eDIRT app user manual

For the eDIRT mobile and web apps version 1.0.1

**Department of Climate Change,
Energy, the Environment and Water**

NSW GOVERNMENT

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

Artist and designer Nikita Ridgeway from Aboriginal design agency Boss Lady Creative Designs created the People and Community symbol.

Cover photo: Using the eDIRT app in the field. Sally McInnes-Clarke/DCCEEW

Published by:
Environment and Heritage
Department of Climate Change,
Energy, the Environment and Water
Locked Bag 5022, Parramatta NSW 2124
Phone: +61 2 9995 5000 (switchboard)
Phone: 1300 361 967 (Environment and Heritage enquiries)
TTY users: phone 133 677, then ask for 1300 361 967
Speak and listen users: phone 1300 555 727, then ask for 1300 361 967
Email info@environment.nsw.gov.au
Website www.environment.nsw.gov.au

ISBN 978-1-76186-318-9
EH 2026/0329 September 2026

Find out more at:

environment.nsw.gov.au

Contents

List of tables

List of figures

1. What is the eDIRT app?

1.1 Purpose

The eDIRT app is a mobile application for the in-field recording of soil information. Its primary role is to capture soil profile information digitally in the field, rather than using field notebooks or scannable data cards.

The eDIRT mobile app can be used anywhere in Australia without a mobile network or internet connection. The eDIRT app is free and easy to use.

The eDIRT app replaces the eDIRT internet information system. This system was introduced in 2013. As a browser-based application, it did not reliably support field use in areas without mobile coverage. The eDIRT system has been withdrawn.

1.2 Versions

The eDIRT app can be used on mobile devices, desktop computers and laptop computers, and is available in 3 versions:

Mobile app:

- for mobile devices running **Google Android** 12 or higher, can be used online or offline
- for mobile devices running **Apple iOS** 18 or higher, can be used online or offline

Web app:

- desktop version in a web browser, for online use only, on desktop and laptop computers

The mobile versions allow users to record soil information without a network or internet connection. Offline functionality is not available in the eDIRT web app, which is designed for use in the office or at home.

The 3 versions work the same way, except for offline use and screen layouts for different devices.

Do not use the eDIRT web app without an internet connection. If you do so, you will lose data. The web app has no ability to store data on your local device. For reliable field use, use the eDIRT app on your Apple or Android mobile device.

1.3 Context

The eDIRT app is part of the NSW Government's soil information framework. See Figure 1 below.

The eDIRT app is the primary means of capturing soil information into the NSW Soil and Land Information System (SALIS), the NSW Government's centralised database for soil and land information.

From SALIS, public soil data can be made available to the community through the eSPADE spatial viewer. This data is also made available through a web service to the Australian National Soil Information System (ANSIS).

SALIS also provides the data dictionary and definitions used in the eDIRT app. This means all data collected through the eDIRT app should be consistent, reliable, and meet required scientific standards.

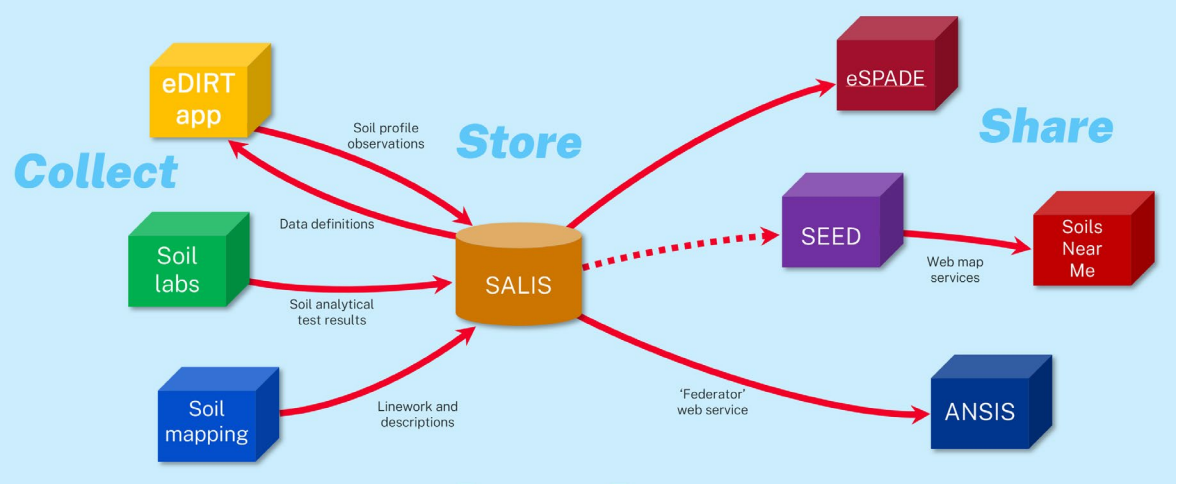


Figure 1 **The NSW Government's soil information framework**

2. For a quick start...

To start using the eDIRT app quickly:

1. If you're going into the field, calibrate the Global Positioning System (GPS) on your mobile device.
2. Download the eDIRT mobile app to your preferred mobile device, or (for online only), open a web browser and go to edirt.environment.nsw.gov.au
3. Sign in, or create an account.
4. Click or tap on the + New profile New profile button.
5. Create or select a **survey** for your new profile to reside in.
6. Select a template to apply to your new **profile**.
7. Enter a location for your new **profile**.
8. Record the landscape and soil information for your new **profile**.
9. Click or tap on the Submit button.

Do not use the eDIRT web app without an internet connection. Doing so will result in data loss. For work in the field, use the eDIRT mobile app on your Apple or Android mobile device.

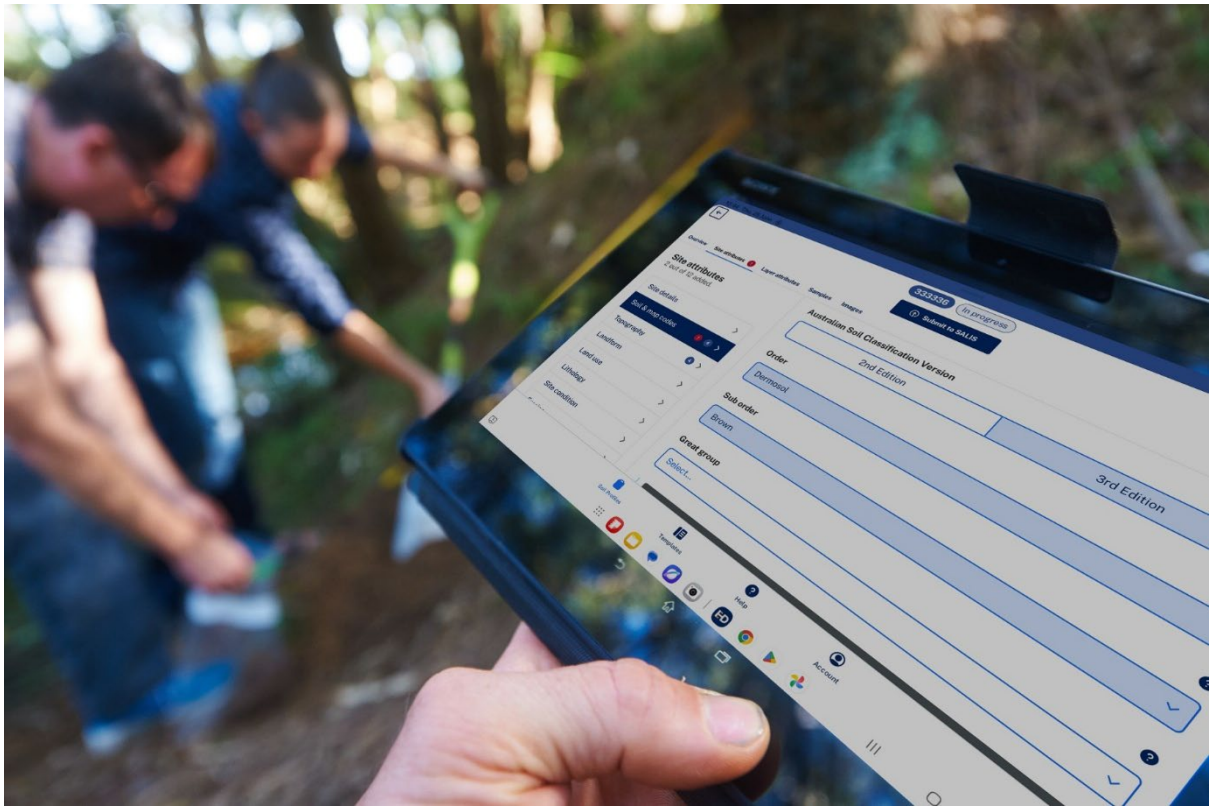


Image 1 **Using eDIRT on a device. Photo: DCCEEW**

3. Setting up for first use

3.1 Installing the eDIRT mobile app

To install the eDIRT mobile app on your mobile device, go to the **Google Play Store** or **Apple App Store** and search for **eDIRT**.

- Google Play
- App Store

You do not need to install the eDIRT web app.

3.2 Start the eDIRT app

To start using the eDIRT mobile app on your device, tap on the **eDIRT** button.

To start using the eDIRT web app, open a web browser on your desktop or laptop computer and navigate to edirt.environment.nsw.gov.au

When you first open the eDIRT app you will be in 'guest' mode. There's a soil profile that you can access and navigate to explore the functions and capabilities of the app. To record soil profile data using the eDIRT app, create an account.

3.3 Internal and external users

If you are an employee of a NSW Government organisation, department or agency with the following email address or domain, you are an **internal** user. You can create an eDIRT account and sign in with your network account, using the same email address and password.

@bct.nsw.gov.au

@botanicgardens.nsw.gov.au

@crownland.nsw.gov.au

@cp.nsw.gov.au

@dpi.nsw.gov.au

@dpie.nsw.gov.au

@dpird.nsw.gov.au

@dphi.nsw.gov.au

@dcceew.nsw.gov.au

@environment.nsw.gov.au

@epa.nsw.gov.au

@lls.nsw.gov.au

@nsw.gov.au

@nrar.nsw.gov.au

@planning.nsw.gov.au

@pwa.nsw.gov.au

@rbgsyd.nsw.gov.au

@regional.nsw.gov.au

@scs.nsw.gov.au

@sopa.nsw.gov.au

If you have an email address other than those above, you are an **external** user.

3.4 For external users

3.4.1 Create your account

To create profiles and save data in the eDIRT app, you will need to create an account and sign in.

What you'll need

You will need an email address to which you have reliable access. This is your eDIRT username.

For added security, the eDIRT app uses 2-factor authentication (2FA). You'll verify your identity by entering a number sent to your email address.

You'll also need to provide a strong password or passphrase that is not easily guessable by others.

What to do

To create an eDIRT app account, follow these steps:

1. Click or tap on the 

Account button in the mobile app, or the 

Account button in the web app.
2. Click or tap on the **Create an account** button.
3. Click or tap on the **Request access** button.
4. Answer 'Yes' to the first question in the **Sign Up Questionnaire**.
5. Click or tap on the **Sign up for eDIRT** button.
6. Click or tap on the **Sign up with email** button.
7. Enter your email address.
8. Click or tap on the **Send verification code** button.
9. Enter the six-number code sent to your email address into the **Secondary Verification Code** field, then click or tap on the **Verify** button.
10. Enter your details into the fields below, including your password or passphrase, then click or tap on the **Create** button.

Once your account has been created, you can log into the eDIRT app and start to record soil profile information using the eDIRT app. Once your account has been authorised, usually within 2 business days, you can submit profiles to SALIS and access them through eSPADE and (if public) ANSIS.

Whenever you're using the eDIRT app or web app, make sure you are logged in on the **Account** page. This will allow you to see, edit and submit any profiles you've already created.

3.4.2 Log in

To sign in to the eDIRT app, follow these steps:

1. Open the eDIRT mobile app or web app.
2. Navigate to the **Account** page.
3. Click or tap on the **Log in** button.
4. Enter your email address and password into the fields provided, then click or tap on the **External user log in** button.
5. Enter the six-number code sent to your email address into the **Secondary Verification Code** field, then click or tap on the **Verify code** button, then the **Continue** button.
6. You are logged into the eDIRT app. The **Account** page shows your name, email address and status.

3.5 For internal users

3.5.1 Create your account

To create profiles and save data in the eDIRT app, you should create an account.

What you'll need

You will need an internal network account.

What to do

To create an eDIRT app account, follow these steps:

1. Click or tap on the Account **Account** button in the app, or the Account **Account** button in the web app.
2. Click or tap on the **Create an account** button.
3. Click or tap on the **Request access** link.
4. Answer 'Yes' to the first question in the **Sign Up Questionnaire**.
5. Click or tap on the **Internal staff sign up** button.

Once your account has been created, you can sign into the eDIRT app and record soil profile information. Once your account has been authorised, usually within 2 business days, you can submit profiles to SALIS and access through eSPADE and (if public) ANSIS.

Whenever you're using the eDIRT app or web app, make sure you are signed in on the **Account** page. This will allow you to see, edit and submit any profiles you've already created.

