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A simple guide for describing soils, 2nd edition

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Primary Industries and
Regional Development

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A simple guide for describing soils

Second edition

Acknowledgement of Country

The Department of Primary Industries and Regional Development (DPIRD) acknowledges the Traditional Custodians of Country, the Aboriginal peoples of the many lands that we work on and their language groups throughout Western Australia and recognises their continuing connection to the land and waters. DPIRD respects the continuing culture of Aboriginal peoples and the contribution they make to the life of our regions, and we pay our respects to Elders past, present and emerging.

A simple guide for describing soils

Second edition

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Cover: Angela Stuart-Street describing soil morphology to DPIRD research scientists (photo: G Stainer)

Recommended reference

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Preface

This second edition updates key information resulting from new editions of the *Australian Soil Classification*, the *Australian soil and land survey field handbook* and the *Western Australian soil groups: a diagnostic key to identify soils in Western Australia*. It includes revised visual aids to classification using a simplified key based on soil supergroups and the WA soil groups, new diagrams that explain the exemplar soil types, and an updated glossary to match the references this guide relies on for technical information.

This edition was initiated following a request from SoilsWest staff at Murdoch University. The revisions were primarily conducted and coordinated by Paul Galloway and edited by Angela Rogerson. Daniel Bussell produced the three-dimensional block diagrams that illustrate the main soil features and serve as examples in the classification section. Alice Ohlsen and Daniel Bussell assisted with updates to criteria used for classifying WA soil groups. Dennis van Gool contributed expertise to discussions on the development of the simple key diagram used to broadly classify the soils of the south-west land division for dryland agriculture.

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 provides 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. While this guide is designed to link with a simple classification system already in use for Western Australia – Western Australian soil groups – the soil description standards used here meet Australian standards and can be used to classify the soil according to other classification systems.

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 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*, fourth edition, also called the 'yellow book' (NCST 2024)
- *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 and Lyons 2010)
- *Soil physical measurement and interpretation for land evaluation*, also called the 'brown book' (McKenzie et al. 2002)
- *The Australian Soil Classification*, third edition (Isbell and National Committee on Soil and Terrain 2021).

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 abbreviations. These codes and abbreviations are mainly for field recording to save space on the site card. Many bold terms are defined in the glossary.

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 chickpeas, 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 (Figures 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 required.

The 9 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. presence, type and abundance of 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 80 cm and 150 cm 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, soil with a **shallow** sandy horizon (with upper depth from ground level to about 15 cm deep) over a clayey horizon will perform differently to soil with a **deep** sandy horizon (ground level to about 50 cm 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, 2 to 4 horizons are usually adequate.

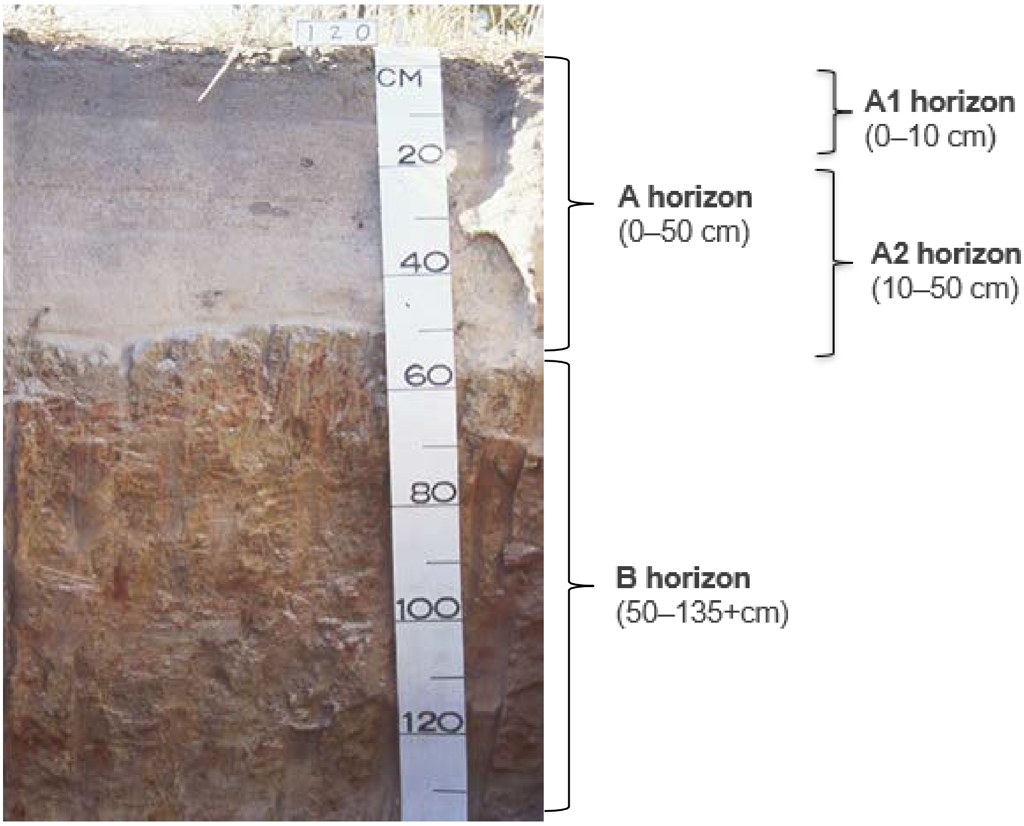


Figure 5 Soil profile showing an abrupt boundary at 50 cm between the sandy A horizon and clayey B horizon. The A horizon could be subdivided into an A1 horizon (topsoil with some organic staining) and an A2 horizon (bleached)

