmic scale from 1 to 14: 7 is neutral — equivalent to pure water, with hydrogen ions exactly balanced by hydroxide ions — lower values are a rapid increase in acidity and higher values are a rapid increase in alkalinity. So, as acid concentration increases, the pH value decreases. For example, a pH value of 6 is 10 times more acidic than 7, and a value of 5 is 100 times more acidic than 7.

The pH of most soils in WA ranges between 4 and 9. Most plants like the soil solution to be near to neutral, although a pH range between 6 and 8 is usually fine.

In the field, pH is usually measured by one of two methods, which provide similar results:

- using a pH kit that uses a universal pH indicator solution which, when mixed with soil and sprinkled with a white powder (usually barium sulfate), will change colour depending on the amount of acid present (Figure 24). A pH colour chart is then used to interpret the pH value (Figure 25). Green in the top left of Figure 24 indicates neutral to mildly acid pH in the A horizon; purple colours indicate the rest of the layers in the soil profile are alkaline. This way of measuring pH provides results similar to pH measurements done in a water solution and so results are recorded as pH_w
- using a field pH meter that has been calibrated with one or several pH standard solutions to measure the pH of a mixture containing one part soil to five parts distilled water and recorded as pH_w.

Figure 24 pH of a soil profile using an indicator solution

Figure 25 pH colour chart to indicate the pH value

In the laboratory, soil pH is measured using more sophisticated equipment and is measured either in a solution of water (pH_w), or in a 0.01 molar calcium chloride solution (pH_{Ca}).

pH is often measured in calcium chloride solution in WA because it is a more reliable indicator of acid soils. The pH in calcium chloride is about 0.8 to 1 pH unit lower than the pH in water. Table 3 classifies the pH range into four classes relevant to soil, and defines the level of acidity or alkalinity as measured by each method.

Table 3 Comparative pH values in water or calcium chloride solution

Category	Value in pH_w	Value in pH_{Ca}
Strongly acid	<5.5	<4.5
Acid	5.5–6.5	4.5–5.5
Neutral	6.5–8.0	5.5–7.5
Alkaline	>8.0	>7.5

Soil salinity

Soil salinity refers to soils that have a high concentration of soluble salts in the profile. The common and highly soluble salt, sodium chloride (NaCl), is the main cause of salinity and many soils in WA contain large amounts, seriously affecting plant growth.

There are a several indicators of salt in the soil profile:

- there are patches or extensive areas of a grey to white, crystalline material on the soil surface
- there are indicator plants for the salinity status of the soil; for example, there are salt-tolerant plants such as sea barley grass, samphire and saltbush present, or salt-intolerant plants are entirely absent from the area, all of which indicate highly saline soils
- a saline watertable is within 2m of the soil surface; saline watertables within 2m can cause decline in plant growth, and within 1m can cause salt accumulation (white crystals) on the soil surface and the death of salt-sensitive plants (Figure 26).

Measuring the separate soil horizons with a pocket electrical conductivity (EC) meter is a common way to discover if the profile is salty. Mix together one part soil taken from a horizon with five parts distilled water — about 50g of soil in 250mL distilled water — in a suitable container; shake hard; then dip the probe into the solution. In WA, salinity is measured in millisiemens per metre (mS/m), and is recorded as EC1:5 mS/m. To convert to decisiemens (dS/m): 100mS/m = 1dS/m.

Figure 26 Sampling soil in a salt-affected area

Soil salinity varies with seasonal conditions as a result of leaching by winter rains and capillary rise of salts from shallow watertables over summer. Soil permeability and soil texture, as well as rainfall, influence the degree of leaching. Table 4 shows the approximate ratings of soil salinity (EC1:5 mS/m) for different soil textures. Because sand particles will not hold as much salt from the soil water as will clay, the same level of salt will more severely affect plants in lighter textured soils (sands) than heavier textured soils (clays).

Table 4 Ratings of soil salinity for different soil textures

Texture group	Soil salinity				
	Nil	Slight	Moderate	High	Extreme
Sand	0–15	15–25	25–50	50–100	>100
Loam	0–20	20–35	35–70	70–150	>150
Clay	0–25	25–50	50–100	100–200	>200

7 Calcareous layer/s (lime)

The presence of lime (calcium carbonate) in the soil profile has significant implications for efficacy of some chemicals applied to plants and soil, and has implications for laboratory testing of soil samples.

The lime particles can be variable, including obvious white or grey nodules and rock fragments, or finely divided and otherwise indistinguishable from the soil (Figure 27).

The presence of lime is detected by a visible effervescence (fizzing) when drops of weak hydrochloric acid (1 molar HCl) are applied to soil or coarse fragments. Create weak hydrochloric acid from one part spirit of salts to five parts water. Adhere to standard safety and chemical protocols and always add the spirit of salts to the water, not the other way around.

Record ‘nil’ (no audible or visible fizzing), ‘weak’ (audible and slightly visible fizzing), or ‘strong’ (strongly visible fizzing) for the fine earth, and ‘calcareous’ for a fizz on coarse fragments.