3.5.2 Log in

To sign into the eDIRT app, follow these steps:

1. Open the eDIRT mobile app or web app.
2. Navigate to the **Account** page.
3. Click or tap on the **Log in** button.
4. Click or tap on the **Internal staff log in** button.
5. You are logged into the eDIRT app. The **Account** page shows your name, email address and status.

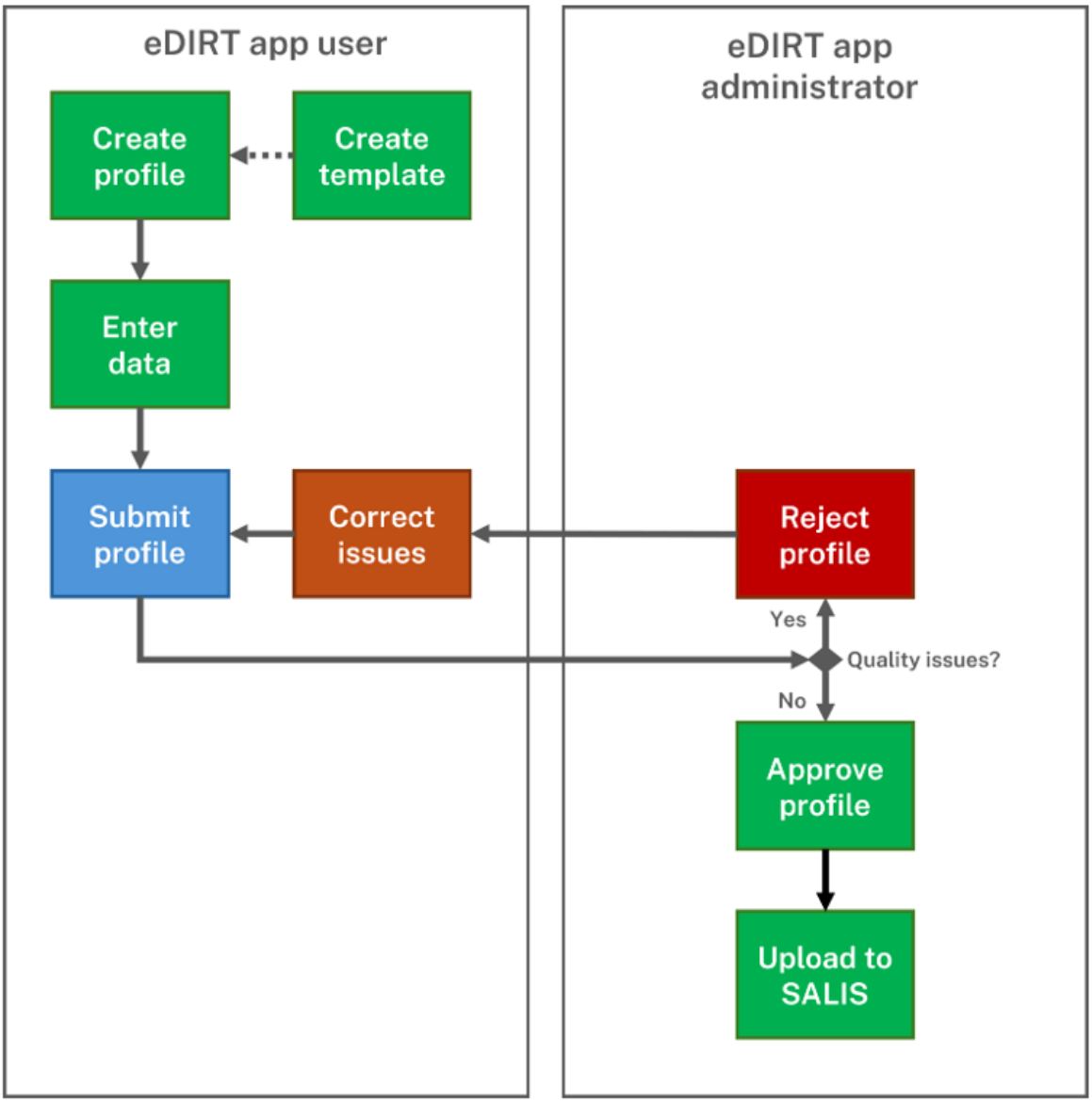


Figure 2 **eDIRT app workflow**

3.5.3 Stay logged in

Stay logged in to the eDIRT mobile app when you are preparing for fieldwork or working in the field.

If you log out while you are in an area with no mobile network coverage, you will not be able to log in again until you return to coverage. You will also be unable to record data in the app until you can log in..

4. Using the eDIRT app

4.1 eDIRT app workflow

Figure 2 (above) shows the essential steps in the eDIRT app workflow.

As a signed in user, you can **create** and describe soil profiles, either using one of the **templates** available in the system or using one that you have created.

Creating a template is optional. There is no requirement for you to create your own template to record soil profile data in the eDIRT app – you can use any one of the existing templates already in the system. For more information, see **4.2 Templates** below.

eDIRT verifies the data you enter as you go; there is no separate verification process as with the old version of eDIRT.

Once you have completed the description of a profile, you can **submit** it. The profile record passes to the eDIRT administrator, who may identify issues with the data requiring correction. Otherwise, the eDIRT administrator will **approve** the profile and it will be uploaded to the SALIS database.

Once a profile is approved you can generate a formatted report showing its details and, if the profile is public (recommended), it will be available for access through eSPADE and ANSIS.

4.2 Templates

4.2.1 What is a template?

A **template** is a predefined set of fields and attributes suitable for different levels or purposes of soil profile description. A template removes from view some fields and attributes that are not required for the particular purpose, either because they are not relevant or because they are too complex for the level of soil description involved.

You do not need to record data in every field of a template. If there is a template that contains more fields than you require, you can continue to use that template rather than create a new one.

4.2.2 Existing templates

At the time of writing, the eDIRT app includes 8 predefined templates that you can use as-is:

- **Standard:** a balanced template covering many core attributes, while still simple
- **Basic**: a basic template for core soil profile information
- **Comprehensive**: a comprehensive template for a detailed soil profile
- **Sample only**: for collection of soil samples only
- **BSAL speciality**: for description of soil profiles for Biophysical Strategic Agricultural Land (BSAL) site assessment

- **Salinity**: for description of soil profiles for salinity monitoring
- **Photos only**: for collection of photos (images) only
- **Universal**: includes all possible attributes, not meant for real-world use.

You can view the contents of each template by clicking on it. The template's detail page shows a hierarchical list of the sections and attributes in the template.

Click or tap each section's ⊕ **Expand** button to explore the attributes within that section. Click or tap the ⊖ **Collapse** button to close that branch of the hierarchy.

The numbers in the green bubbles show how many attributes within each section are included in the template. A section or cell that is greyed out indicates that section has no attributed or fields selected in that part of the template.

4.2.3 Compare templates

You can compare the content of each template to other templates to see how they differ from each other.

1. Navigate to the Templates **Templates** section and click or tap on a template.
2. Click or tap on the Compare **Compare** button.

The template you selected is listed in the column to left, and the other templates are listed in subsequent columns.

Click or tap each section's ⊕ **Expand** button to explore the attributes within that section. Click or tap the ⊖ **Collapse** button to close that branch of the hierarchy.

The numbers in the green bubbles show how many attributes within each section are included in the template. A section or cell that is greyed out indicates that section has no attributed or fields selected in that part of the template.

4.2.4 Create a new template

If none of the existing templates suit your purposes, you can make a new template. To do this, follow these steps:

1. Navigate to the Templates **Templates** section and click or tap on the + New Template **New Template** button.
2. Enter a name for your new template, and (optionally) a subtitle and description.
3. In the **New template** page that appears, navigate through the data structure and select/deselect the attributes you do/do not want included in your template.

Some attributes in the schema are required for every soil profile record. You cannot deselect these in the attribute tree. There are also some attributes that are paired with other fields. You cannot select or deselect one paired field without the other.

4. When you have finished selecting/deselecting fields, click or tap on the Continue **Continue** button.
5. Your new template is listed in the **Created** section of the **Templates** page.

4.2.5 Modify an existing template

If one of the existing templates is close to meeting your needs, you can create a copy of that template and modify it. To do this, follow these steps:

1. Navigate to the Templates **Templates** section and click or tap on the template you want to modify.
2. Click on the Modify **Modify** button.
3. Enter a name for your modified template, and (optionally) a subtitle and description.
4. In the **New template** page that appears, navigate through the data structure and select/deselect the attributes you do/do not want included in your template.

Some attributes in the schema are required for every soil profile record. You cannot deselect these in the attribute tree. There are also some attributes that are paired with other fields. You cannot select or deselect one paired field without the other.

5. When you have finished selecting/deselecting fields, click or tap on the Continue **Continue** button.
6. Your new template is listed in the **Created** section of the **Templates** page.

4.3 Remote or offline use

There are no special procedures required to use the eDIRT mobile app in remote areas without a network or internet connection. The eDIRT mobile app will operate the same way whether your device is online or not, with the only difference being submission of profiles – you are unable to submit profiles when your device is offline.

Do not attempt to use the eDIRT web app without an internet connection. If you do so, you will lose data. The web app has no ability to store data on your local device. For reliable use in the field, use the eDIRT app on your Apple or Android mobile device.

4.4 Satellite navigation system support

For best use of eDIRT we recommend a mobile device incorporating properly calibrated Global Navigation Satellite Systems (GNSS) satellite navigation technology. Such a system receives signals from a number of satellites that continuously broadcast both their current time and position, allowing the receiving device to mathematically calculate its position to a high level of accuracy. The system requires line-of-sight to at least 4 satellites to achieve a fix, and access to more satellites will provide a more accurate position.

There are now several Global Navigation Satellite Systems (GNSS) in service, including **GPS** (United States of America), **GLONASS** (Russia), **Galileo** (European Union), **BeiDou** (People's Republic of China) and (in the Asia–Pacific region) the **Quasi-Zenith Satellite System** (Japan). The more of these systems your device can access, the more accurate its reported position will be. Accuracy can also be influenced by atmospheric effects, sky blockage (for example, trees, buildings or hills), weather conditions, the quality of the hardware, any ancillary systems available in your device (such as accelerometers, gyroscopes or magnetometers) and the software algorithms your device uses to process the GNSS signals.

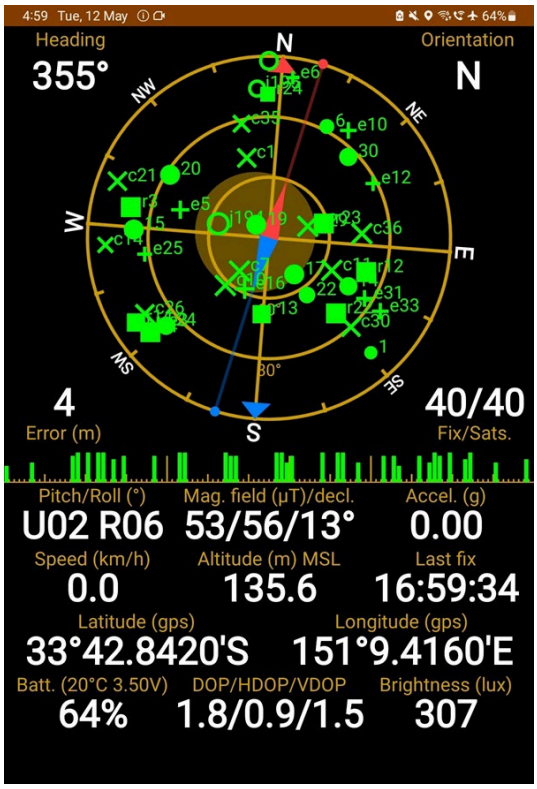


Figure 3 GPS Status, for Android devices

In areas with mobile data coverage, a device incorporating **A-GPS** technology will provide a more accurate position, particularly where satellite reception is poor, as it uses cell tower data and Wi-Fi signals to reduce time taken to achieve an accurate locational fix.

It is very important to ensure that the onboard GPS in your device is calibrated before use. This allows the GPS receiver to provide the most accurate location possible. To do this, see Section 4.4.1 below.

4.4.1 Calibrating onboard GPS

You can do this on an Android device by using a GPS app that includes a calibration function. Figure 3 shows an example – GPS Status, available on Android devices, which shows the status of the onboard GPS and has a calibration function. On an Apple device, calibration of the GPS requires a 'hard reset', which is performed by holding down the **Power** and **Home** buttons until the Apple logo is displayed. This should be performed every time your device is switched on; otherwise, the GPS readings it supplies to the eDIRT app may be inaccurate.

4.5 Moving between devices

Once you have logged into the eDIRT app, you can seamlessly access any profiles you have recorded, whether on the current device or another device, provided both devices are online. There is no procedure required to transfer profiles between devices, as with the previous eDIRT information system.

4.6 Help and support

Almost every function and field in the eDIRT app has a help item attached to it. You can access the help system either through the 

Help button for each section, or by clicking or tapping the **Help** icon next to each field.

If you need more information, contact the eDIRT administrators by email at edirt.admin@environment.nsw.gov.au

5. Important concepts

5.1 Surveys

A **survey** is a group of soil profiles collected for the same purpose – for example, a project, goal, or as part of a scientific study of the same geographic area or soil type. You can think of a survey as a folder or container in which one or more soil profile records are stored.

Every soil profile recorded in the eDIRT app and in SALIS must be a member of a **survey**. Each **survey** has a unique name and seven-digit identifying number.