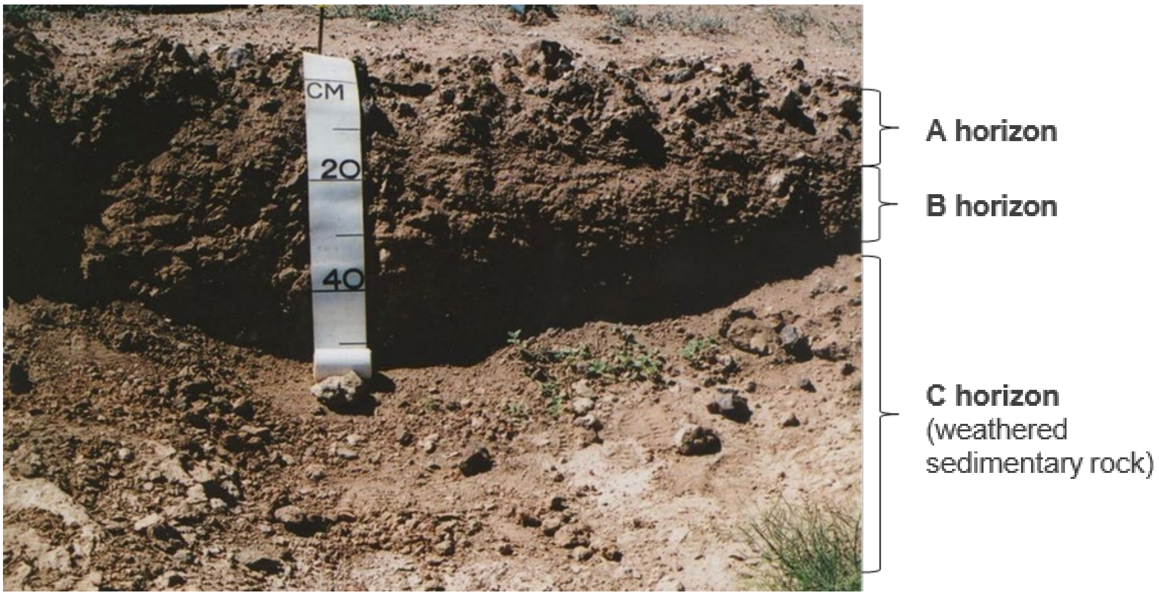


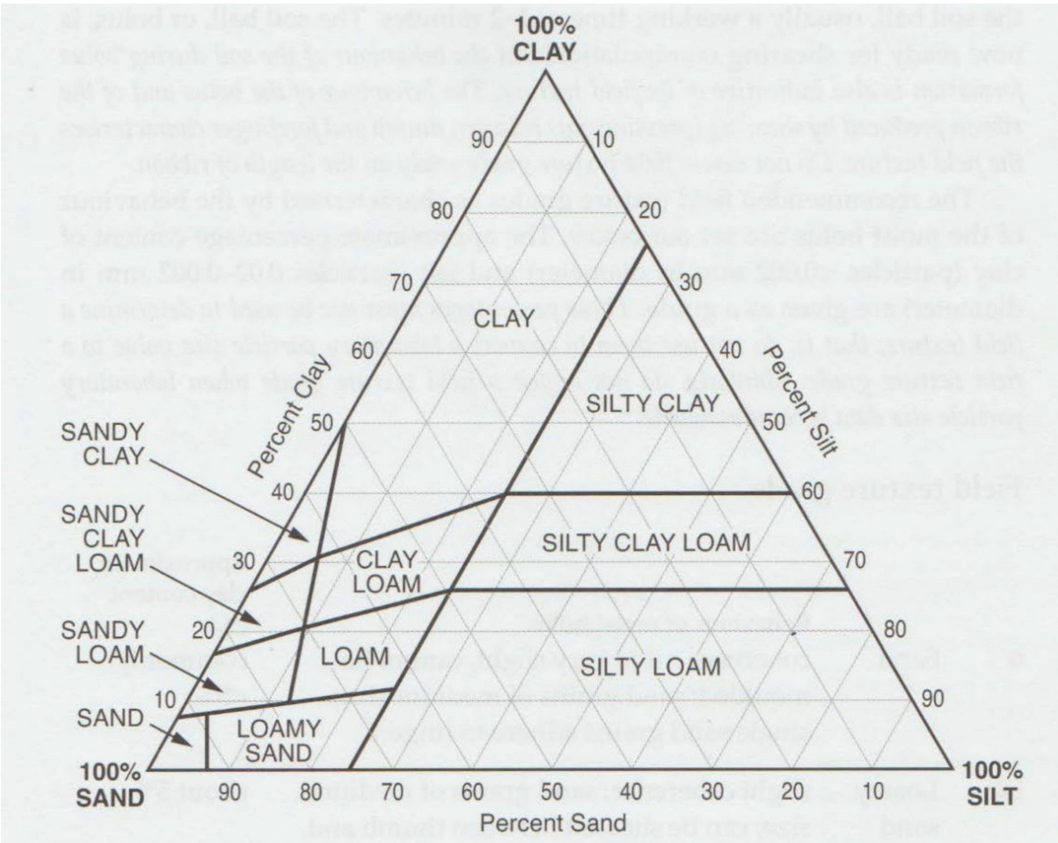
Figure 6 Soil profile showing a shallow loamy soil over weathered rock parent material

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 are important factors 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: NCST (2024)

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).

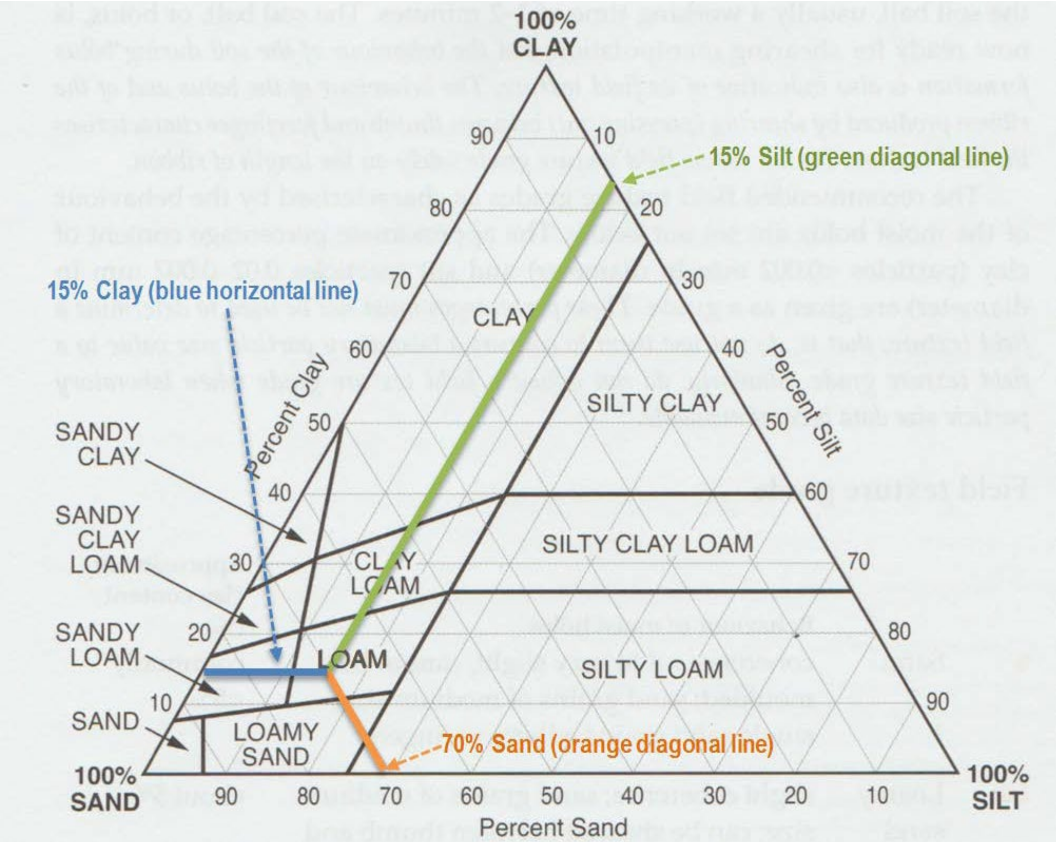


Figure 8 A worked example determining a soil texture grade (loam) from laboratory-measured particle size data showing 70% sand, 15% silt and 15% clay

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 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 2 mm are **coarse fragments** (gravels and stones) and all the particles 2 mm 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 3 main size groups:

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

- clay particles are less than 0.002 mm 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 3 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 3 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 (NCST 2024).

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 identify its texture.

Before you start

It is a good idea to sieve your soil using a 2 mm 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.

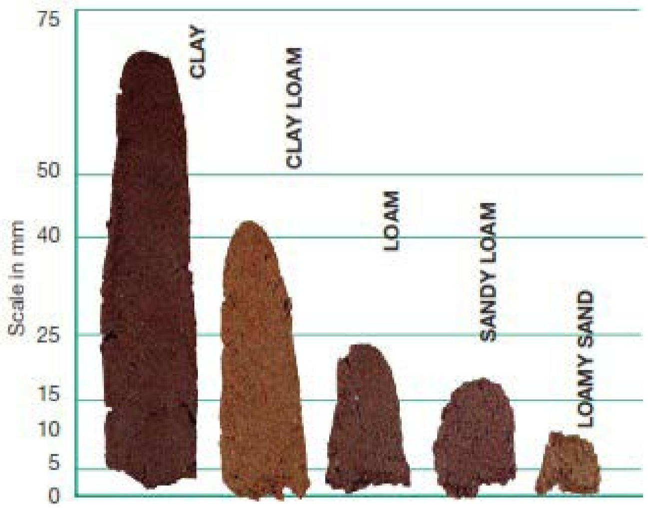
Hand texturing

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 2–3 mm 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 and 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 are medium sized; 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	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 3 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 (Figures 10 and 11).