Figure 27 Calcium carbonate (lime) nodules in upper layers and masses in lower layers

8 Structure

Soil structure is a description of the nature of the aggregation of soil particles. It affects plant root growth, but can be hard to recognise and describe. It may take some time to understand its various arrangements. Soil particles may bond together into a featureless mass, into soil aggregates, or not bond at all (for example, loose sand).

Where aggregates are present, structure exists, and these are called **pedal** soils. **Peds** are aggregates that are separable from each other by lines of weakness. Peds may be less than 2mm to more than 500mm. Where aggregates are absent, the soils are called **apedal** or **massive** soils.

Soil structure for pedal soils is a complex area of soil description and is often not included in simple soil descriptions. The following categories are sufficient for simple soil description:

- **apedal** — no visible soil structure; recorded as ‘single grain’ (such as for sands) or ‘massive’
- **pedal** — soil structure (peds) are evident throughout the profile.

A detailed explanation for identifying structures and structural features of soil is presented in NCST (2009), pages 171–183. The full set of soil structure types is provided in ‘Code definitions for characterising Western Australian soils’ (Department of Primary Industries and Regional Development 2017).

9 Water regime

Whether a soil is waterlogged during the year — permanently, seasonally or occasionally — is a characteristic that can override other basic soil properties. Waterlogging affects soil productivity by limiting gas exchange to roots, and can severely curtail production of crop, pasture and tree species, complicate farm management, and contribute to on-site and off-site degradation.

Such soils generally occur where the groundwater is always near the surface, or where a rock or hardpan layer or the upper surface of the clay horizon in a duplex soil impedes drainage. A wet surface horizon can suggest one of these situations.

It is often difficult to tell whether a soil is waterlogged when examining the soil during a dry time. There are usually other indicators that give clues, including:

- landscape position, such as in a depression or floodplain
- vegetation that prefers wet conditions, such as samphire, melaleucas and reeds (Figure 28)
- colour, including mottling, or grey, olive or blue colours (gleying) through the soil (Figure 29).

It is a useful soil property if known, but it can be difficult to determine.

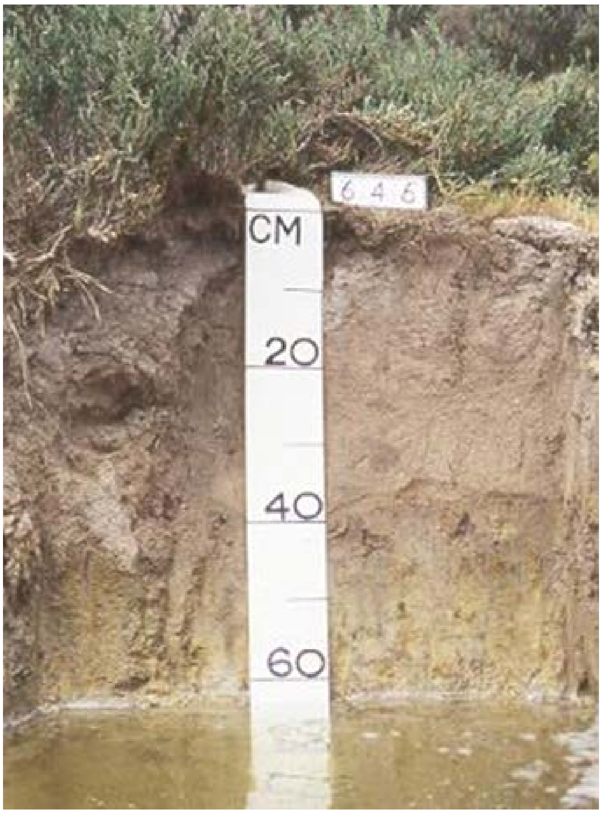


Figure 28 A salt-affected duplex soil, with salt- and waterlogging-tolerant samphire vegetation at the surface

Figure 29 A duplex soil with typical colouring from regular waterlogging

Other important soil-related properties

Soil sodicity

Soil sodicity refers to the presence of high levels of exchangeable sodium in a soil. In Australia, soils are called **sodic** if they have an exchangeable sodium percentage (ESP) of 6 to 15, and **highly sodic** if more than 15.

Soil ESP can only be determined by laboratory analysis (it is a measure of cation exchange capacity), but field indicators of sodicity are a domed clay subsoil with a bleached sandy A horizon just above the clay layer, and a hard clay subsoil with a 'soapy' feel when hand texturing.

High levels of exchangeable sodium are usually restricted to soil layers with high levels of clay particles. In WA, most sodicity problems occur in the clayey subsoils of duplex (texture contrast) soils.

The main effect of soil sodicity is the dispersion of clay and blockage of water movement through soil pores, leading to poor soil structure and drainage. If a sodic subsoil layer is brought to the soil surface by cultivation, the clay within larger clods can become dispersed into individual particles by rain. As the water evaporates and permeates through the soil, the individual clay particles merge (or flocculate) at the soil surface, causing crusting and hardsetting, which can affect plant germination and emergence.

Soil sodicity and alkalinity are usually linked. In addition, soils which become saline through secondary salinity often become sodic over time.