5.2 Stations

A **station** is a location that is revisited over time to measure change in soil conditions. Each observation over time at a **station** is recorded as an individual **profile** associated with that **station**. This allows monitoring, evaluation and reporting of changes in landscape and soil characteristics.

5.3 Soil profiles

The fundamental soil record in the eDIRT app is the **(soil) profile**. This is a point on the earth's surface around which the site is described. The **profile** consists of a column of soil extending downwards from the soil surface through all its horizons to parent material, other substrate material or to a specified depth (NCST 2009).

The **profile** may include observations of the soil surface, soil layers, substrate, and the landscape at and around the site, including its geology, vegetation, hydrology, land use, any land or soil degradation, any samples of soil collected from the profile and tested at a laboratory, and any images (photographs) collected. These are together known as **site** attributes.

A **profile** can be as simple as a location and one or more **samples** and/or **images**. The complexity of the information recorded for each **profile** depends on the purpose for which it is being collected.

Each **profile** is identified by a description of its location and a number of up to 6 digits, which must be unique within the parent **survey** or **station**.

5.4 Soil layers and soil horizons

A (soil) **layer** is an individual section of a **profile**. It is a distinct, relatively homogeneous stratum of soil, running approximately parallel to the land surface, with a unique set of physical, chemical and biological properties.

A (soil) **horizon** is a layer of soil with morphological properties different to those soil layers above and below it. Horizons are classified based on their unique characteristics, ecosystem functions, and assumed genesis.

A **layer** does not necessarily have to be a **horizon**. This is particularly the case in soils where layers have been laid down by depositional processes rather than developing in situ.

In the eDIRT app, as in SALIS, soil layers are identified by their number:

- Layers -2 and -1 are layers of organic material above the mineral soil surface. Their depth is measured in negative numbers from the soil surface. They may be considered O horizons.
- Layer 0 is the soil surface. It is a two-dimensional layer with no depth.
- Layers 1 to 98 are soil layers. Their depth is measured in positive numbers from the soil surface. They include the various soil horizons, for example, A, B, C and D horizons.
- Layer 99 is the substrate, the bedrock or sediment underlying the soil profile.

5.5 Release status

The **release status** of a profile determines who, apart from the person who created it, can access it once it has been uploaded to SALIS.

You can allocate one of the following levels of status to each soil profile:

- **Public:** the soil profile is accessible to members of the public through SALIS and eSPADE.
- **Internal:** the data is held pending submission of more data, completion of an associated project, report or publication, or for some other reason of timing. Data may be held in Internal status for up to 1 calendar year, with an indication of the date to be made public supplied in the Public release date field.
- **Confidential:** the data is only accessible to the data owner, that is, the person who submitted it, and to system administrators. This status is only to be used in special circumstances, for example, for privacy or legal reasons. Justification for the allocation of this status must be provided in the Request confidentiality field.

It is expected that soil profiles collected through eDIRT will be made public to increase the public knowledge base of soils in NSW, particularly if these soil profiles have been collected using public funding (see the NSW Government's Open Data Policy). Permanently restricting access to soil profiles recorded through eDIRT must be justified.

6. The eDIRT app desktop

6.1 eDIRT mobile app

The eDIRT mobile app's main page is shown in Figure 4 below.

The page includes: a menu bar (bottom), a list of your soil profiles recorded in the eDIRT app, and a map showing the location and status of your soil profiles. The profiles are listed in order by the date and time of last update, so the profile most recently created or edited appears at the top of the list.

On the map, **profiles** are shown as dots while **stations** are displayed as triangles.

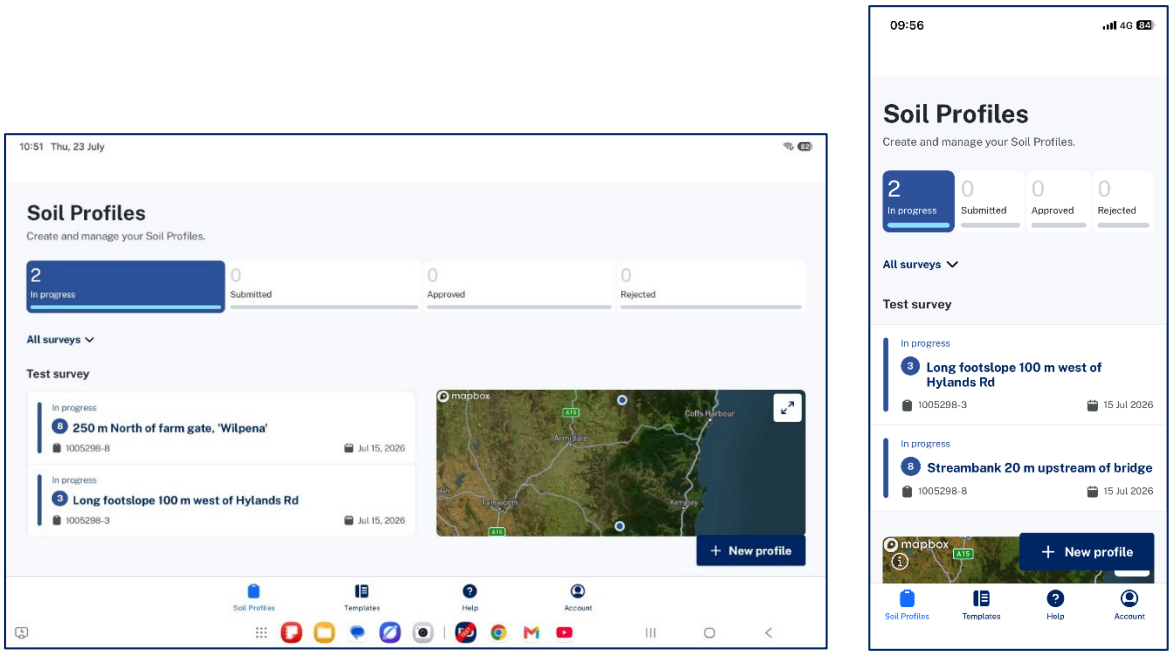


Figure 4 **eDIRT mobile app main page – Android tablet (left) and Apple smartphone (right)**

6.1.1 Profile status

Profiles that are in progress (that is, not yet submitted) are coloured blue.

Profiles that have been submitted are coloured yellow.

Profiles that have been approved are coloured green.

Profiles that have been rejected are coloured red.

6.2 eDIRT web app

The eDIRT app's main page is shown in Figure 5 below.

The page includes: a **menu bar** (dark blue, to left), a **list** of your **soil profiles** recorded in the eDIRT app, and a **map** showing the location and status of your soil profiles.

6.2.1 Profile status

Profiles that are in progress (that is, not yet submitted) are coloured blue.

Profiles that have been submitted are coloured yellow.

Profiles that have been approved are coloured green.

Profiles that have been rejected are coloured red.

6.2.2 Profile list

The profile list shows all profiles that you have created in the eDIRT app. Each line in the table represents an individual profile, and shows its number, name, parent survey and station (where recorded), the date on which the profile was described, and its status.

You can filter the list by selecting/deselecting the buttons at the top of the list that show the number of profiles of each status.

Profile sync status

Profiles displayed with a red crossed cloud icon have not yet been synchronised to the eDIRT server. The eDIRT app needs to be connected to the internet for these profiles to be synchronised. This should happen shortly after your device goes online, provided the eDIRT app is running.

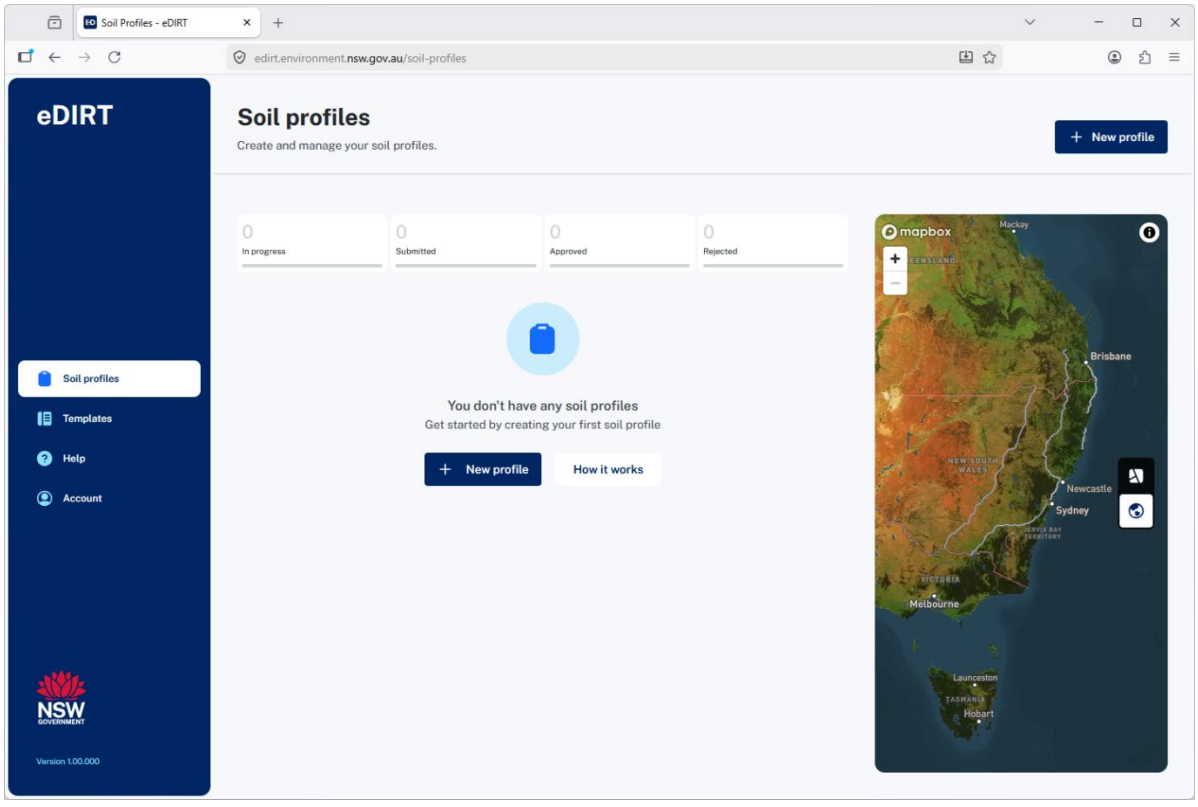


Figure 5 eDIRT web app desktop

6.2.3 Profile map

The map shows the location of the soil profiles you have recorded in the eDIRT app.

On the map, **profiles** are shown as dots while **stations** are displayed as triangles. Each point is coloured according to its profile status and is identified by its profile (or station) number.

To fully identify a profile on the map, click or tap on its marker. A pop-up will display the profile's number, name, parent survey and station number (if recorded) and the date on which the profile was described.

You can filter the profiles displayed on the map by selecting/deselecting the buttons at the top of the profile list.

To zoom in/out, click or tap on the  or  buttons.

To change the map background to roadmap, click or tap on the  button. To change the map background to satellite imagery, click or tap on the  button.

7. Creating a soil profile

7.1 Select or create a survey

To create a soil profile, you first need a **survey** for it to reside in. During the creation of a new profile, you can either nominate an existing survey or create a new one.

7.2 For normal (not monitoring) sites

If your new profile is a normal observation of the landscape and soil at a site and is not to be revisited over time to measure change in soil conditions, follow these steps.

1. Navigate to the **Soil profiles** page.
2. Click or tap on the + New profile **New profile** button.
3. If your new soil profile is part of an existing survey, click or tap on the **Existing survey** button. If you intend your new soil profile to be the first in a new survey, click or tap on the **New survey** button.

For a profile being assigned to an existing survey, follow these steps.

4. Enter part or all of the survey's name or unique seven-digit identifying number into the **Search surveys** field and click or tap to select the survey to which you wish to assign the soil profile.
5. Enter your new profile's number in the **Enter profile number** field. This number must be unique within the profile's parent **survey**. eDIRT advises on profile numbers that are available in the **Available numbers** field below. Then click or tap on the Continue **Continue** button.
6. Go to step 7 below.

For a profile being assigned to a new survey, follow these steps.

7. Enter the name of your new survey in the **Survey title** field, then click or tap on the Continue **Continue** button.
8. Click or tap on the **No** button in the **Is this a time monitoring site?** field.
9. Enter your new profile's number in the **Enter profile number** field. This must be unique within the profile's parent **survey**. eDIRT advises on profile numbers that are available in the **Available numbers** field below. Then click or tap on the Continue **Continue** button.

Continue to describe your new soil profile.

10. Select a **template** to apply to your new soil profile. See **Section 3.2 Templates** for more information. Then click or tap on the Continue **Continue** button.
11. Enter a description of your profile's location into the **Site location** field. This should be a concise description that allows you and others to identify the site of your profile, and also to corroborate the geolocation of the site that you will enter later in this process.

12. Select the state or territory of Australia within which your new profile is located using the **State** field. This field defaults to **NSW**.
13. Enter the date on which your new profile was described into the **Profile date** field.
14. Enter the release status of your new profile in the **Release status** field. See **Section 3.3 Profile status** above for more information. If you choose *Internal Release* you should provide a **Public release date**; if you choose *Confidential* you must provide justification in the **Request confidentiality** field that appears. Then click or tap on the Continue **Continue** button.
15. In the **Location** page that appears, describe the location of your soil profile, either by entering coordinates manually or by using the onboard GPS in your mobile device (where available).