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

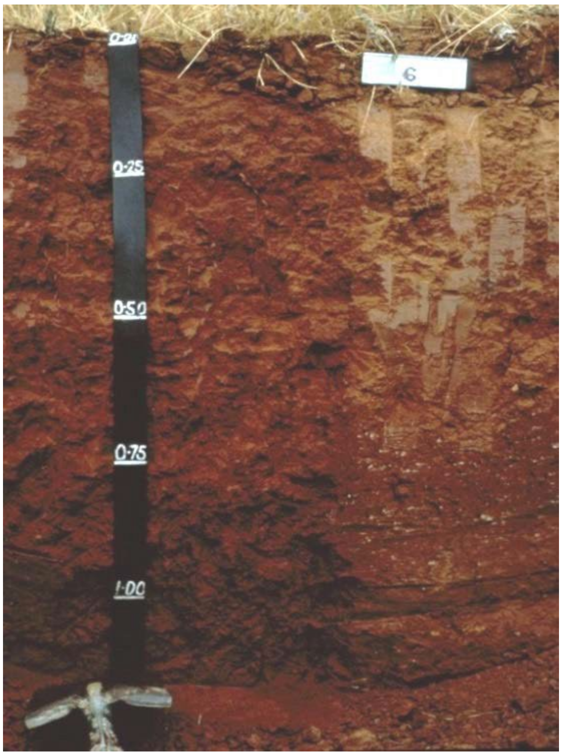


Figure 11 Profile of a uniform soil with clayey textures down the profile

A gradational soil has a gradual increase in texture (becomes more clayey) down the soil profile (Figures 12 and 13). 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 10 cm, although the texture change of gradational soil often grades over a much greater depth range.

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

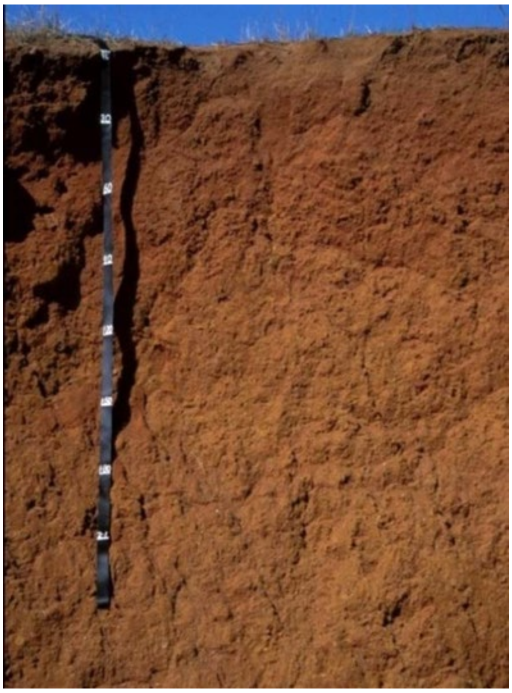


Figure 13 Profile of a gradational soil with clayey sand topsoil grading to sandy clay loam subsoil

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, abrupt or clear increase in texture within 5 cm. A typical example of a duplex soil is sand **over** clay (Figures 14 and 15). The term 'over' indicates this rapid change in texture with depth, although sometimes, as in Figure 15, the change is harder to see.

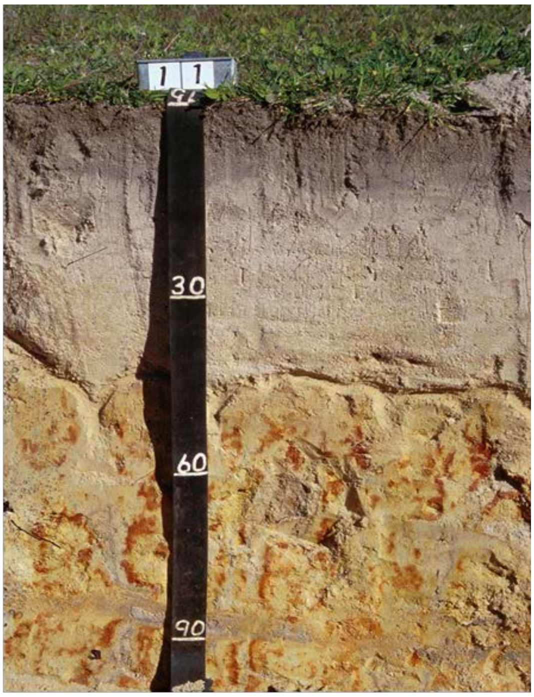


Figure 14 Profile of a duplex soil with a sandy A horizon over a clayey B horizon at 45 cm

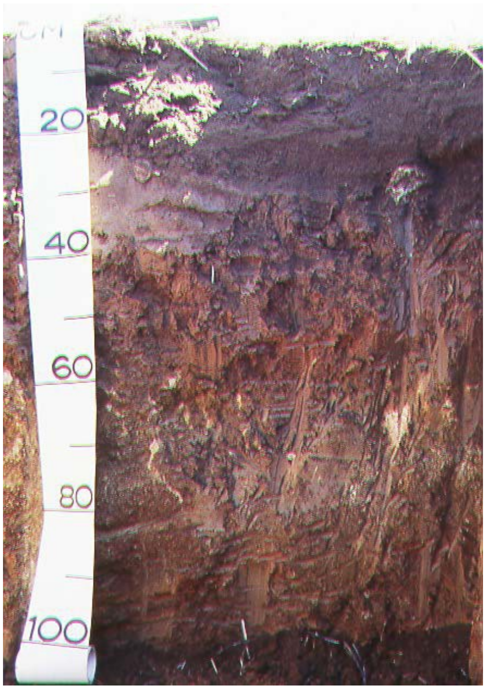


Figure 15 Profile of a duplex soil with a loamy A horizon over a clayey B horizon at 35 cm

4 Coarse fragments

Coarse fragments in the soil are the particles bigger than 2 mm 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 (2–20 mm), coarse gravels (20–60 mm), cobbles (60–200 mm), stones (200–600 mm) or even boulders (>600 mm). Significant amounts of coarse fragments can affect soil properties, such as effective rooting volume and amount of plant available water in the profile.

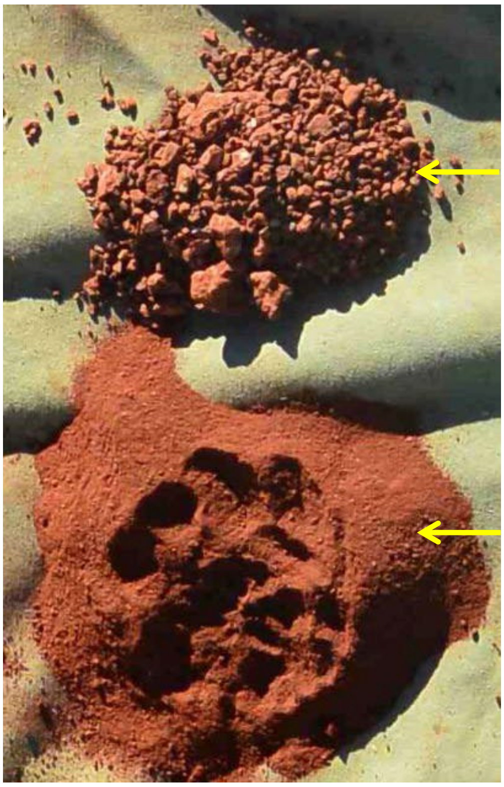
Coarse fragments are normally recorded by type and abundance. In WA, the main types of coarse fragments are:

- ironstone gravels (code FE) – ferruginous hard concretions or nodules (Figures 17 and 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 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 (Figures 16–18). 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%.