More information on this issue is available in 'Soilguide' (Moore 2001) and on the dispersive (sodic) soils page on the DPIRD website.

Soil surface condition

Many soil surfaces have a characteristic appearance when dry. These conditions should be recorded because sometimes they affect land use. The main forms of surface condition are:

- **cracking** — there are cracks at least 5mm wide when the soil is dry; usually associated with clayey surfaced soils
- **self-mulching** — the soil surface forms many small loose peds on drying; usually associated with clayey surfaced soils
- **loose** — the soil particles are separate; for example, sand
- **hardsetting** — the surface becomes compact and hard on drying.

Water repellence

Water repellence of some surface soils, especially sands, is common in WA. Water repellence is caused by the coating of soil particles with hydrophobic (water repelling) organic materials, such as waxes (Figure 30).

Figure 30 A water droplet on water repellent sand

The presence of water repellent surface soil can be identified by gently placing a drop of water on the dry soil surface with a squeeze bottle or eye dropper. If the soil is repellent, the droplet will form a bead and sit on the soil surface or only penetrate the soil slowly. The degree of water repellence is accurately tested by using water–ethanol solutions of varying concentration. However, for simple soil descriptions, recording the presence or absence of water repellence is adequate.

Other important land-related properties

Landform

When describing soil, it is very helpful to understand what type of landform the soil is part of. This contributes to understanding how the soil was formed, how the soil can be used and what possible land management issues the soil and landscape in that location might have for the landholder. For example, a sandy earth soil on top of a hill might be very productive, but because of the position in the landscape, it will be very vulnerable to wind erosion. If the same soil is in on a valley flat, the risk of erosion from wind is reduced, but it may have a risk of waterlogging or if it is near a river, it may have a risk of flooding.

It is ideal to make a note of the landform for about a 20m radius around the site where the soil is described. As a starting point, there are some simple terms you can use to broadly define the landform. Landform elements include:

- crest — the top of a mountain or hill
- hillock — narrow crest and short adjoining slopes that are not very wide; small hill
- ridge — narrow crest and short adjoining slopes, the crest length being greater than the width of the landform element
- slope — neither a crest nor depression and has an inclination greater than about 1%
- simple slope — slope below a crest or flat, and above a depression or flat
- upper slope — slope below a crest or flat; the top section of a slope or inclination
- mid-slope — slope not near a crest or flat or depression, but a slope in the middle of an inclination
- lower slope — slope above a depression or flat; the bottom of a slope or inclination
- flat — a level or very gently inclined land
- depression — a landform sunken or depressed below the surrounding area
- open depression (vale) — landform that extends at the same elevation, or lower, beyond the locality where it is observed, such as a valley
- closed depression — landform that is sunken or depressed below the surrounding area, such as a swamp or lake area; a closed depression does not extend from where it is observed.

For more detail about landform descriptions and definitions, see the *Australian soil and land survey field handbook* (NCST 2009).

Soil types and classification

Formal and informal soil classifications allow us to group soils with similar properties and characteristics. This helps with general conversations about soils so that we can transfer knowledge and information relevant to agriculture and the environment on similar soils that occur in different locations. It also allows us to correlate different formal soil classifications, which is useful for research at higher levels.

If you have worked through the steps outlined in this guide, you will have enough basic knowledge of a soil profile to be able to place it in a group with similar soils.

The properties, depths and arrangement of the layers you have described are used to assign the soil profile to a broad **soil surface** type classification (Level 1) or a general **whole soil profile** type classification (Level 2). One of the most important features in the classification is the texture criterion of how quickly texture changes occur between layers down the profile: uniform = no change; gradational = gradual change; or duplex = rapid change.

Further levels of soil classification are possible using texts specifically written on soil classification. The common references for soil classification in WA are:

- 'Soil groups of Western Australia' (Schoknecht & Pathan 2013): a guide to the main soils of WA which uses similar terminology to this guide, but provides more detail
- *The Australian Soil Classification* (Isbell & the National Committee on Soil and Terrain 2016): the Australian standard for the technical classification of soils (a new edition of this standard is currently being finalised).

Refer to the section on resources related to this guide for more information on other helpful texts.

Levels of soil classification

This guide outlines the classification of soils to two levels:

- Level 1 is based on soil surface properties only, and at best gives a very general idea of the properties. Soils cannot be adequately described unless the deeper features of the soil are examined in a cutting or by digging a hole.
- Level 2 is based on a general examination of the whole soil profile, enabling soils to be assigned to **soil supergroups**.