    To enter coordinates manually:

    – Select the **Coordinate type**, either *GDA94* or *MGA94/UTM*.
    – For a Geocentric Datum of Australia (GDA) location, enter the **Latitude** and **Longitude**, or click or tap on the **Use device location** button at the base of the map; for a Map Grid of Australia (MGA)/Universal Transverse Mercator (UTM) location, select the **Zone** and enter an **Easting** and **Northing**.

    To enter coordinates automatically from your device's GPS (if available):

    – Click or tap on the Use current location **Use current location** button in the map pane.
16. Click or tap on the Create soil profile **Create soil profile** button.

eDIRT creates your new soil profile and displays the **Profile** main page. You can now start entering data for this profile.

7.3 For monitoring sites (stations)

If your new profile is being collected at a time monitoring site (a **station**), follow these steps.

1. Navigate to the **Soil profiles** page.
2. Click or tap on the + New profile **New profile** button.
3. If your new soil profile is part of an existing survey, click or tap on the **Existing survey** button. If your new soil profile is the first in a new survey, click or tap on the **New survey** button.

For a profile being assigned to an existing survey, follow these steps.

4. Enter part or all of the survey's name or unique seven-digit identifying number into the **Search surveys** field and click or tap to select the survey for the new soil profile.
5. Enter your new profile's number in the **Enter profile number** field. This number must be unique within the profile's parent **survey**. eDIRT tells you profile numbers that are available in the **Available numbers** field below. Then click or tap on the Continue **Continue** button.
6. Go to step 9 below.

For a profile being assigned to a new survey, follow these steps.

7. Enter the name of your new survey in the **Survey title** field, then click or tap on the Continue **Continue** button.
8. Click or tap on the **Yes** button in the **Is this a time monitoring site?** field.
9. To allocate your new profile to an existing station, click or tap on the **Existing** button. To create a new station, click or tap on the **New station** button.
10. For an existing **station**, enter its number. For a new **station**, enter its number and name. These must be unique within the parent **survey**.
11. Enter your new profile's number in the **Enter profile number** field. This number must be unique within the parent **station**. eDIRT advises on profile numbers that are available in the **Available numbers** field below. Then click or tap on the Continue **Continue** button.

Continue to describe your new soil profile.

12. Select a **template** to apply to your new soil profile. See **Section 3.2 Templates** for more information. Then click or tap on the Continue **Continue** button.
13. Enter a description of your profile's location into the **Site location** field. This should be a concise description that allows you and others to identify the site of your profile, and also to corroborate the geolocation of the site that you will enter later in this process.
14. Select the state or territory of Australia within which your new profile is located using the **State** field. This field defaults to **NSW**.
15. Enter the date on which your new profile was described into the **Profile date** field.
16. Enter the release status of your new profile in the **Release status** field. See **Section 3.3 Profile status** above for more information. If you choose *Internal Release* you should provide a **Public release date**; if you choose *Confidential* you must provide justification in the **Request confidentiality** field that appears. Then click or tap on the Continue **Continue** button.
17. In the **Location** page that appears, describe the location of your soil profile, either entering coordinates manually or using the onboard GPS in your mobile device (where available).

    To enter coordinates manually:

    - Select the **Coordinate type**, either *GDA94* or *MGA94/UTM*.
    - For a GDA94 location, enter the **Latitude** and **Longitude**, or click or tap on the **Use device location** button at the base of the map; for an MGA94/UTM location, select the **Zone** and enter an **Easting** and **Northing**.

    To enter coordinates automatically from your device's GPS (if available):

    - Click or tap on the Use current location **Use current location** button on the map pane.
18. Click or tap on the Create soil profile **Create soil profile** button.

eDIRT creates your new soil profile and displays the **Profile** main page. You can now start entering data for this profile.

8. The Profile page

The **Profile** page gives you access to a profile's defining details and all of the attributes available to be described given the **template** you have selected for that profile.

The profile number (and station number, if recorded) is displayed at the top left with its status. Immediately beneath is a horizontal menu bar giving access to each profile's **Overview**, **Site attributes**, **Layer attributes**, **Samples** and **Images**.

Click on the ← **Back** button to return to the **Soil profiles** page.

8.1 Overview page

The **Overview** page shows a profile's essential details, including:

- the name and number of its parent **survey**
- the name and number of its parent **station** (if recorded)
- the **template** applied to the profile record
- the profile's **site location**, the state or territory in which it has been recorded, its date of recording and its **release status**
- the **location** of the profile, shown as a point on a map and its coordinates
- the number of **layers**, **samples** and **images** recorded for the profile.

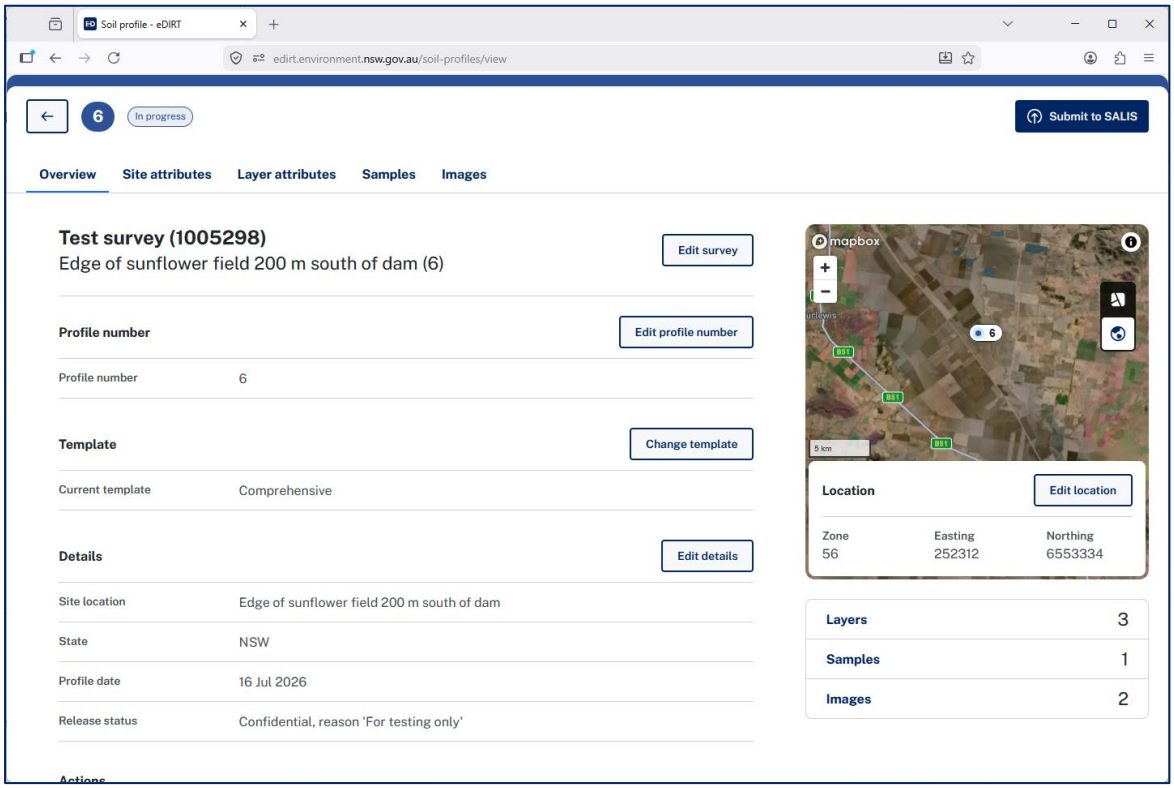


Figure 6 **eDIRT web app's Profile page**

To change the **survey** and **station** (where recorded) to which the profile has been assigned, click or tap on the Edit survey **Edit survey** button.

To change the profile number, click or tap on the Edit profile number **Edit profile number** button.

To change the template used for a profile, click or tap on the Change template **Change template** button.

To change the details of a profile, click or tap on the Edit details **Edit details** button.

To delete a profile, click or tap on the Delete soil profile **Delete soil profile** button.

To submit a profile, click or tap on the Submit to SALIS **Submit to SALIS** button.

Click or tap on the ← **Back** button to return to the **Soil profiles** page.

8.1.1 Profile map

The map shows the location of the soil profile.

Your **profile** is shown either a dot or (if associated with a **station**) a triangle. The profile marker is coloured according to its profile status and is identified by its profile (or station) number.

To zoom in/out, click or tap on the + or − buttons.

To change the map background to roadmap, click or tap on the button. To change the map background to satellite imagery, click or tap on the button.

To change the location of your profile, click or tap on the Edit location **Edit location** button.

8.2 Site attributes page

Depending on the template you have selected, there will be a range of **site attributes** available to be recorded for your soil profile. Click or tap on the **Site attributes** item in the menu bar to view, add and edit these attributes.

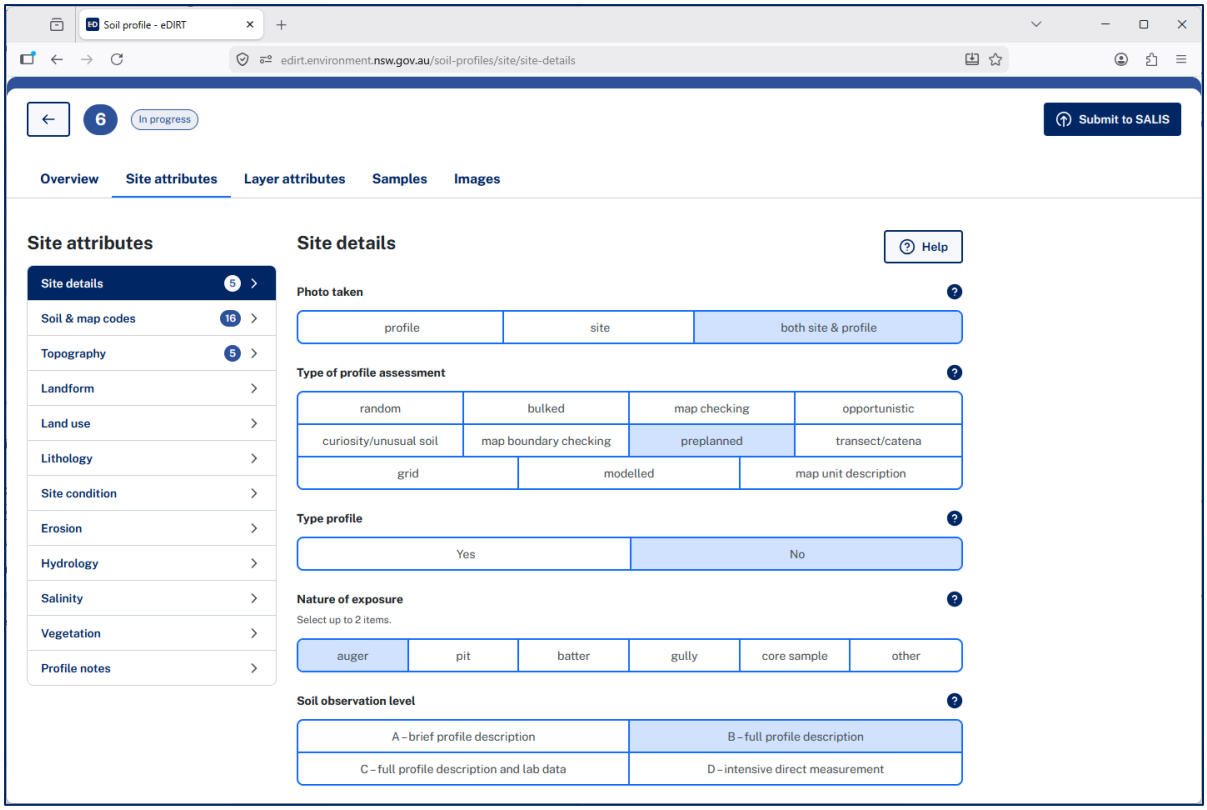


Figure 7 **eDIRT web app's Sites Attributes page, showing the Site details attributes**

Site attributes are grouped into categories. To view the attributes in each category, click or tap on its item in the left-hand menu.

As you enter data, the menu displays (in the dark blue bubbles) the number of attributes that you have recorded, and an **Alert** bubble to alert you to any errors in the data you have entered.

8.3 Layer attributes page

Depending on the template you have selected, there will be a range of **layers** and **layer attributes** available to be recorded for your soil profile. Click or tap on the **Layer attributes** item in the menu bar to create layers and to view, add and edit these attributes.

We recommend creating the layers for your profile sequentially in order of depth, from top to bottom of the profile. The eDIRT app does not allow you to insert layers between other existing layers, so if you need to add a new soil layer midway through the profile, you will need to delete any lower layers first.