Estimate of coarse fragments:
40% or many

Fine earth fraction

Figure 16 A sieved soil sample showing proportions of coarse fragments and fine earth

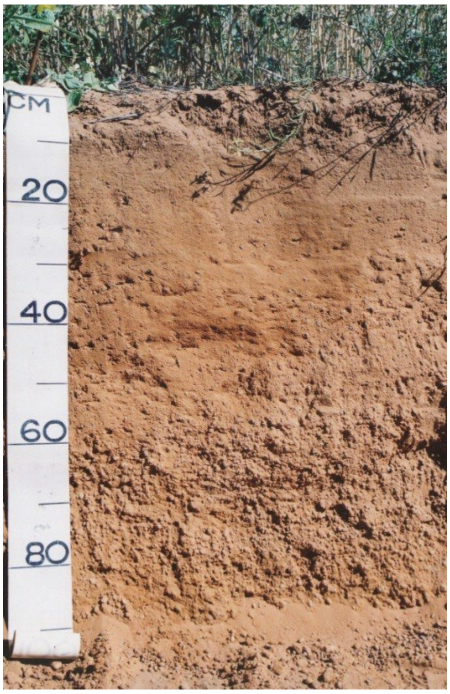


Figure 17 Profile of an Ironstone gravelly coloured deep sand: gravel estimate is few (5%) in the upper horizon (0–55 cm) and many (40%) in the lower horizon (55–90 cm)

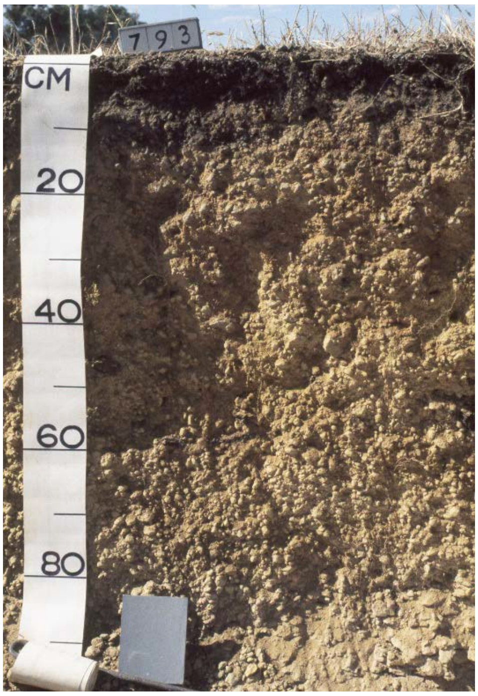


Figure 18 Profile of a Deep sandy gravel with abundant ironstone gravels throughout

5 Colour

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

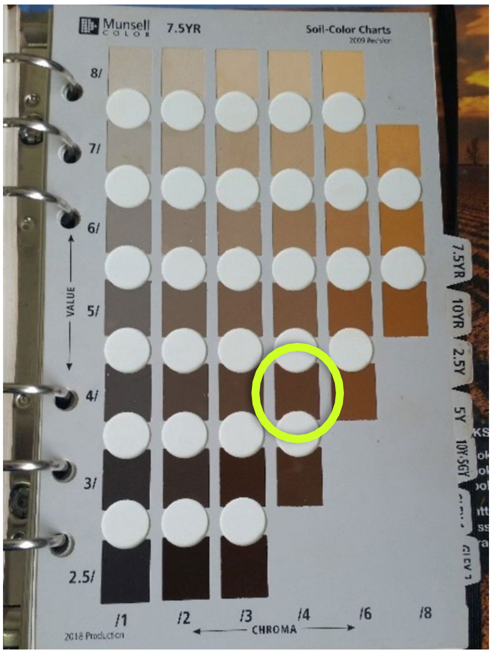


Figure 19 Colour range of hue 7.5YR in the Munsell soil colour chart

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.

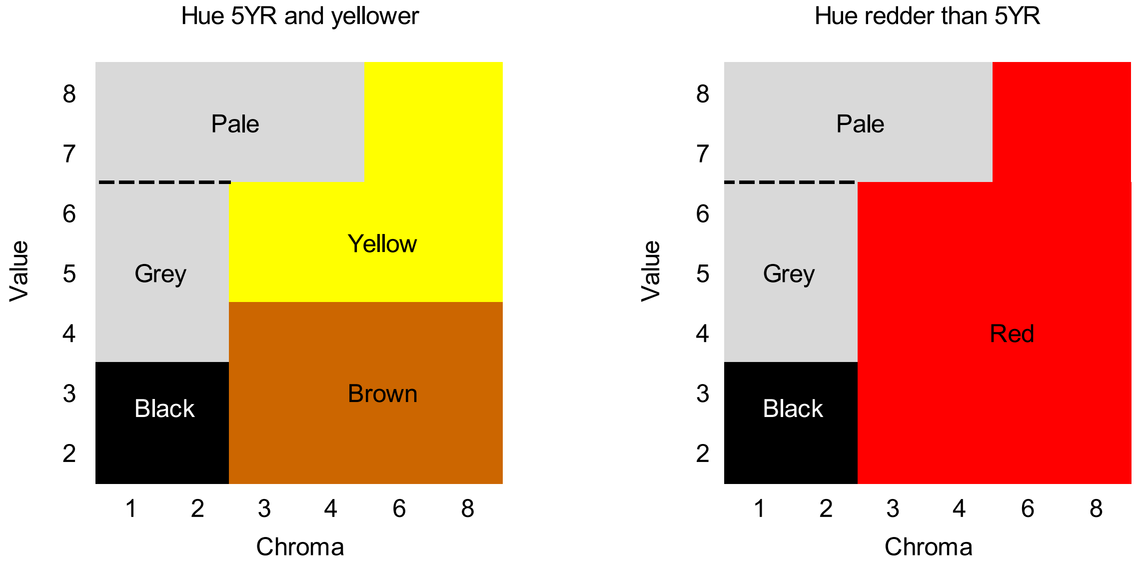
If no Munsell colour chart is available, a general description using the 5 main soil colours – red, brown, yellow, grey (including white) and black – is acceptable (Figure 20).

Red Brown Yellow Grey Black

Figure 20 Five soil profiles showing the main colour groups

These main colours relate to the Munsell hue, value and chroma (Figure 21). Note that this figure cannot be used to colour soil; use the Munsell soil colour book which describes colours using these classes and facilitates objectivity and consistency.

Occasionally, if soil has been exposed to long periods of wetness, it can be blueish or greenish in colour, which is known as **gleying**. Other common colour descriptors for soils include pale yellow, red-brown, yellow-brown, white (bleached layers), grey-brown, dark grey. Some soil horizons have a mixture of colours, generally called mottles (see below).



Note: These class limits are slightly different to the Australian Soil Classification limits and are optimised for Western Australian soil conditions

Source: Galloway et al. (2024)

Figure 21 Colour class limits for the Western Australian Soil Group classification based on Munsell soil colour chart terminology

Mottles

Mottles are spots, blotches or streaks of colours different from the main soil matrix. They are commonly seen in clayey subsoils and may occur along roots and root channels. Where mottles are obvious, their presence should be recorded because they may indicate soil characteristics, such as waterlogging, or animal activity.

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 A mottled clay subsoil, where the main soil colour is yellow and there are prominent rust-red mottles

Figure 23 A mottled clay subsoil, where the main soil colour is grey and there are faint pale-yellow mottles

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: it is a function of the concentration of hydrogen ions (H+) in the solution. It is expressed as a unitless 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 represent a rapid increase in acidity; and higher values represent 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 2 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 1 part soil to 5 parts distilled water and recorded as pH_w.

Figure 24 pH of a soil using an indicator solution

Figure 25 pH of a soil using a colour chart

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 measure of pH in 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 4 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 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 2 m of the soil surface; saline watertables within 2 m can depress plant growth, and within 1 m can cause salt accumulation (white crystals) on the soil surface and the death of salt-sensitive plants (Figure 26).

Figure 26 Sampling soil in a salt-affected area

Measuring the separate soil horizons with a pocket electrical conductivity (EC) meter is a common way to discover if the profile is salty. Mix 1 part soil taken from a horizon with 5 parts distilled water – about 50 g of soil in 250 mL distilled water – in a suitable container; shake well; 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):
100 mS/m = 1 dS/m.