Keys to simple soil classification (soil generic groups)

Level 1: Broad soil types based on surface observation only

Soil surface dominated by stones or rocks → Rocky or stony surfaced soils

Soil surface dominated by ironstone gravel → Ironstone gravelly surfaced soils

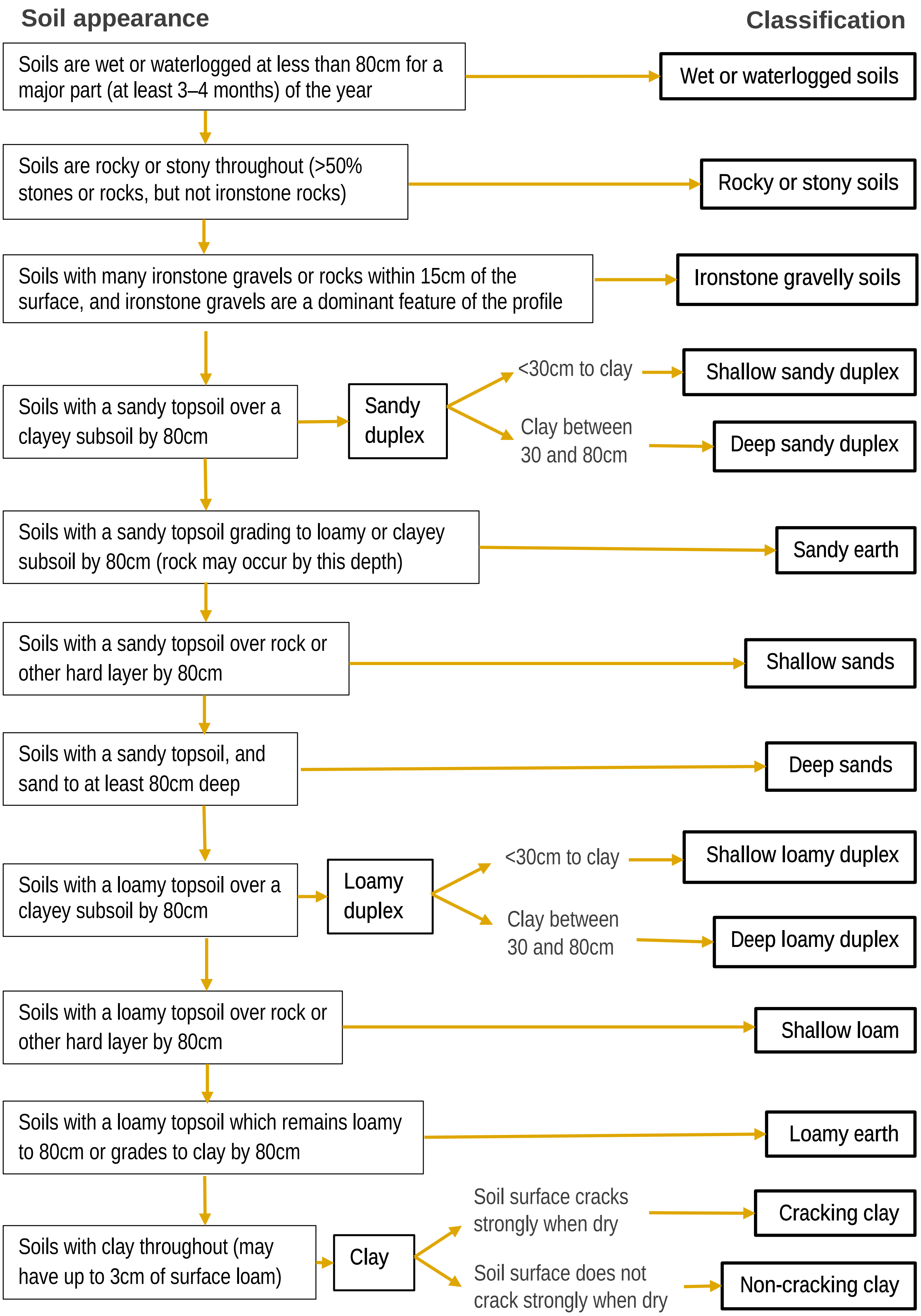
Soil surface is sandy → Sandy surfaced soils

Soil surface is loamy → Loamy surfaced soils

Soil surface is clayey → Clayey surfaced soils

Level 2: Soil supergroups based on key profile characteristics to 80cm

For an expanded classification beyond soil supergroups, refer to 'Soil groups of Western Australia' (Schoknecht & Pathan 2013).