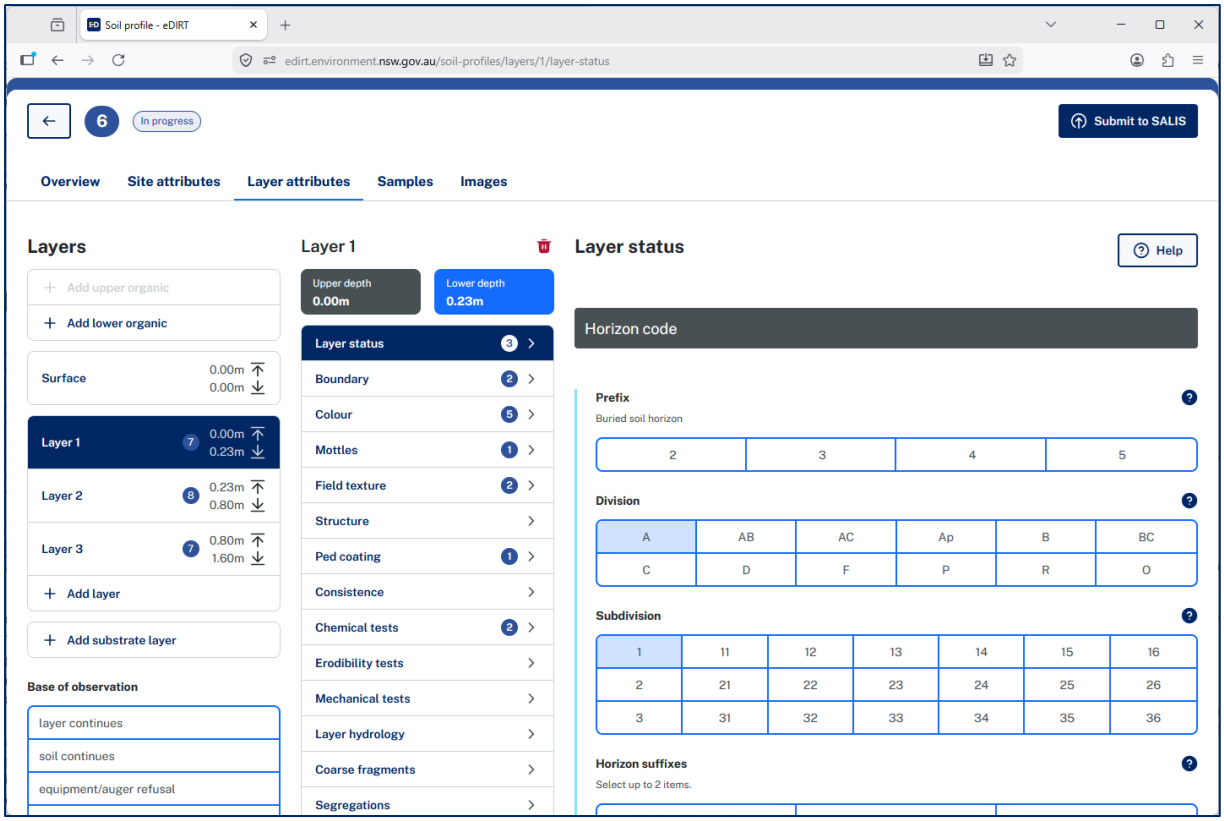


Figure 8 **eDIRT web app's Layer attributes page**

The menu on the far left of the page contains buttons to create new organic (-1, -2), soil (1-98) and substrate (99) layers. See **Section 4.4** for more information on layer numbers.

As you create layers in your profile, these are listed from uppermost to lowermost in the far-left menu, with their ⤒ upper depth and ⤓ lower depth displayed. As you enter data for these layers, the menu displays (in the dark blue bubbles) the number of attributes which you have recorded, and an ❗ **Alert** bubble to alert you to any errors in the layer.

Layer attributes are grouped into categories, which are listed in the centre-left menu. To view the attributes in each category, click or tap on its item in the left-hand menu. As you enter data, the menu displays (in the dark blue bubbles) the number of attributes that you have recorded, and an ❗ **Alert** bubble to alert you to any errors in the data you have entered.

8.3.1 Create organic layers

To create an organic layer, click or tap on the **Add lower organic** button.

The depth slider allows you to select the **upper depth** for the organic layer you are creating. The depth of organic layers is measured as a negative number (in metres) from the mineral soil surface. You can either click-drag or tap-drag to move the slider to select the upper depth for the organic layer you are creating, or you can click or tap on the depth marker (blue box) to manually enter the organic layer's upper depth.

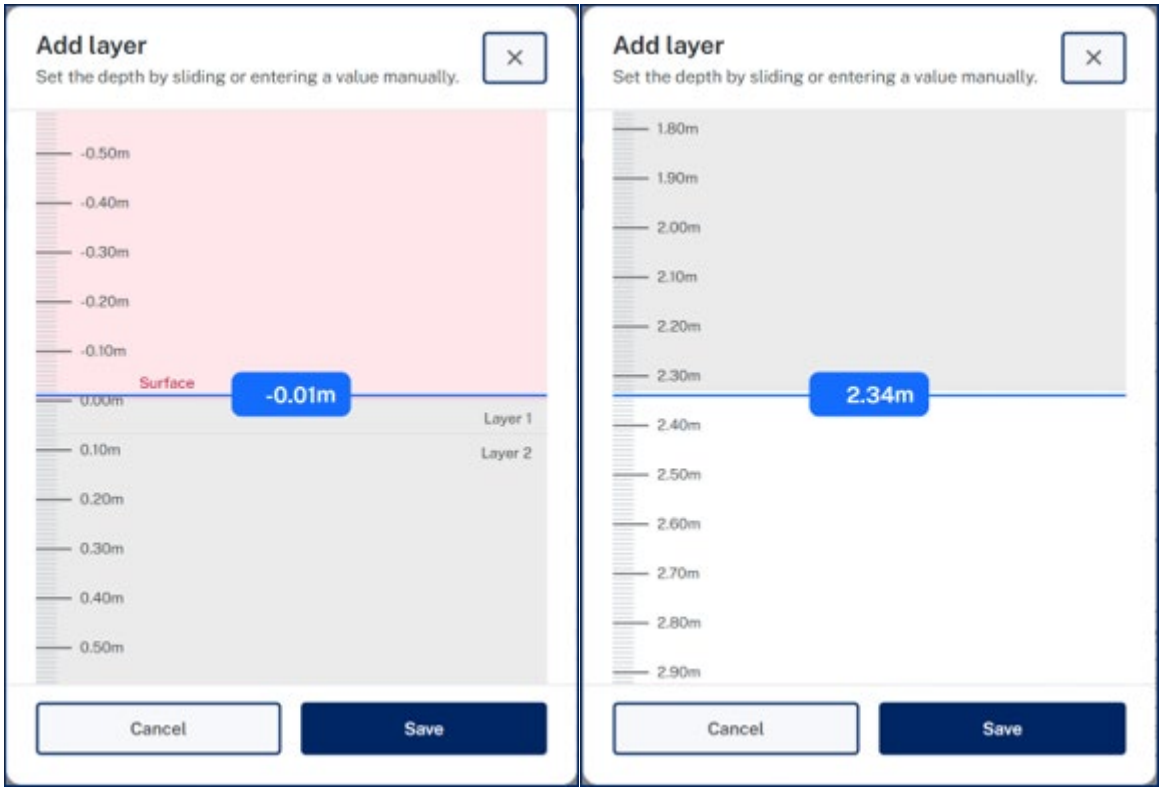


Figure 9 **Depth sliders for organic layers (left) and soil layers (right)**

8.3.2 Create soil layers

To create a soil layer, click or tap on the **Add layer** button.

The depth slider allows you to select the **lower depth** for the soil layer you are creating. The depth of soil layers is measured as a positive number (in metres) from the mineral soil surface. You can either click-drag or tap-drag to move the slider to select the lower depth for the soil layer you are creating, or you can click or tap on the depth marker (blue box) to manually enter the layer's lower depth. The layer's upper depth is taken as the lower depth of the previous layer.

8.3.3 Create substrate layer (optional)

To create a substrate layer, click or tap on the **Add substrate layer**. You may use the **Base of observation** field in conjunction with a substrate layer to describe the occurrence and depth of the substrate, where known. Unless your soil profile observation has definitively reached the substrate, it is best not to create a substrate layer.

The substrate layer's upper depth is taken as the lower depth of the lowest/deepest soil layer recorded.

8.4 Samples page

Depending on the content of the template you have selected for your profile, you can record one or more **samples** for that profile – or you can supply laboratory test results in spreadsheet form to eDIRT administrators for loading in bulk.

For more information, contact edirt.admin@environment.nsw.gov.au

A **sample** is a small volume of soil material collected from a profile that is tested at a laboratory for one or more physical, chemical or biological characteristics. Each sample is uniquely identified by its code and its upper and lower depths.

Soil samples may or may not be collected from within individual **layers** or **horizons** – for example, some soil sampling strategies require samples to be gathered from predefined soil depth intervals.

8.4.1 Sample code

The unique identifier for a sample is assembled from a number of individual fields:

1. A 3-letter or four-letter code denoting the laboratory at which the soil sample was tested
2. A two-digit number describing the year in which the sample was tested
3. A number of up to 4 digits that identifies the batch number of the sample
4. A number of up to 8 digits that identifies the individual sample within the batch
5. A number of up to 4 digits that identifies the fraction of the sample that was tested (optional).

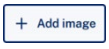
8.4.2 Sample tests

There are a large number of tests (770 at the time of writing) for which results may be recorded in eDIRT. These tests are identified by their unique test code and name, which come from the National reference texts:

- For soil chemical tests, Rayment GE and Lyons DJ (2011) *Soil Chemical Methods – Australasia*, CSIRO Publishing.
- For soil physical tests, McKenzie NJ, Cresswell H and Coughlan K (2002) *Soil Physical Measurement and Interpretation for Land Evaluation*, CSIRO Publishing.

8.5 Images page

Depending on the content of the template you have selected for your profile, you can record one or more **images**.

To associate an image with your profile, click or tap on the 

Add image button.

9. Submit a profile

When you have completed the description of your soil profile, you can **submit** it. To do so, click or tap on the 

Submit to SALIS button in the top-right corner of the **Profile** page. The **Submit** pop-up that appears will inform you whether your profile is ready to be submitted.

There are 3 conditions in which submitting a profile is not possible:

1. The **profile** contains errors (identified in the list of attributes with the icon).
2. Your eDIRT account has not been approved.
3. Your device is offline.

Otherwise, click or tap on the **Submit** button to submit your profile.

Once your profile has been submitted, it appears in your list of soil profiles with a status of **Submitted** (yellow). You can still view all of the details of the profile but can no longer edit it.

eDIRT administrators will process your profile and upload it to SALIS, creating new **survey** and **station** records as required. Once the upload is completed, you can view and access it in eSPADE.

10. Site attributes

10.1 Profile summary

This section contains essential identifying and locating information about a profile. Individual fields can be edited through the various sections of the **Overview** page.

10.1.1 Survey title (Survey number)

A **survey** is defined by a unique number and name. The survey title is assigned by the user. The survey number is automatically allocated. If you wish to create a new survey, you can add the new survey name yourself and the survey will be created for you when your data is submitted to SALIS. Alternatively, you can contact the eDIRT administrator in advance of your fieldwork by email at edirt.admin@environment.nsw.gov.au

The new survey will be automatically synchronised to your device.

10.1.2 Profile number

Each **profile** in a **survey** or **station** must have a unique profile number. It is recommended that a **survey** commence with **profile** number 1 and that subsequent **profiles** be numbered in sequential order to avoid confusion.

10.1.3 Station

Stations are used to designate time series data collection – that is, a site that will be revisited again in the future to measure any change. Each station in a survey must have a unique station number. It is recommended that a survey commence with station number 1 and that subsequent stations be numbered in sequential order to avoid confusion. Each station will have 1 or more profiles, each of which records the data collected at a single visit.

A single **survey** in eDIRT should contain either only individual unattached profiles, or only profiles assigned to stations. A survey should not contain a mixture of both, as this may cause problems with data integrity, particularly during data loading.

10.1.4 Site location

A short description of the location of the profile – for example, 'cutting 10 m west of bridge'. Up to 120 characters may be used, including spaces. If details require more than 120 characters, you may use abbreviations; some commonly used examples are shown in the table below.

Table 1 List of abbreviations used

Abbreviation	Term
ADJ	adjacent
BR	bridge
CK	creek

Abbreviation	Term
CNR	corner
E	east
FR	from
HWY	highway
MT	mountain
N	north
NP	national park
NR	near
R	river
RD	road
RES	reserve
S	south
SF	state forest
ST	street
STR	stream
T/O	turnoff
TR	track
W	west
XRD	crossroad or intersection

10.1.5 Profile date

The date on which the **profile** was described in the field.

10.1.6 Release status

Soil profile data can be submitted through eDIRT with one of 3 levels of status:

- **Public:** the soil profile is accessible to members of the public through SALIS and eSPADE.
- **Internal:** the data is held pending submission of more data, completion of an associated project, or for some other reason of timing. Data may be held in Internal status for up to 1 calendar year, with an indication of the date to be made public supplied in the Public release date field.
- **Confidential:** the data is only accessible to the data owner – that is, the person who submitted it – and to system administrators. This status is only to be used in special circumstances – for example, for privacy or legal reasons. Justification for the allocation of this status must be provided in the Request confidentiality field.

10.1.7 Public release date

Use this attribute to delay the release of **profiles** to a status of Public until the date specified is reached (limited to one calendar year after the date on which the **profile** was described).