Soil salinity varies with seasonal conditions: winter rains can leach salt downwards and summer heat can evaporate surface moisture and wick salty water from shallow watertables via capillary rise. Soil permeability and soil texture, as well as rainfall, influence the degree of leaching and wicking. 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).

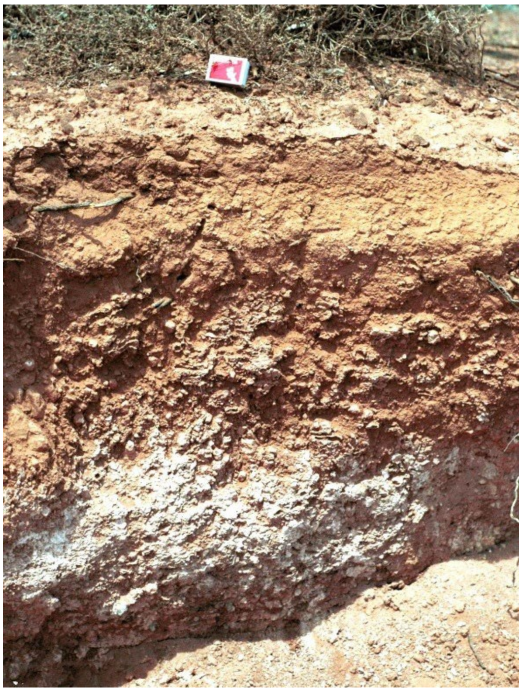


Figure 27 Calcium carbonate (lime) nodules in upper layers and masses in lower layers

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 1 part spirit of salts to 5 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.

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, there is structure, and these are called **pedal** soils. **Peds** are aggregates that are separable from each other by lines of weakness. Peds may be less than 2 mm to more than 500 mm. Where aggregates are absent, the soils are called **apedal** and can be single grain 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) is evident throughout the profile.

A detailed explanation for identifying structures and structural features of soil is presented in NCST (2024), pages 146–156. The full set of soil structure types is provided in ‘Code definitions for characterising Western Australian soils’ (DPIRD 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.

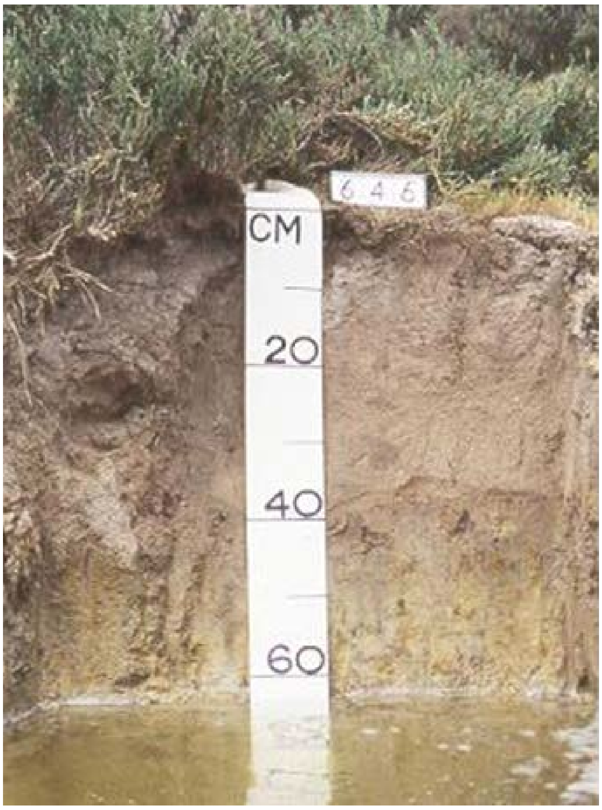


Figure 28 A salt-affected duplex soil with salt- and waterlogging-tolerant samphire vegetation at the surface

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, highly sodic if more than 15, and extremely sodic if more than 25.

Soil ESP can only be determined by laboratory analysis (it is a component 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 restricted water and air 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 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 Managing 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 5 mm 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).

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.

Figure 30 A water droplet on water repellent sand

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 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 20 m 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 2024).

Soil types and classification

Formal and informal soil classifications group soils with similar properties and characteristics. This helps us communicate knowledge and information about soils relevant to agriculture and the environment. Soil classifications can help identify similar soils that occur in different locations and permits the transfer of research results and management information from soils where research was conducted to similar soils elsewhere. 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, the properties, depths and arrangement of the layers you have described can be used to classify the soil profile to 2 levels:

- level 1 is based on a general examination of the whole soil profile, enabling soils to be assigned to **soil supergroups**
- level 2 includes additional details about the soil profile that help to explain aspects of soil productivity relevant to rainfed agriculture in south-west WA.

The level 2 classification is like the general soil classes defined by van Gool et al. (2018) in *Distribution of classified soils in south-west Western Australia*.

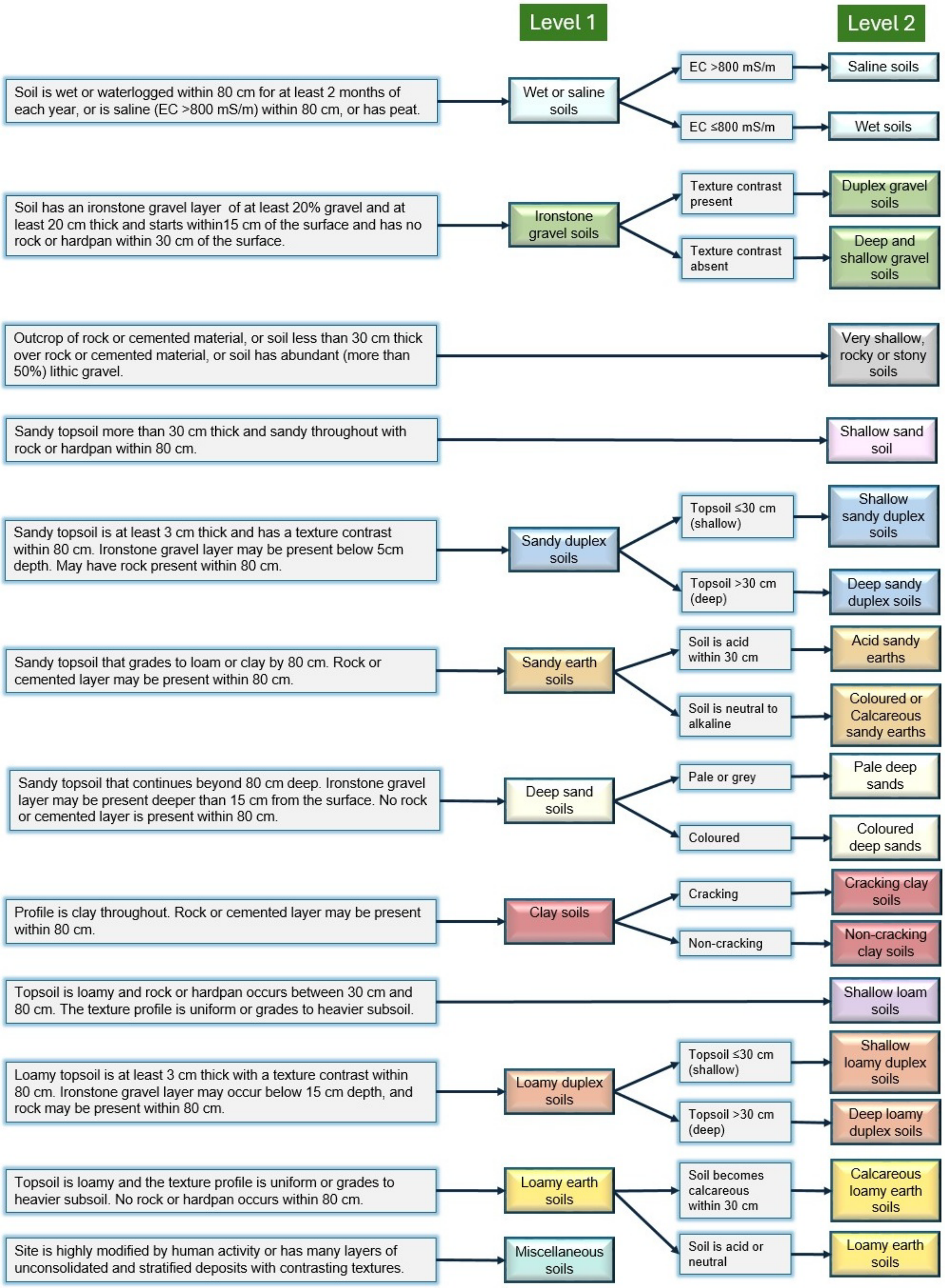
The examples below classify the soils described to these 2 levels and to the **WA soil group** level. However, classifying to a WA soil group or to an Australian Soil Classification is more complex than can be described here. These formal soil classifications are described in:

- 'Western Australian soil groups: a diagnostic key to identify soils in Western Australia' (Galloway et al. 2024) which classifies soils of WA into a limited set using criteria that are easy to recognise in the field. It focuses on agronomic and rangeland grazing potential of soil
- *The Australian Soil Classification* (Isbell and National Committee on Soil and Terrain 2021) which is the Australian standard for the technical classification of soils.

Refer to Resources related to this guide for more information.

A simple key to classify soil

The following key is based on the Western Australian Soil Groups classification (Galloway et al. 2024) and classifies to soil supergroup (level 1) and general soil management class (level 2).



Examples of simple soil classification

The examples of simple soil classification below use the standard legend for WA soil groups (Figure 31).

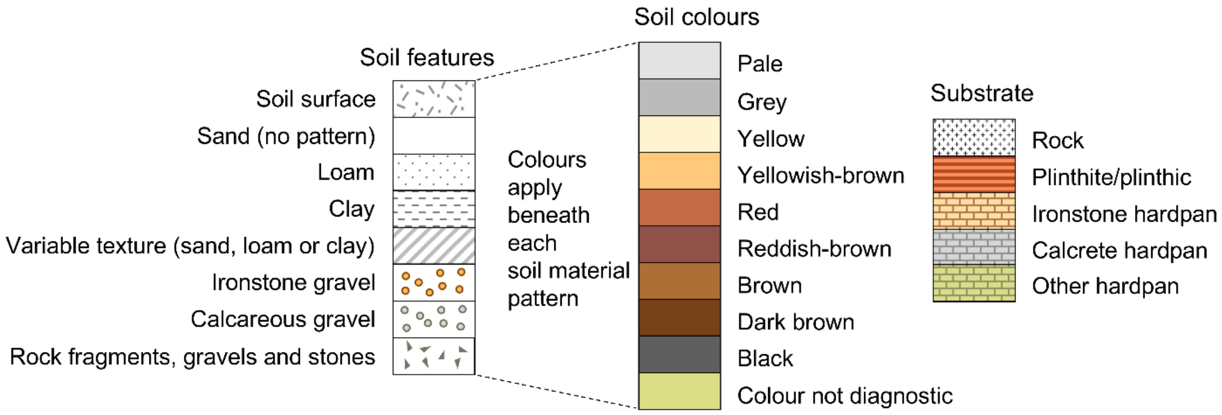


Figure 31: Standard legend for the WA Soil Groups classification

Example 1

For this example, imagine you are inspecting a site located on a broad valley floor in the southern grainbelt near Nyabing, which is east of Katanning. The vegetation on the site is dominated by samphire and bare patches have a white crust, which you presume is salt. You dig a hole: it is damp near the surface and becomes wet by 50 cm, despite being dry for part of the year. The hole fills with water to within 85–90 cm of the surface.

The main site characteristics are presence of salt-tolerant plants, salt on the surface and the soil is wet within 80 cm for at least 2 months. This information is sufficient to classify the soil as a ‘Wet or saline soil supergroup’. If you had a salinity meter and could test the soil salinity using 10 g of soil in 100 mL of distilled water or rainwater to confirm that the salinity rating is at least highly saline (>800 mS/m), you could classify to the WA soil group level as a Saline wet soil (Figure 32).

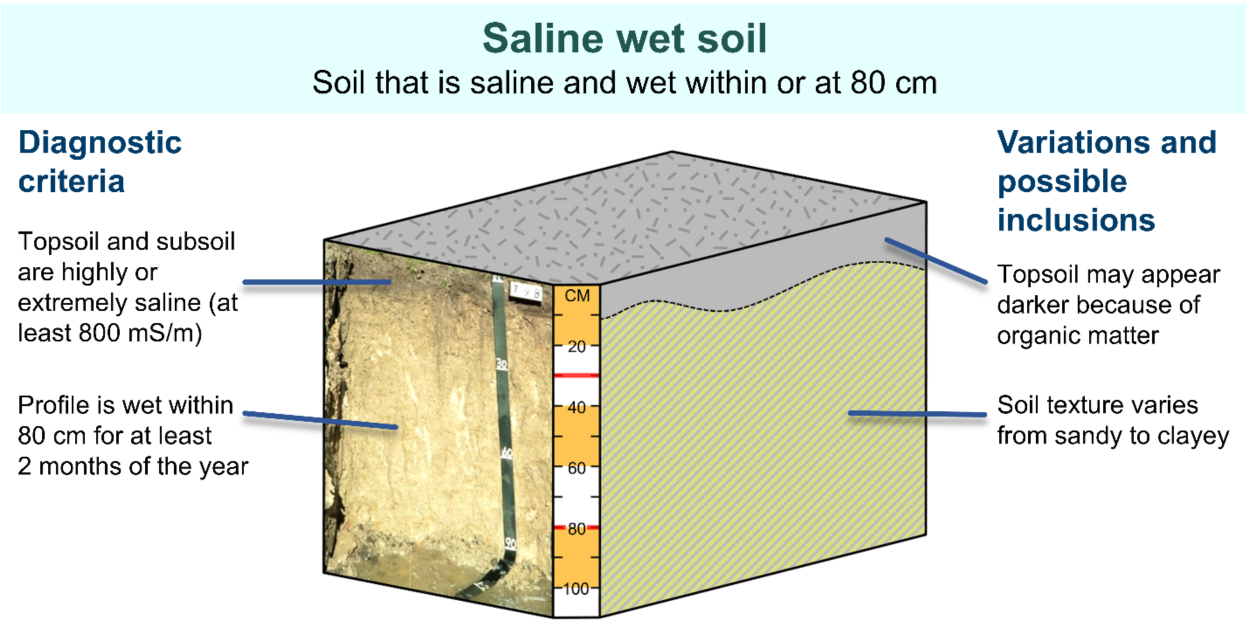


Figure 32: Characteristics of Saline wet soil (WA soil group)

Example 2

You are digging a posthole on a gentle slope near Katanning, and you find that the top 10 cm is easy to dig, and the soil will not form a ball when moistened and worked in your hand. But below 10 cm, the soil abruptly becomes very difficult to dig, and you revert to using a mattock to complete your hole. The grey subsoil you remove is very difficult to texture and when you add water and try and work it, it feels very slippery, almost soapy. You use your pH test kit to get a pH of the subsoil, and it turns a strong purple colour, which means it is alkaline.

The main soil characteristics are sandy topsoil with an abrupt change to clay subsoil. This information is sufficient to classify the soil as a Sandy duplex soil supergroup. Because you also know that the topsoil is less than 30 cm thick, you can assign this to a Shallow sandy duplex soil management class. By knowing that the grey subsoil is alkaline, you can classify the soil to the WA soil group level as an Alkaline grey shallow sandy duplex (Figure 33). Because the subsoil was difficult to texture and soapy, you can guess that the subsoil is sodic, which helps with classifying at the Australian Soil Classification level.