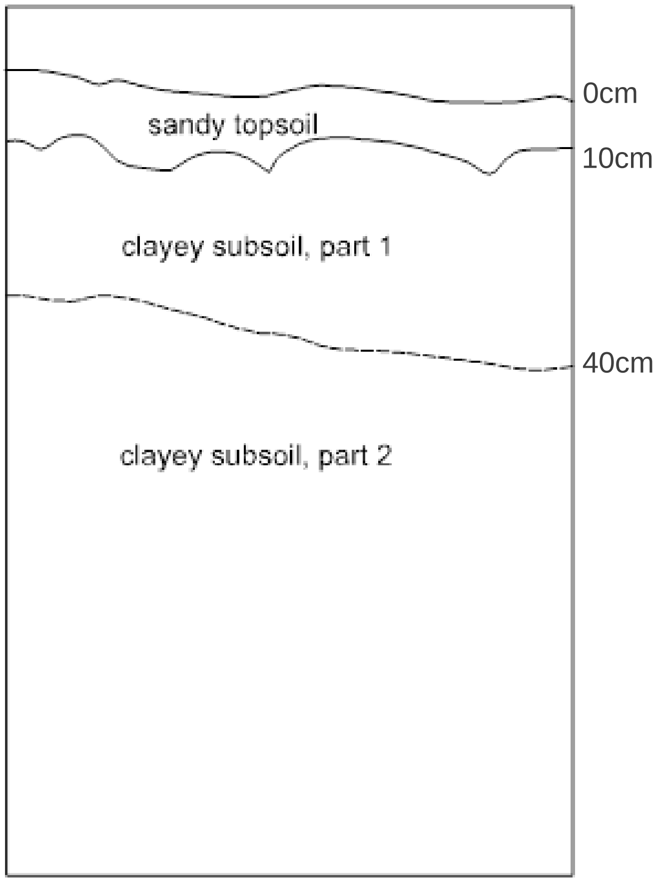
Examples of simple soil classification

Example 1

Location notes: gentle slope; Katanning

Key soil characteristics

- sandy topsoil less than 30cm thick
- abrupt change to a clayey subsoil; in the profile pictured, the subsoil is sodic (high in sodium) — at least in the upper part, as indicated by the domed top to the subsoil clay — and alkaline



WA Soil Supergroup classification

- sandy topsoil over a clayey subsoil by 80cm = **Sandy duplex**
- with less than 30cm of sand over clay = **Shallow sandy duplex**

WA Soil Group classification

Soil profile characteristics that would allow further definition of this soil within the WA Soil Groups (Schoknecht & Pathan 2013):

- grey-coloured topsoil
- alkaline (calcareous) subsoil.

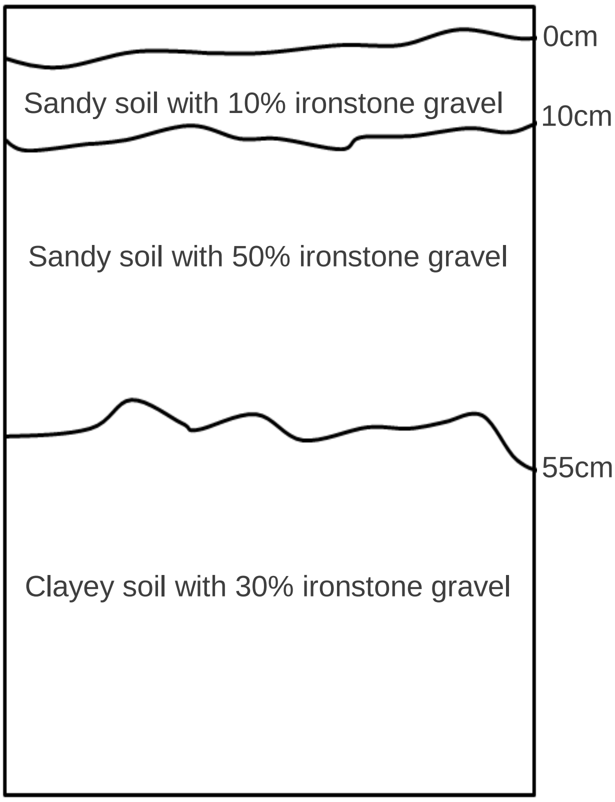
Using this extra information, this profile would be classified as **Alkaline grey shallow sandy duplex** (WA Soil Group 402).

Example 2

Location notes: hill slope; Kojonup

Key soil characteristics

- ironstone gravel layer in the top 15cm
- ironstone gravel a key feature of the profile



WA Soil Supergroup classification

- soil has many ironstone gravels or rocks within 15cm of the surface, and ironstone gravels are a dominant feature of the profile = **Ironstone gravelly soil**

WA Soil Group classification

Soil profile characteristics that would allow further definition of this soil within the WA Soil Groups (Schoknecht & Pathan 2013):

- abrupt change to a clayey subsoil at 55cm.

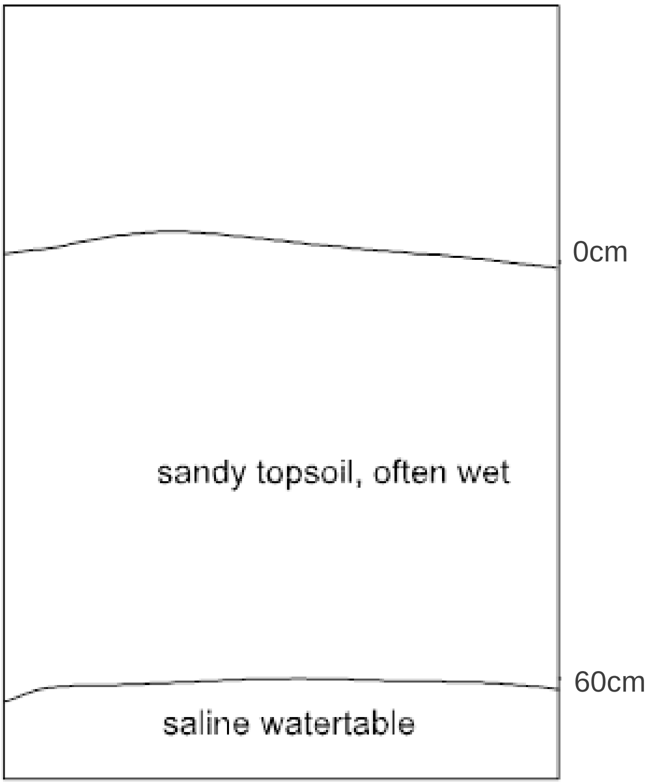
Using this extra information, this profile would be classified as **Duplex sandy gravel** (WA Soil Group 302).