10.1.8 Request confidentiality

Provide justification for the allocation of **Confidential** status to your **profile** in this field.

10.2 Location

This section contains essential information about the geographic location of a **profile** on the earth's surface, such as its grid references and supporting information. If your device has an onboard GPS you can use it to precisely locate yourself using the **Use current location** button.

You should calibrate the GPS inside your device before going offline to ensure it is accurate. You can do this (Google Android) by downloading a specialised GPS app that includes calibration software or (Apple iOS) perform a hard reset.

10.2.1 Coordinate type: MGA94/UTM

MGA94/UTM is a metric rectangular grid system comparable to the AMG66 grid in use in Australia since the 1980s. Grid references are recorded as an *Easting*, a *Northing* and a *Zone* (see Figure 10).

The *Map Grid of Australia* (*MGA*) is based on the Universal Transverse Mercator (UTM) projection and the Geocentric Datum of Australia (GDA) datum. Its parameters are the same as the AMG66 system, but because it is projected from a different datum, the coordinates of the same place in MGA94 will be different by several hundred metres from the coordinates of the same place in AMG66.

To deliver MGA94 coordinates from a separate handheld GPS unit, the coordinate position format should be set to UTM.

State/Territory

This field specifies the state or territory within which the **profile** is being described.

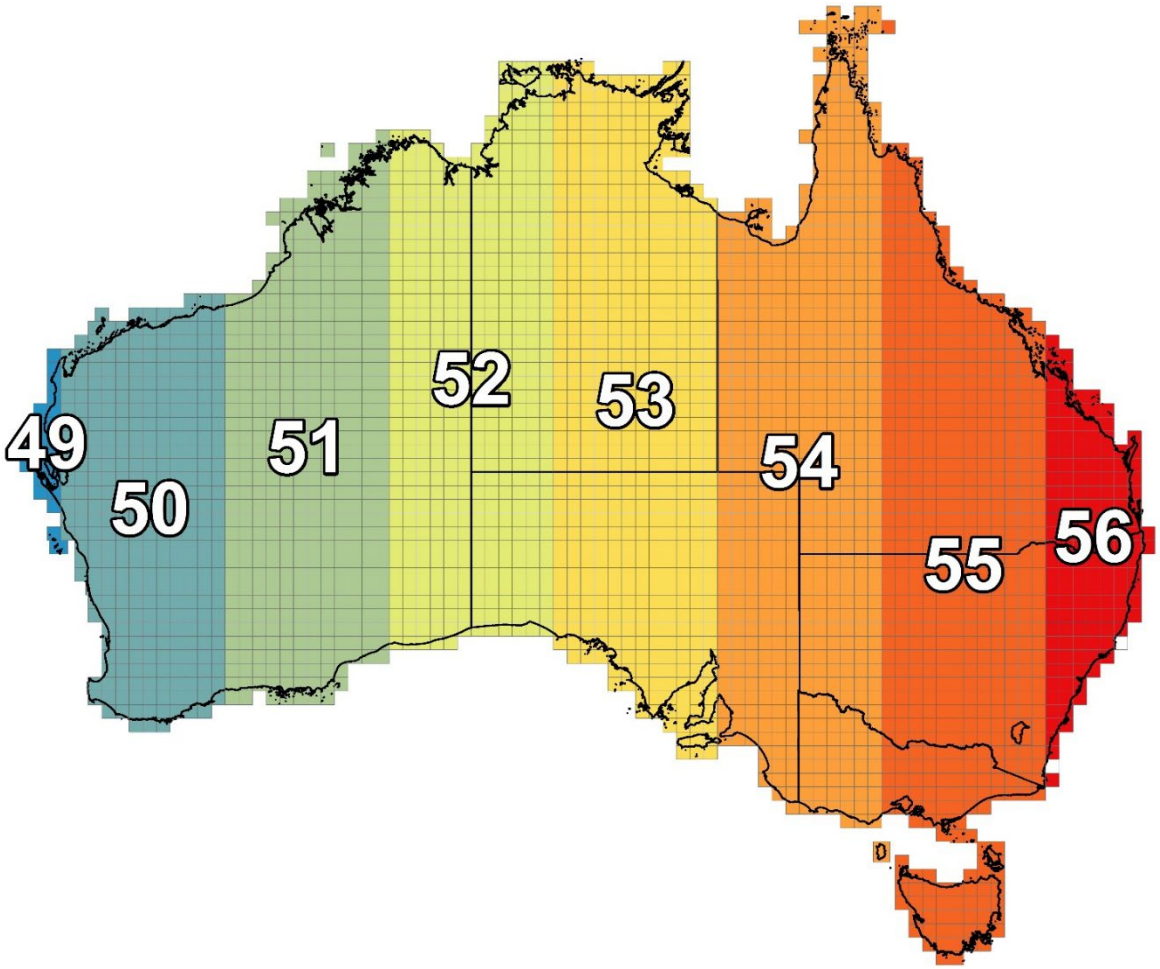


Figure 10 Map showing UTM zones in Australia

Zone

Zones divide Australia into several distinct north–south slices to manage the distortions produced when a rectangular grid system is projected onto the curved surface of the earth (an oblate spheroid) and are used in conjunction with **Easting** and **Northing** to locate a point on the earth's surface. The zones are defined globally as part of the UTM coordinate system, and each zone is 6° longitude in width. The zones covering Australia are shown in Figure 10 (above) and are defined as:

Zone 49: 108° E to 114° E

Zone 50: 114° E to 120° E

Zone 51: 120° E to 126° E

Zone 52: 126° E to 132° E

Zone 53: 132° E to 144° E

Zone 54: 138° E to 144° E

Zone 55: 144° E to 150° E

Zone 56: 150° E to 156° E

MGA Easting

This field specifies the east–west position of the **profile** on the earth's surface within the specified Zone using MGA94/UTM. Easting should be entered as a 6-digit number in metres (m).

MGA Northing

This field specifies the north–south position of the **profile** on the earth's surface within the specified Zone using MGA94/UTM. Northing should be entered as a 7-digit number in metres (m).

10.2.2 Coordinate type: GDA94

GDA94 is a geocentric coordinate system using *Latitude* and *Longitude* to identify locations on the earth's surface. It provides a consistent National coordinate system that is directly compatible with global coordinate systems such as those used by the Global Positioning System (GPS). GDA94 is almost identical to the WGS84 datum used by GPS.

Latitude

This field specifies the north–south position of the **profile** on the earth's surface using GDA. Latitude represents an angle ranging from 0° at the equator to 90° at the north or south poles. Latitudes in NSW range from approximately 24° S (-24°) to 38° S (-38°). Latitude should be entered in decimal degrees (DD).

Longitude

This field specifies the east–west position of the **profile** on the earth's surface using GDA. Longitude represents an angle east or west from the Prime Meridian (a north–south line passing through the Royal Observatory, Greenwich, UK) and ranges from 0° at the Prime Meridian to 180° W (-180°) and 180° E (180°). Longitudes in NSW range from approximately 141° E (141°) to 154° E (154°). Longitude should be entered in decimal degrees (DD).

10.2.3 Use current location

This control allows the eDIRT app to query the integrated GPS receiver inside your device to report your location. The accuracy of the location information depends on several factors, including:

- atmospheric effects
- sky blockage (for example, trees, buildings or hills)
- quality of the GPS receiver
- the range of satellite navigation systems the GPS can access
- whether the GPS has been calibrated.

The accuracy of the location information will be improved if you ensure your device has a clear view of the sky and its GPS has been correctly calibrated. Failure to do so can result in locational information that is inaccurate by up to several hundred metres. A

device that can access only one satellite navigation system (for example, GPS) will be less accurate than one that can access 2 (for example, GPS, GLONASS), and a device that can access 3 (for example, GPS, GLONASS, BeiDou) can provide levels of locational accuracy close to those of a dedicated handheld GPS receiver.

10.3 Site attributes

10.3.1 Photo taken

Record whether at least one photograph of the **profile**, **site** or both was taken. Any notes about the photographs taken may be recorded in the **Images** tab, where images you take can be associated with each **profile**.

10.3.2 Site type (BSAL)

For BSAL assessment only. Record the site type, using the 3 types defined in the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSW Government 2013), from which the following definitions are drawn.

Available values are:

- **check**: sites that are examined in sufficient detail to allocate the site to a soil type (ASC) and soil map unit. Soils at check sites must be classified (using the ASC) to suborder level (but need not be restricted to this level). Check sites are also commonly used to accurately position the boundaries of soil map units, to describe the variability within a soil map unit and to validate soil predictions. Check sites complement detailed sites. Only attributes that confirm a check site as belonging to a particular soil type need to be recorded along with the unique identification and the location (provided as GPS coordinates).
- **detailed**: sites that are described in sufficient detail to allow all major physical and chemical soil features of relevance to BSAL to be clearly identified. Soils at detailed sites must be classified (using ASC) to family level. The location of detailed sites must be representative of the soil type being assessed and have attributes that are typical for that soil. The description of the detailed site must be accompanied by a photograph of the site and of the soil profile (or soil material) being described.
- **exclusion**: observation sites used only within areas that fail the obvious landscape requirements of the BSAL classification – for example, rock outcrop, surface rockiness or gilgai microrelief. Neither detailed soil profile description nor soil survey is necessary.

10.3.3 Potential BSAL

For BSAL assessment only. This field allows an appropriately qualified soil scientist to record, in their expert opinion, whether the site is likely to be in an area of BSAL – that is, whether the site meets the definition of BSAL as defined by the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSW Government 2013).

10.3.4 Type of profile assessment

Record a value that best describes the purpose for which the **profile** was described and recorded. This may relate both to the purpose for which the soil was described and the purpose of the survey that the profile is part of.

Available values are:

- **random**: the location of the profile was determined completely randomly – for example, through generation of grid references within the survey area using a random number generator.
- **bulked**: the profile describes a number of sub-samples taken at several sites within a defined area – for example, a paddock. In this case, the grid references recorded for the profile should indicate the centre of the defined area, and the area across which the samples were taken should be recorded in the **profile notes**.
- **map checking**: the profile location was determined to assist in the definition of a soil or land mapping unit or classification, such as a Soil Landscape. In this case, the identity or basic characteristics of the mapping unit or classification should be recorded in the **profile notes**, and if available, the abbreviation for that mapping unit should be recorded in the **Soil map code**.
- **opportunistic**: the profile location was determined based on the opportunity of gaining a good description of the soil, due to prevailing circumstances at the time of description including ease of access to the site, availability of a good soil exposure in a batter or road cutting, etc.
- **curiosity/unusual profile**: the profile was described at this location because the soil was intrinsically interesting or unusual (a striking colour, unusual soil type, etc.) and therefore may not necessarily represent the dominant soils of the area around it. In this case, an indication of why the profile was described should be recorded in the **profile notes**.
- **map boundary checking**: the **profile** location was determined to assist in the location of boundaries between soil or land mapping units or classifications, such as Soil Landscapes. In this case, the identity or basic characteristics of the mapping unit or classification should be recorded in the **profile notes**, and if available, the abbreviation for that mapping unit should be recorded in the **soil map code.**
- **pre-planned**: the profile location was determined based on hypotheses or modelling of the most appropriate locations likely to present a typical example of the land, soil and other features found in the local landscape or land mapping unit, such as a Soil Landscape. In this case, the identity or basic characteristics of the mapping unit or classification should be recorded in the **profile notes**, and if available the abbreviation for that mapping unit should be recorded in the **soil map code**.
- **transect/catena**: the profile was described at its location as part of a set of observations taken along a transect, a Catena (a cross-section of the local landscape from highest to lowest point), or another linear feature such as a road or pipeline. In this case, the type of transect, Catena or other feature used should be recorded in the **profile notes.**

- **grid**: the profile location was chosen as part of a set of observations taken on a grid pattern. An indication of the grid used (for example, its size) should be recorded in the **profile notes.**
- **map unit description**: the profile location was determined to inform and support the description of a soil or land mapping unit or classification, such as a Soil Landscape. In this case, the identity or basic characteristics of the mapping unit or classification should be recorded in the **profile notes**, and if available, the abbreviation for that mapping unit should be recorded in the **soil map code.**
- **modelled**: the location of the profile was determined to inform, test or support the application of a model of landscape and/or soil distribution, typically produced through digital analysis of environmental information such as digital terrain modelling or radiometric image analysis.

10.3.5 Type Profile

Use this attribute to indicate if the **profile** is considered to be a 'Type Profile' – that is, a soil description that characterises the dominant soils in the Soil Landscape in which the profile occurs.

10.3.6 Nature of exposure

Indicate the method by which the soil was exposed to enable description.

10.3.7 Soil observation level

Four levels of detail of soil description can be defined based on attributes adapted from Hackett (1983) and Bouma (1989) by McKenzie (1992) and described in the following table.