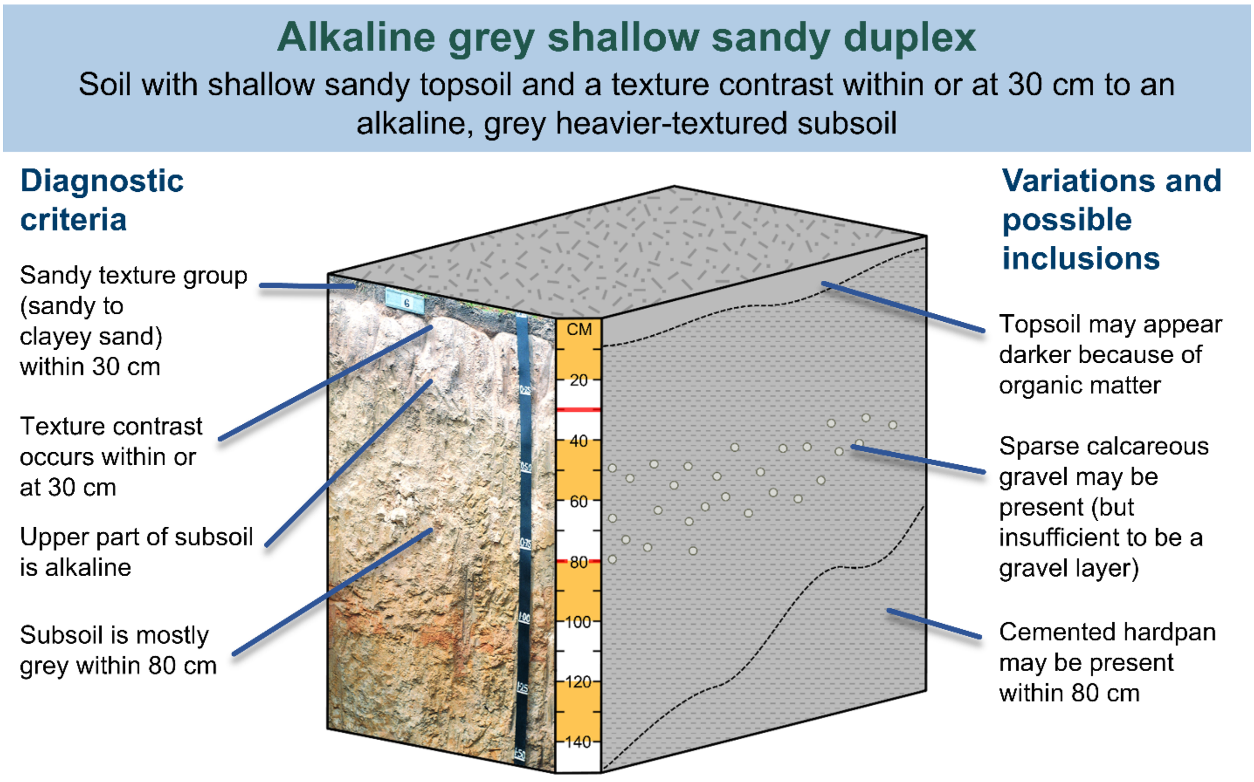


Figure 33: Characteristics of Alkaline grey shallow sandy duplex (WA soil group)

Example 3

You are driving along a road in Kojonup Shire and you stop at the edge of a road cutting in hilly terrain. The cutting shows that a shallow sandy topsoil with few gravels overlies a dense gravelly layer that starts from 10 cm deep and continues to about 55 cm. You scrape the face of the cutting and fine sandy particles fall out from between the gravel. As you scrape further down the cutting below 55 cm, you notice that the gravels end abruptly, and the soil underneath is coherent. You take a penknife to extract the soil at 70 cm, then you wet and knead it. The soil rolls into a thin rod like a pencil and it doesn't break when you bend it.

The main soil characteristic is that, at shallower than 15 cm, an ironstone gravel layer begins and it contains more than 20% gravel and is more than 20 cm thick. This information is sufficient to classify the soil as an Ironstone gravel soil supergroup. Because you also know that the sandy gravel upper soil abruptly ends and there is clay beneath it, you can assign this to a duplex sandy gravel soil management class. Since the texture contrast occurs at 55 cm, you can classify the soil to the WA soil group level as a Deep duplex sandy gravel (Figure 34).

Deep sandy duplex gravel

Soil that has a sandy topsoil and prominent gravels within or at 15 cm and a texture contrast below 30 cm

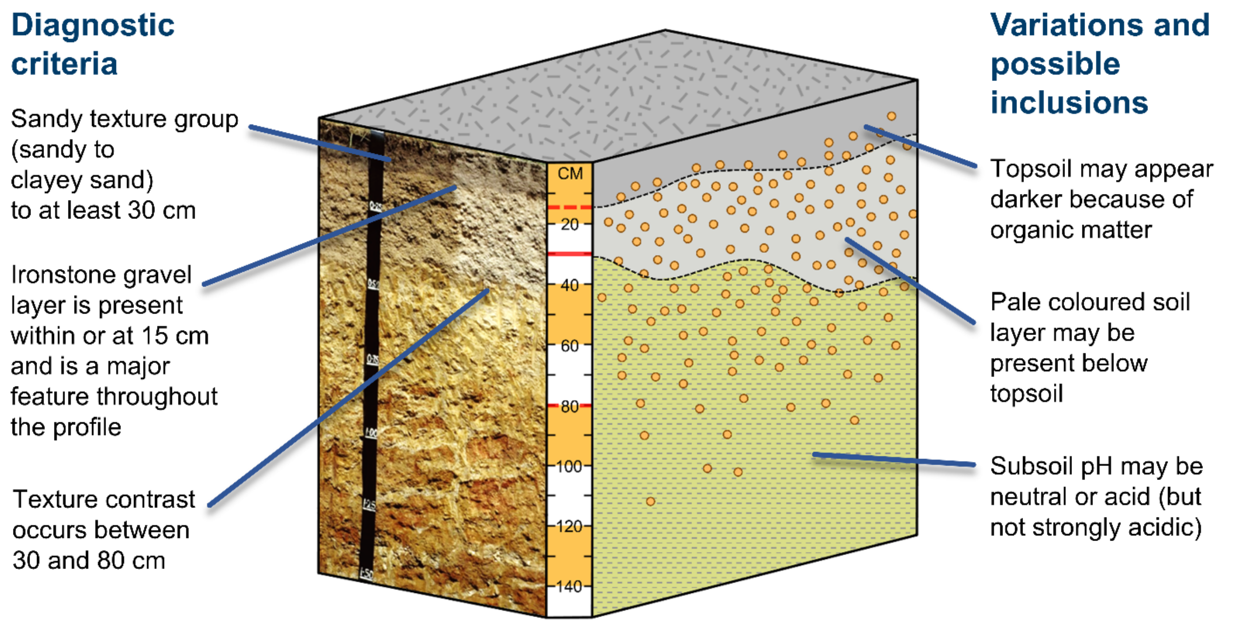


Figure 34: Characteristics of Alkaline grey shallow sandy duplex (WA soil group)

Example 4

You are conducting ecology studies on a gently rolling plain near Binnu. You have identified the vegetation in a quadrat and now dig a hole to determine the soil type. The soil is red from the surface, and you can dig to more than 80 cm deep. You run your fingers up the pit sides and notice that the soil is coherent at depth but looser near the surface. You moisten a handful of topsoil and try to work it into a ball: it stains your palm but the ball falls apart. This soil is sand. Because there doesn't seem to be any obvious place where the soil changes, but it feels different, you do the same with a handful of subsoil from 70 cm. When you work it, it forms a strong ball and is a bit sticky, but it won't roll into a thin rod properly. This soil is clay loam. To confirm there is no abrupt change in texture, you take a sample from 30–40 cm and do the same procedure. This soil strongly stains your hand, and it holds together in a ball when wet but will not form a proper rod. This sample is a sandy loam. You take another sample from this depth and perform a pH test. The indicator turns a greenish colour, which means the pH is 6.5.