Example 3

Location notes: valley floor; Nyabing

Key soil characteristics

- soil is wet within 80cm for at least 3–4 months



WA Soil Supergroup classification

- soil is wet or waterlogged within 80cm for at least 3–4 months of the year = **Wet or waterlogged soil**

WA Soil Group classification

Soil profile characteristics that would allow further definition of this soil within the WA Soil Groups (Schoknecht & Pathan 2013):

- saline watertable; the salt-tolerant vegetation indicates the water is likely to be salty.

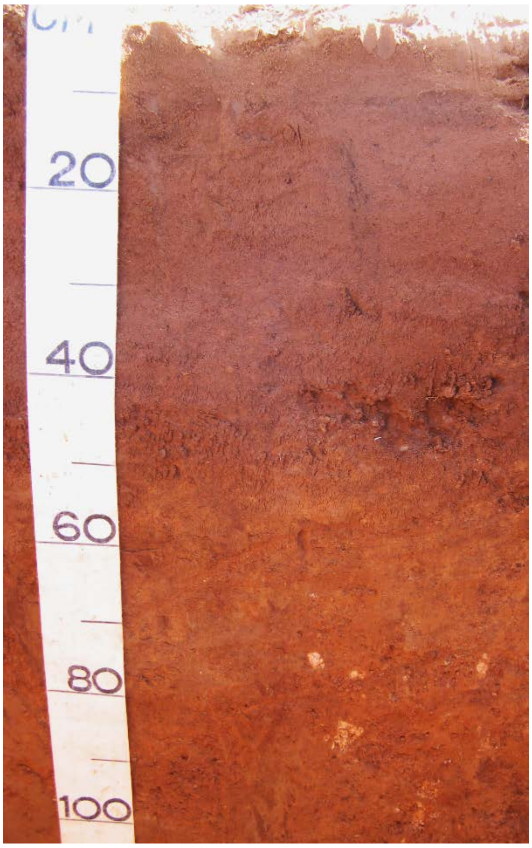
Using this extra information, this profile would be classified as **Saline wet soil** (WA Soil Group 101).

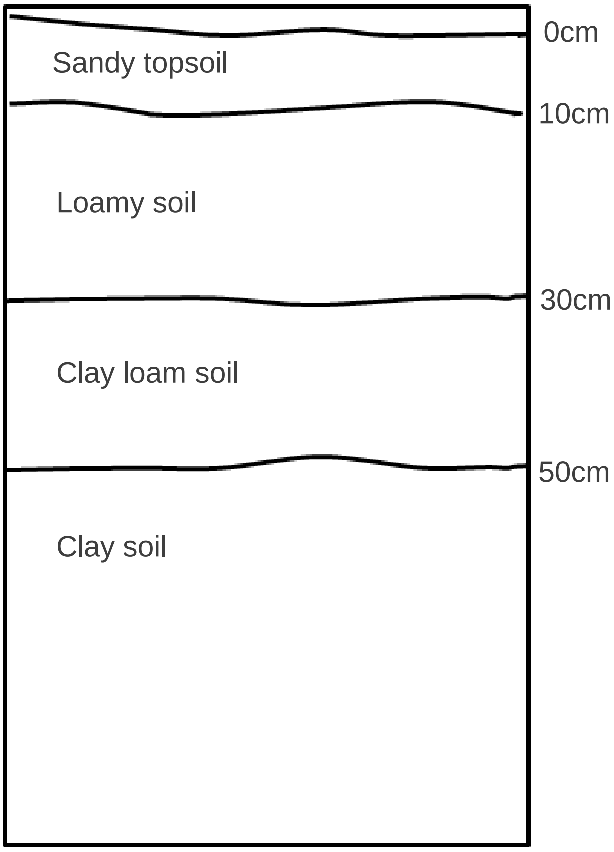
Example 4

Location notes: plain; East Binnu

Key soil characteristics

- soil has a sandy surface
- soil texture grades to clay by 50cm





WA Soil Supergroup classification

- soil has a sandy topsoil grading to loamy or clayey subsoil by 80cm = **Sandy earth**

WA Soil Group classification

Soil profile characteristics that would allow further definition of this soil within the WA Soil Groups (Schoknecht & Pathan 2013):

- red colour throughout profile.

Using this extra information, this profile would be classified as **Red sandy earth** (WA Soil Group 463).

Glossary

Auger: a tool, sometimes resembling a large corkscrew, used for making holes in the ground and extracting soil material.