Table 2 Soil descriptions

Level	No. of variables	Time taken	Type of data	Nature of description	Interpretation
A	1	1–30 mins	Soil name or brief profile description	Broad, qualitative, static and empirical	General statements of suitability for major types of land use; basic template
B	50–200	20–60 mins	Profile description	Can be detailed but qualitative, static and semi-empirical	Specific statements on some limitations; standard template
C	80–400	2–20 days	Profile description and laboratory data	Detailed, quantitative and static but mechanistic	Specific statements of most forms of limitations; comprehensive template
D	100–500	10–30 days	Direct measures of parameters	Detailed, quantitative,	Dynamic and probabilistic prediction of processes controlling land use. Input

Level	No. of variables	Time taken	Type of data	Nature of description	Interpretation
			controlling soil processes	dynamic and mechanistic	for computer models; comprehensive template

10.4 Soil and map codes

10.4.1 Geology map code

Record the Geology Map Code as published by the Australian Geological Society Organisation (AGSO). Please clearly use the appropriate case for the specified code. Otherwise, record the reference to the geology in **profile notes**.

10.4.2 Soil map code

A code may be recorded by the soil surveyor for possible use on a soils map.

10.4.3 Estimated land and soil capability

An eight-class system indicating the inherent physical capability of the land and soil to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources. For more information about the LSC assessment scheme, see *The land and soil capability scheme, Second approximation* (Murphy et al. 2012), available online on the LSC mapping page at Land and Soil Capability Mapping for NSW.

Available values are:

- **1**: very slight to negligible limitations. Land capable of sustaining high impact land uses – for example, cultivation – and no special land management practices required.
- **2**: slight but significant limitations. Land capable of sustaining high impact land uses which can be managed by readily available and easily implemented management practices.
- **3**: moderate limitations. Land capable of sustaining high impact land uses using more intensive, readily available and accepted management practices.
- **4**: moderate to severe limitations. Land generally not capable of sustaining high impact land uses unless using specialised management practices with high level of knowledge, expertise, inputs, investment and technology. Limitations are more easily managed for lower impact land uses – for example, grazing.
- **5**: severe limitations. Land not capable of sustaining high impact land uses except where resources allow for highly specialised land management practices to overcome limitations (e.g. high value crops). Lower impact land uses (e.g. grazing) can be managed by readily available practices.
- **6**: very severe limitations. Land incapable of sustaining many land use practices – for example, cultivation, moderate to high intensity grazing and horticulture. Highly specialised practices can overcome some limitations for some high value products. Land often used for low intensity land uses (low intensity grazing).

- **7**: extremely severe limitations. Land incapable of sustaining most land uses. Limitations cannot be overcome.
- **8**: extreme limitations. Land incapable of sustaining any land use and best left undisturbed and managed for conservation.

10.4.4 Regolith classification

A classification system of soil regolith stability defined and described in *Soil regolith stability classification for State Forests in eastern NSW* (Murphy et al. 1998).

Available values are:

- **R1**: high coherence soils with low sediment delivery potential. Stable soils with no appreciable erosion. Generally well drained, permeable soils. Earth batters are stable. No or little general evidence of coarse or fine sediment movement.
- **R2**: low coherence soils (when wet) with low sediment delivery potential. Sandy soils which, when exposed, commonly exhibit sheet wash and evidence of coarse sediment movement such as sediment fans at drain outlets and in gutters. Little sediment transport into drainage network.
- **R3**: high coherence soils with high sediment delivery potential. Clayey and silty soils which are liable to sheet erosion. Typically slowly permeable and drainage generally impeded. Earth batters and exposed surfaces subject to minor to moderately extensive rilling and moderate slumping. Minor gully erosion may develop in drainage lines and incision may occur along road drains. Localised films of fine sediment at drain outlets and in drainage lines.
- **R4**: low coherence soils (when wet), with very high fine sediment delivery potential. Unstable, dispersible soils which are prone to severe sheet and rill erosion and to gully erosion. Rilling and/or slumping is common on batters and gully erosion is common in drainage lines and along road drains. Snig tracks display frequent rill erosion. Drainage lines show extensive films of fine sediment.

10.4.5 Australian Soil Classification

Under the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) agreement the *Australian Soil Classification* (ASC) must be used as the primary soil classification for all work relating to the New South Wales or Australian Governments.

Australian Soil Classification Version

This field records the version of the Australian Soil Classification (ASC) that is being used to classify the soil profile. Available values are:

- **2nd Edition**: refers to the *Australian Soil Classification, 2nd Edition* (Isbell, 2002).
- **3rd Edition**: refers to the *Australian Soil Classification, 3rd Edition* (Isbell and National Committee on Soil and Terrain, 2021).

Order

A 2-letter code is recorded at the Order level; and further codes are added for Sub-order, Great Group, Subgroup and Family levels where appropriate classes are available, as described in the 2 versions of the *Australian Soil Classification* supported by the eDIRT app.

Sub order

As described in the *Australian Soil Classification* (version selected in **Australian Soil Classification Version**). Recording of **Sub order** is mandatory for a valid ASC classification; if not known, use Class Undetermined (YY).

Great group

As described in the *Australian Soil Classification* (version selected in **Australian Soil Classification Version**). Recording of **Great group** is mandatory for a valid ASC classification; if not known, use Class Undetermined (YY).

Sub group

As described in the *Australian Soil Classification* (version selected in **Australian Soil Classification Version**). Recording of **Sub group** is mandatory for a valid ASC classification; if not known, use Class Undetermined (YY).

Horizon thickness

As described in the *Australian Soil Classification* (version selected in **Australian Soil Classification Version**).

Family

As described in the *Australian Soil Classification* (version selected in **Australian Soil Classification Version**).

Confidence level

As described in the *Australian Soil Classification* (version selected in **Australian Soil Classification Version**).

Final ASC

As described in the *Australian Soil Classification* (version selected in **Australian Soil Classification Version**).

10.4.6 Great Soil Group

GSG code

As described in A handbook of Australian soils (Stace et al. 1968).

GSG affinity

An affinity is given based on *A handbook of Australian soils* (Stace *et al.* 1968)

10.4.7 Factual key

As described in A factual key for the recognition of Australian soils (Northcote 1979).

Division

As described in A factual key for the recognition of Australian soils (Northcote 1979).

Subdivision

As described in A factual key for the recognition of Australian soils (Northcote 1979).

Section

As described in A factual key for the recognition of Australian soils (Northcote 1979).

Class

As described in A factual key for the recognition of Australian soils (Northcote 1979).

Prefix

As described in A factual key for the recognition of Australian soils (Northcote 1979).

10.4.8 World reference base

As described in *World reference base for soil resources 2014* (Food and Agriculture Organisation of the United Nations, 2014).

Reference soil group

As described in *World reference base for soil resources 2014* (Food and Agriculture Organisation of the United Nations, 2014).

Principal qualifiers

As described in *World reference base for soil resources 2014* (Food and Agriculture Organisation of the United Nations, 2014).

Non listed principal qualifiers

Text field that allows the users to specify a new principal qualifier that has not yet been published formally in *World reference base for soil resources 2014* (Food and Agriculture Organisation of the United Nations, 2014).

Supplementary qualifiers

As described in *World reference base for soil resources 2014 (*Food and Agriculture Organisation of the United Nations, 2014).

Non listed supplementary qualifiers

Text field that allows the users to specify a new supplementary qualifier that has not yet been published formally in *World reference base for soil resources 2014* (Food and Agriculture Organisation of the United Nations, 2014).

10.5 Topography

Topography has attributes that describe the site, generally extending from the profile to a radius of 10 m, or the edge of the landform element whichever is the lesser.

10.5.1 Slope measurement

The slope of the land at each site is the tangent of the ground surface, from the horizontal angle, an incline upwards or downwards expressed as a percentage (Morse *et al.* 1982). If the site is an excavation, record the probable natural slope prior to disturbance.

10.5.2 Slope measurement type

Indicate whether the slope gradient was measured, for example, with a clinometer or Abney level, or estimated.

10.5.3 Slope measurement method

Indicate which method was used to measure the slope at the site.

Available values are:

- **inclinometer:** a basic handheld instrument used for visually measuring inclines of slope, usually known as a clinometer.
- **Abney level:** a surveying instrument consisting of a fixed sighting tube, moveable spirit level connected to a pointing arm, and a protractor scale, providing a more accurate measurement of slope than a handheld instrument.
- **total station:** an electronic/optical instrument that typically includes an electronic theodolite integrated with an electronic distance meter; capable of greater accuracy of measurement than purely optical instruments, modern total stations typically log survey information to internal or external data storage.
- **RTK GPS:** Real-Time Kinematics (RTK) provides enhanced accuracy of location and measurement to a Global Positioning System (GPS) by deploying carrier phase tracking via a fixed base station and several mobile stations, allowing relative calculation of location to potentially millimetric accuracy.
- **LIDAR:** Laser Imaging Detection and Ranging (LIDAR) provides highly accurate landform imaging capable of detecting subtle topographic features and providing accurate measurements of slope across a surveyed area. LIDAR imagery is typically collected by airborne sensors and requires a Geographic Information System (GIS) for analysis and display.
- **photogrammetry:** slope has been determined through the analysis of photographic images, typically using stereo aerial photography. Using this technology, individual images are geo-located and triangulated, then analysed as stereo pairs through specialised computer software to generate a three-dimensional model of the land surface. The slope of the land at a site can then be calculated from this modelled surface.

10.5.4 Slope percentage

The slope of the land at each site is the tangent of the ground surface, from the horizontal angle, an incline upwards or downwards expressed as a percentage (Morse *et al.* 1982). If the site is an excavation, record the probable natural slope prior to disturbance.

10.5.5 Elevation

Usually determined from a topographic map or from a GPS. Record the elevation in whole metres, above mean sea level. Negative elevation, that is the depth of a land surface below sea level, may be entered by adding a minus sign (-) before the numeric value.

10.5.6 Aspect

Refers to the direction that the slope faces and should be recorded in the field using one of the 8 cardinal points. Note that level sites will have no aspect and the central position (flat) should be used to record that the site is without aspect.

10.6 Landform

10.6.1 Site process

Describe the principal form of geomorphological activity using one of the values defined below. Additional or more detailed information can be recorded in **Soil Landscape Geomorphic Class**.

Available values are:

- denudational process
  - **residual**: in situ processes of weathering, leaching and new mineral formation are dominant. Lateral surface movement is minimal. A residual site may occur either on low gradient topography, such as a plateau surface, or where soil material is of such a nature as to resist lateral movement despite a considerable slope gradient (Paton 1978).
  - **transportational**: both subsurface in situ processes and surface processes of lateral movement occur. These processes are normal on hillslopes but, depending on the type of materials involved, the slope gradient necessary for lateral movement of surface material can be very low (Paton 1978).
- depositional process
  - **depositional**: The processes of lateral surface movement are dominant (Paton 1978). It typically occurs in colluvial areas – for example, footslopes.
  - **alluvial**: Unconsolidated surface material deposited mainly by running water – for example, streams or rivers.
  - **littoral**: Surface material is comprised of unconsolidated sediments deposited by tidal water.
  - **lacustrine**: Unconsolidated surface material deposited mainly in standing water – for example, lakes.

  - **aeolian**: Dominant surface materials have been transported and deposited by the wind.
- disturbed terrain
  - **disturbed**: Landform components have been permanently altered from their original state by human activity.

10.6.2 Site morphology

Site morphology is the morphological type that best describes the landform element. The morphological types are illustrated in Figure 11 and defined below.

Available values are:

- **flat**: is neither a crest nor a depression and is level or very gently inclined (<3% slope gradient).
- **crest**: stands above all or almost all points in the adjacent terrain. It is characteristically smoothly convex upwards.
- **hillock**: comprised of a narrow crest and adjoining slopes, the crest length being less than the width of the landform element; compare to ridge.
- **ridge**: comprised of a narrow crest and adjoining slopes, the crest length being greater than the width; compare to hillock.
- **upper slope**: adjacent to and below a crest or flat but not adjacent to or above a depression.
- **midslope**: below but not adjacent to a crest or a flat, and above but not adjacent to a flat or a depression.
- **simple slope**: adjacent to either a crest and a flat, a crest and a depression, 2 flats, or a flat and a depression.
- **lower slope**: adjacent to and above a flat or a depression but not adjacent to and below a crest or flat.
- **open depression**: is situated below most points in the adjacent terrain. It extends at the same elevation as, or lower than, the locality where it is observed.
- **closed depression**: stands below all points in the adjacent terrain.

10.6.3 Plan curvature

Refers to the degree of concavity or convexity across (perpendicular) to the slope - in other words, whether the surface shape is convergent, divergent or broadly parallel. This is in contrast to slope morphology, which refers to the landform shape upslope and downslope.

Available values are:

- **divergent**: the cross-section of the slope is convex – that is, the cross-section curves downwards towards its extremities, so that any runoff diverges from the centre towards the extremities.
- **parallel**: the cross-section of the slope is straight – that is, the slope is planar, so that any runoff flows downslope in the same direction.

- **convergent: t**he cross-section of the slope is concave – that is, the cross-section curves downwards towards its centre, so that any runoff converges from the extremities towards the centre.