The main soil characteristics are that the topsoil is sandy and it slowly grades to a heavier subsoil. This information is sufficient to classify the soil as a Sandy earth soil supergroup. Because you know the soil pH is neutral, you can assign this to a Coloured or calcareous sandy earth soil management class. Since the soil is red throughout and it continues to greater than 80 cm deep, you can classify the soil to the WA soil group level as a Red sandy earth (Figure 35).

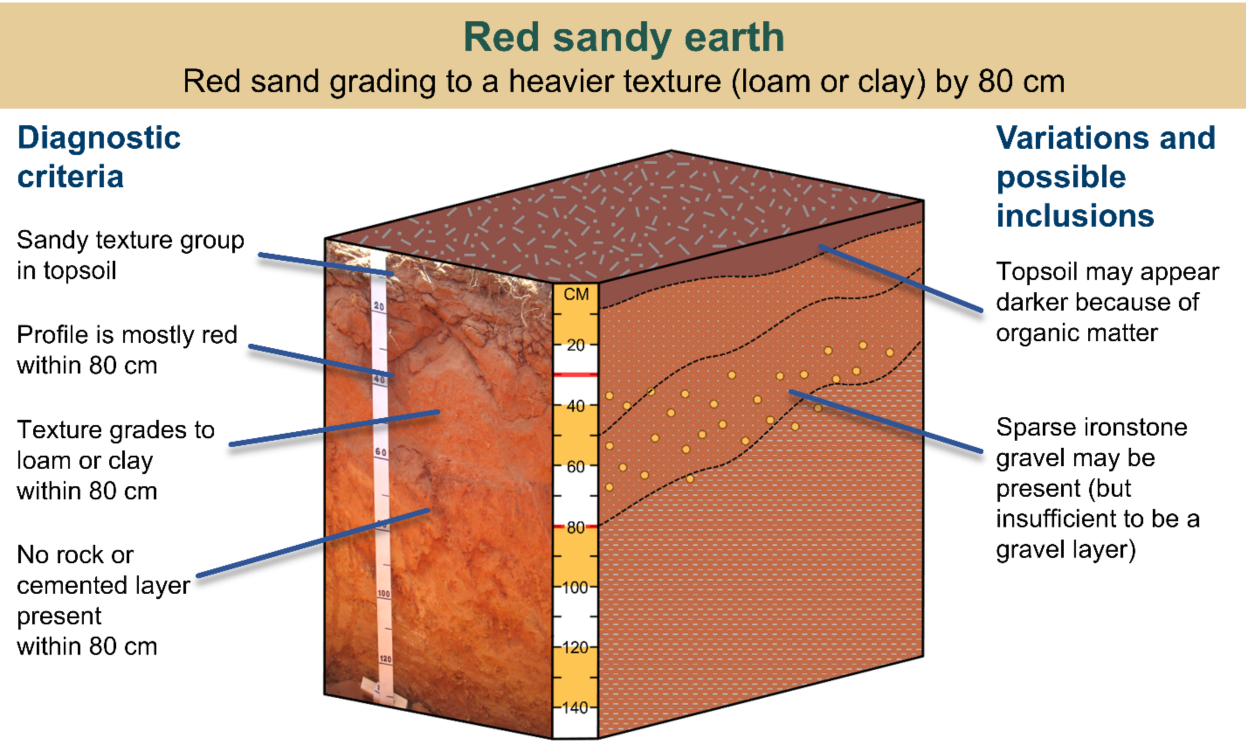


Figure 35: Characteristics of Red sandy earth (WA soil group)

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 moist soil by hand to estimate texture.

Boulder: Coarse fragments larger than 600 mm in size.

Clay: 1) Soil mineral material whose particle size is smaller than 0.002 mm.

2) The texture grade or texture qualifier of soil that contains a significant clay component: clay particles are very fine. They impart a stiff and often sticky feel to the texture when forming a bolus and ribboning. Fine earth soil material that contains much clay can be moulded when wet and is sometimes dried and baked to make bricks, pottery and ceramics.

Coarse fragments: Soil particles larger than 2 mm in size (i.e. gravel, stones and rocks).

Coarse gravel: Coarse fragments between 20 and 60 mm in size.

Cobble: Coarse fragments between 60 and 200 mm in size.

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

Duplex soil: Soil with an abrupt increase in soil texture (becomes more clayey) over a short (less than 5 cm) vertical distance (also known as a texture contrast).

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 because it is a useful measure in its own right because it provides a guide to soil behaviour.

Fine earth: Soil particles smaller than 2 mm in size.

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 10 cm.

Gravel: Coarse fragments between 2 and 20 mm in size.

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

HCl: Hydrochloric acid: a weak solution (diluted to 1 molar) is 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 from where soil has been described.

Mottles: Spots, blotches or streaks of colours different from the main soil colour.

Parent material: The underlying geological material in which soil horizons form; soils inherit 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: 1) Soil mineral material whose particle size is 0.02 to 2 mm.

2) The texture grade or texture qualifier of soil that is mostly sand particles: sand is coarse and does not readily form a coherent ball when moist.

Shearing: Pressing the soil out between the thumb and forefinger in a sliding motion to form a ribbon when conducting a field texture test (motion is like a slow, low-pressure thumb-click).

Silt: 1) Soil mineral material whose particle size is between 0.002 and 0.02 mm (smaller than sand and larger than clay).

2) The texture grade or texture qualifier of soil that contains a significant silt component: silt particles are fine and impart a silky feel to the texture when ribboning.

Soil profile: Total depth of soil described.

Stone: Coarse fragments between 200 and 600 mm in size.

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

Texture contrast soil: See duplex soil

Texture grade: The texture class as determined by hand (field texture) or by comparison to the texture triangle; for example, loamy sand, sandy loam, sandy clay loam.

Texture group: The mineral component of the soil classified by the range of particle sizes (i.e. sand, silt and clay) present; 3 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 profile whose texture group does not change down the profile.

Resources related to this guide

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Other resources

Australian National Soil Information System website

DPIRD website:

- 'Managing soils' page – sodicity, acidity, compaction, salinity, waterlogging, water repellence and managing difficult soils
- 'NRInfo (natural resource information)' page – digital mapping and information for natural resources across WA

Soil quality ebooks (only available on Apple platforms):

- 1: Constraints to plant production
- 2: Integrated soil management
- 3: Soil organic matter
- 4: Soil acidity
- 5: Soil biology
- 6: Soil compaction
- 7: Soil water repellence
- 8: Sodic and alkaline soil
- 9: Gravel soil
- 10: Plant nutrition

Contact

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

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:** **Surface condition:** (*circle one*) cracking; self-mulching; loose; hardsetting; other **Surface water repellence:** Yes / No	**Landform element:** (*circle one*) crest; ridge, hillock; slope – simple, upper, mid or lower; flat; depression – open or closed **Site/location notes:** e.g. vegetation, landform	
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 Soil Profile Database 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 0 cm.*
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 or colour change)	Abrupt (**A,** <2 cm), Clear (**C**, 2–5 cm), Gradual (**G,** 5–10 cm), Diffuse (**D,** >10 cm)
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 2–6 mm; **2** gravel 6–20 mm; **3** coarse gravel 20–60 mm, **4** cobbles 60–200 mm, **5** stones 200–600 mm, **6** boulders >600 mm
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 <5 mm, **M** medium 5–15 mm, **C** coarse 15–30 mm, **L** very coarse >30 mm
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' (DPIRD 2017).