Bolus: the ball of soil formed by manipulating the moist soil by hand.

Boulder: particle size greater than 600mm.

Clay: a stiff, sticky fine-grained earth that can be moulded when wet, and is dried and baked to make bricks, pottery and ceramics; soil composed chiefly of this material has particles smaller than 0.002mm.

Coarse fragment: soil particle larger than 2mm.

Coarse gravel: soil particle size is 20–60mm.

Cobble: soil particle size is 60–200mm.

Coherence: the soil bolus holds together and does not collapse readily.

Duplex soil: soil with a texture contrast where there is an abrupt increase in soil texture (becomes more clayey) over a short (less than 5cm) vertical distance.

Field texture: soil texture determined in the field using the characteristics of a hand-kneaded, moist bolus of soil. Field texture estimations of particle size may differ from laboratory estimations of particle size, but field texture should not be discounted as it is a useful measure in its own right because it provides a guide to soil behaviour.

Fine earth: soil particles smaller than 2mm.

Gley/gleying: soil that has developed grey, bluish or grey–green colours because of permanent or severe intermittent waterlogging.

Gradational soil: soil with a gradual increase in soil texture (becomes more clayey) down the soil profile.

Grades to: the gradual change in texture over at least 10cm.

Gravel: soil particle size is 2–20mm.

Hardpan: a hardened or cemented soil horizon, occurring in, or below, the soil and may impair drainage and plant growth.

HCl: weak hydrochloric acid (1 molar HCl) solution used to test for presence of lime — the fizz test.

Horizon: layer based on change in soil colour, texture, coarse fragments and other soil qualities; typically used to subdivide and describe the soil profile.

Landform: a description of the shape of the land around the area where a soil is described.

Mottles: spots, blotches or streaks of colours different to the main soil colour.

Parent material: the underlying geological material in which soil horizons form; soils typically inherit a great deal of structure and minerals from their parent material.

pH: a figure expressing the acidity or alkalinity of a solution on a logarithmic scale from 1 to 14, where 7 is neutral, lower values (1–6) are more acidic and higher values (8–14) are more alkaline.

Plasticity: a property with various degrees; plastic soils (or soils with high plasticity) can be deformed and holds its new shape strongly; typical of clays.

Rock: the solid mineral material forming part of the surface of the earth; exposed on the surface or underlying the soil.

Sand: a loose granular substance typically formed from the erosion of siliceous and other rocks and contributing a major component of beaches, riverbeds, the seabed and deserts; soil particle size is 0.02 to 2mm.

Shearing (relates to soil texture): sliding the thumb across the soil to press out a ribbon.

Silt: sedimentary material consisting of grains or particles of disintegrated rock, smaller than sand and larger than clay; soil particle size is 0.002 to 0.02mm. When texturing the soil, silt particles are fine and feel silky.

Soil profile: total depth of soil described.

Stone: soil particle size is 200–600mm.

Subsoil: the layer of soil beneath the topsoil, generally below 10cm, and usually lower in organic matter and generally higher in clay content than the topsoil.

Texture contrast soil: see duplex soil

Texture grade: a more-detailed grouping of texture groups; for example, loamy sand.

Texture group: soil groups divided by their particle size; three main texture groups are sand, loam and clay.

Topsoil: surface layer of soil that is usually higher in organic matter and lower in clay content than the subsoil.

Uniform soil: soil with no change in soil texture group down the soil profile.

Resources related to this guide

Soil classification

Isbell, R and the National Committee on Soil and Terrain 2016, *The Australian Soil Classification* 2nd edn, Australian soil and land survey handbooks, CSIRO Publishing, Melbourne.

Schoknecht, N & Pathan, S 2013, 'Soil groups of Western Australia: a simple guide to the main soils of Western Australia', 4th edn, *Resource management technical report 380*, Department of Agriculture and Food, Western Australia, Perth.

Field handbooks for describing soils

McKenzie, NJ, Coughlan, K & Cresswell, H 2002, *Soil physical measurement and interpretation for land evaluation*, CSIRO Publishing, Melbourne

McKenzie, NJ, Grundy, MJ, Webster, R & Ringrose-Voase, AJ 2008, *Guidelines for surveying soil and land resources*, 2nd edn, CSIRO Publishing, Melbourne.

Munsell Color Company 2000, *Munsell soil color chart*, Munsell Color Company Inc., Baltimore, USA.

National Committee on Soil and Terrain (NCST) 2009, *Australian soil and land survey field handbook,* 3rd edn, Australian soil and land survey handbooks series, CSIRO Publishing, Melbourne.

Other resources

Australian Soil Resource Information System, www.asris.csiro.au.

Department of Primary Industries and Regional Development 2017, 'Code definitions for characterising Western Australian soils'*, Resource management technical report 403*, Department of Primary Industries and Regional Development, Perth.

Department of Primary Industries and Regional Development website, www.agric.wa.gov.au:

- Estimating soil texture by hand
- Managing soils — sodicity, acidity, compaction, salinity, waterlogging, water repellence and managing difficult soils
- NRInfo (natural resource information) — digital mapping and information for natural resources across WA
- Soil classification in Western Australia.

Hunt, N & Gilkes, B 1992, *Farm monitoring handbook: a practical down-to-earth manual for farmers and other land users*, Land Management Society and National Dryland Salinity Program, University of Western Australia, Perth:

- Chapter 3 Soil structure and drainage.

Moore, G (ed.) 2001, 'Soilguide: a handbook for understanding and managing agricultural soils', *Bulletin 4343*, Department of Agriculture, Western Australia, Perth.

Newman, H 2012, *Determining soil texture types*, Farmnote 508, Department of Agriculture and Food, Western Australia, Perth.

Rayment, GE & Lyons, DJ 2010, *Soil chemical methods – Australasia*, CSIRO Publishing, Melbourne.

Soil quality ebooks (currently only available on Apple platforms):

- 1 Constraints to plant production
- 2 Integrated soil management
- 3 Soil organic matter
- 4 Soil acidity
- Future topics include soil biology, soil compaction, soil water repellence, sodic and alkaline soils, nutrient management and gravel soil.

van Gool, D, Stuart-Street, A & Tille, P 2018, 'Distribution of classified soils in south-west Western Australia', *Resource management technical report 401*, Department of Primary Industries and Regional Development, Perth.

Contact

If you have any questions or comments, please email Soil.Data@dpird.wa.gov.au.

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Brief soil description card (site card)

Where appropriate, use codes (over page) to save space on this site card.

Project code:	Site number:	Date (ddmmyyyy):	Described by:
Location: GDA94 / GDA2020 Zone: Easting: Northing:	Geology of parent material:	Landform element: (*circle one*) crest; ridge, hillock; slope – simple, upper, mid or lower; flat; depression – open or closed,	
	Surface condition: (*circle one*) cracking; self-mulching; loose; hardsetting; other	Site/location notes: e.g. vegetation, landform	
	Surface water repellence: Yes / No		
Soil classification			

Layer	Layer name	Layer depth		Texture (Texture group or grade)	Boundary distinctness	Soil water status	Coarse fragments			Colour (Munsell, moist)	Mottles Colour, abundance, size, contrast	pH_w (1:5)	EC (1:5)	Calcareous	Structure	Layer notes e.g. mottles, rock, saline, major horizon depths
		Upper (cm)	Lower (cm)				Abundance (%)	Size	Type							
1																
2																
3																
4																

Please send your site cards or data to Soil.Data@dpird.wa.gov.au for possible addition to the WA profiles dataset to help refine state data collections.

Codes for site card

Property	Code and definition
Layer names	A topsoil, B subsoil, C weathered rock, R rock*
Depth	*Centimetre measures are standard; soil surface is 0cm.*
Texture group or texture grade	S sand, LS loamy sand, CS clayey sand, SL sandy loam, L loam, SCL sandy clay loam, CL clay loam, LC light clay, MC medium clay
Boundary distinctness (Texture change)	A <5cm abrupt, G >5cm gradual (grades to), D >10cm no change in texture with depth
Soil water status	*Leave blank if unknown.* W wet, D dry, M moist, T moderately moist
Coarse fragments, abundance	*Use actual percentage or these codes:* N nil, V very few <2%,F few 2–10%, C common 10–20%, M many 20–50%, A abundant 50–90%, T very abundant >90%
Coarse fragments, size	1 fine gravel 2–6mm; 2 gravel 6–20mm; 3 coarse gravel 20–60mm, 4 cobbles 60–200mm, 5 stones 200–600mm, 6 boulders >600mm
Coarse fragments, type	FE ironstone, CA calcareous, SI siliceous, RF rock fragments
Colour	*Use Munsell colours on moist soil* (e.g. 7.5YR4/2) *or use these codes, singly or combined:* R red, O orange, Y yellow, BR brown, BL black, G grey, D dark, L gley, P pale
Mottles, abundance	*Use estimated percentage or these codes:* N nil, V very few <2%, F few 2–10%, C common 10–20%, M many 20–50%
Mottles, size	F fine <5mm, M medium 5–15mm, C coarse 15–30mm, L very coarse >30mm
Mottles, contrast	F faint, D distinct, P prominent
Mottles, colour	*Use Munsell colour charts or codes for soil colour above.*
pH method and value	*Circle one method and record pH in each layer.* PR indicator solution, W5 water 1:5 (soil:water), W1 water 1:1, C1 calcium chloride 1:1, C5 calcium chloride 1:5
EC1:5 (soil salinity)	*Record EC in each layer as millisiemens per metre EC1:5 mS/m.*
Calcareous (HCl fizz test on fine earth or coarse fragments)	*Leave blank if unknown*. N non-calcareous or nil (no audible or visible fizzing), M moderate or weak (audible and slightly visible fizzing), H highly or 'strong' (strong visible fizzing).
Structure	A apedal (no observable peds; either 'single grain' or 'massive') P pedal (peds observed)
Layer notes	*e.g. rock, hard layer, roots*

* More examples are in 'Code definitions for characterising Western Australian soils' (Department of Primary Industries and Regional Development 2017).