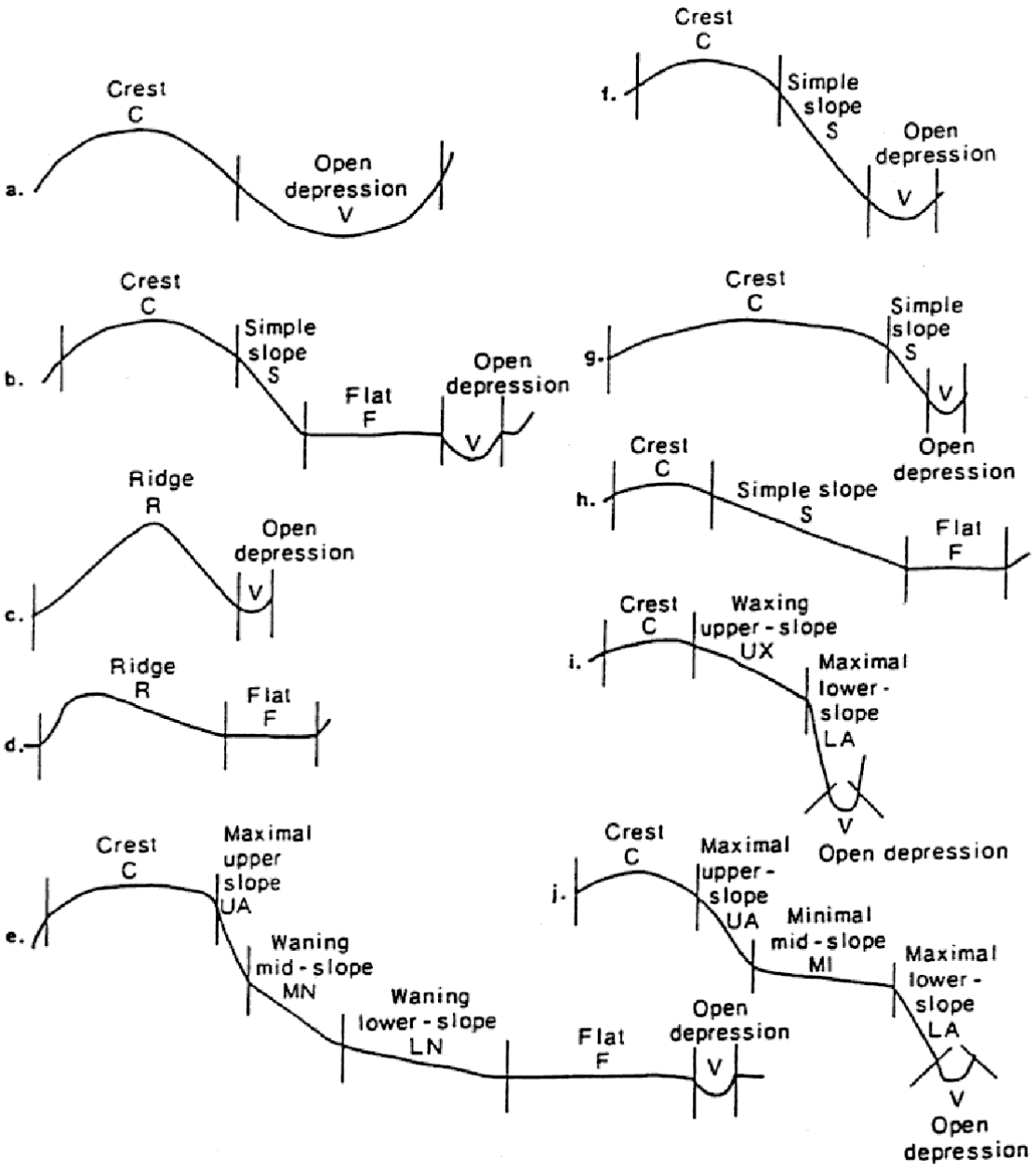


Figure 11 Morphological types of landform element (after NCST 2009)

10.6.4 Slope morphology

Refers to the slope inclination relative to adjacent landform elements (see Figure 11). In general, crests are similar to waxing slopes, and depressions to waning slopes, whereas flats do not relate to such a scheme.

Available values are:

- **waxing**: element upslope is gentler and element downslope is steeper.
- **waning**: element upslope is steeper and element downslope is gentler.
- **maximal**: element upslope is gentler and element downslope is gentler.
- **minimal**: element upslope is steeper and element downslope is steeper.

10.6.5 Local relief

Local relief is the difference in elevation between the high and low points of the landscape. The table below illustrates the relationship between local relief, slope percentage, and landform pattern and can be used to help assign a value.

Table 3 Slope percentage

Local Relief	Level (<1%)	Very Gently Inclined (1–3%)	Gently Inclined (>3–10%)	Moderately Inclined (>10–32%)	Steep (>32–56%)	Very Steep (>56–100%)	Precipitous (>100%)
Very High (>300 m)	–	–		rolling mountains	steep mountains	very steep mountains	precipitous mountains
High (90–300 m)	–	–	undulating hills	rolling hills	Steep hills	very steep hills	precipitous hills
Low (30–90 m)	–	–	undulating low hills	rolling low hills	steep low hills	very steep low hills	badlands
Very Low (9–30 m)	–	gently undulating rises	undulating rises	rolling rises	steep rises	badlands	badlands
Extremely Low (<9 m)	level plain	gently undulating plain	undulating plain	rolling plain	badlands	badlands	badlands

(from NCST 2009)

10.6.6 Landform pattern

Record a value which best describes the general landform within a radius of 300 m of the site. **Landform Patterns** descriptions are based on those from NCST (2009).

Available values are:

- **alluvial fan**: level to very gently inclined complex pattern of extremely low relief. The rapidly migrating alluvial stream channels are shallow to moderately deep, locally numerous, but elsewhere widely spaced. The channels form a centrifugal to divergent, integrated, reticulated to distributary pattern. Includes areas that are bar plains being aggraded or eroded by frequently active channelled stream flow, and other areas comprising terraces or stagnant alluvial plains with slopes that are greater than usual formed by channelled stream flow but now relict; incision in the upslope area may give rise to an erosional stream bed between scarps. Typical elements are stream bed, bar and plain. Also includes scarp (compare *sheet-flood fan*, *pediment*).
- **alluvial plain**: level with extremely low relief. The shallow to deep alluvial stream channels are sparsely to widely spaced, forming a unidirectional integrated network. There may be frequently active erosion and aggradation by channelled and overbank stream flow, or relicts from these processes. Typical elements are stream channel plain, bar, scroll, levee, backplain, swamp, ox bow, flood out, lake. Includes other active patterns such as floodplain, bar plain, meander plain, covered plain, anastomotic plain, delta. Also includes the relict patterns stagnant alluvial plain, terrace.
- **anastomotic plain**: a floodplain with slowly migrating deep stream channels, usually moderately spaced, forming a divergent to unidirectional integrated reticulated network. There is frequently active aggradation by overbank and channelled stream flow. Typical elements are stream channel, levee, backplain (dominant) (compare *alluvial plain*, *floodplain*).
- **badlands**: steep to precipitous slopes, with low to extremely low relief typically with numerous fixed erosional stream channels which form a non-directional integrated tributary network. There is continuously active erosion by collapse, landslide, sheet flow, creep and channelled stream flow. Typical elements are ridge (dominant), stream bed, gully. Also includes summit surface, hillcrest, hillslope, talus (compare *mountains*, *hills*, *low hills*, *rises*, *plain*).
- **bar plain**: floodplain with numerous rapidly migrating, shallow, alluvial channels forming a unidirectional integrated reticulated network. Active aggradation and erosion by channelled stream flow are frequent. Typical elements are stream bed, bar (dominant) (compare *alluvial plain* and *floodplain*).
- **beach ridge plain**: level to gently undulating with extremely low relief on which stream channels are absent or very rare. Consists of relict parallel beach ridges. Typical elements are beach ridge (co-dominant), swale (co-dominant). Also includes beach, foredune, tidal creek (compare *chenier plain*).

- **caldera**: a large basin-shaped volcanic depression of very high relief and steep to precipitous slope. Either without stream channels or has fixed erosional channels forming a centripetal integrated tributary pattern. Typical elements are scarp, hillslope, lake. Also includes cone, hillcrest, stream channel.
- **chenier plain**: level to gently undulating with extremely low relief on which stream channels are very rare. Consists of relict, parallel linear ridges built up by waves, separated by and built over flats (mudflats) aggraded by tides or overbank stream flow. Typical elements are beach ridge (co-dominant), flat (co-dominant). Also includes tidal flat, swamp, beach, foredune, tidal creek (compare *beach ridge plain*).
- **coral reef**: may be active or relict, built up to sea level of the present day or of a former time by corals and other organisms. Mainly level, with moderately inclined to precipitous slopes below sea level. Stream channels are generally absent, but there may occasionally be fixed deep erosional tidal stream channels forming a disintegrated non tributary pattern. Typical elements are reef flat, lagoon, cliff (submarine). Also includes beach and beach ridge.
- **covered plain**: floodplain with slowly migrating deep alluvial channels, usually widely spaced and forming a unidirectional integrated non tributary network. There is frequently active aggradation by overbank stream flow. Typical elements are stream channel, levee, backplain (dominant). Also includes swamp (compare *alluvial plain*, *floodplain*).
- **delta**: floodplain projecting into a sea or lake, with slowly migrating, deep alluvial channels, usually moderately spaced, typically forming a divergent integrated distributary network. Aggraded by frequently active overbank and channelled stream flow that is modified by tides. Typical elements are stream channel, levee, backplain (co-dominant), swamp (co-dominant), lagoon (co-dominant). Also includes beach ridge, swale, tidal creek (compare *alluvial plain*, *floodplain*, *chenier plain*).
- **dunefield**: level to rolling with very low or extremely low relief without stream channels, built up or locally excavated, eroded or aggraded by wind. Typical elements are dune, swale, blow out.
- **escarpment**: steep to precipitous, forming a linearly extensive, straight or sinuous, inclined surface which separates terrain at different altitudes. Above the escarpment commonly is a plateau. Relief may be high (hilly) or low (planar). The upper margin is often marked by an included cliff or scarp. Typical elements are hillcrest, hillslope. Also includes cliff, scarp, talus, footslope, alcove.
- **floodplain**: an alluvial plain characterised by frequently active erosion and aggradation by channelled or overbank stream flow. Includes other patterns: bar plain, meander plain, covered plain, anastomotic plain and delta (compare *alluvial plain*).
- **hills**: gently inclined to precipitous slopes of high relief. Fixed, shallow erosional stream channels, closely to very widely spaced, form a non-directional or convergent, integrated tributary network. There is continuously active erosion by wash and creep and occasionally active erosion by landslides. Typical elements are hillcrest, hillslope (dominant), drainage depression, stream bed. Also includes

footslope, alcove, valley flat, gully, tor, summit surface, scarp, landslide, talus, bench, doline (compare *mountains*, *low hills*, *rises*, *plain*).

- **karst**: a pattern of unspecified relief and slope, typically with fixed deep erosional stream channels forming a non-directional disintegrated tributary pattern and many closed depressions without stream channels. Eroded by continuously active solution and rarely active collapse, the products are removed through underground channels. Typical elements are hillcrest, hillslope (dominant), doline. Also includes summit surface, valley flat, plain, alcove, drainage depression, stream channel, scarp, footslope, landslide, talus.
- **lacustrine plain**: level landform pattern with extremely low relief formerly occupied by a lake but now partly or completely dry. It is relict after aggradation by waves and by deposition of material from suspension and solution in standing water. The pattern is usually bounded by wave-formed features such as cliffs, rock platforms, beaches, berms and lunettes. These may be included or excluded. Typical elements are plain, beach, cliff, rock platform and berm (compare *playa plain*).
- **lava plain**: level to undulating with very low to extremely low relief typically with widely spaced fixed erosional stream channels which form a non-directional, integrated or interrupted tributary pattern. Aggraded by volcanism (lava flow) that is generally relict, it is subject to erosion by continuously active sheet flow, creep, and channelled stream flow. Typical elements are plain, hillslope, stream bed.
- **longitudinal dunefield**: dunefield characterised by long, narrow sand dunes and wide, flat swales. The dunes are oriented parallel with the direction of the prevailing wind, and in cross-section one slope is typically steeper than the other. Typical elements are dune, swale, blow out (compare *parabolic dunefield*).
- **low hills**: gentle to very steep slopes of low relief, typically with fixed erosional stream channels, closely to very widely spaced, which form a non-directional or convergent integrated tributary pattern. There is continuously active sheet flow, creep, and channelled stream flow. Typical elements are hillcrest, hillslope (dominant), drainage depression, stream bed. Also includes footslope, alcove, valley flat, gully, tor, summit surface, landslide, doline.
- **made land**: where human activity has brought about severe disturbance to the natural landscape features. It includes irrigation areas, reclaimed land, restored mining areas, etc. Typical elements are fill top (dominant), cut over surface, cut face, embankment, berm, trench. Also includes mound, pit, dam.
- **marine plain**: plain eroded or aggraded by waves, tides or submarine currents, and aggraded by deposition of material from suspension and solution in sea water, elevated above sea level by earth movements or eustasy, and little modified by subaerial agents such as stream flow or wind. Typical elements include plain, dune and stream channel.
- **meander plain**: a floodplain with widely spaced, rapidly migrating, moderately deep alluvial stream channels which form a unidirectional integrated non-tributary network. There are frequently active aggradation and erosion by channelled stream flow with subordinate aggradation by overbank stream flow. Typical elements are

stream channel, scroll, plain (dominant). Also includes ox bow (compare *alluvial plain*, *floodplain*).

- **meteor crater**: extremely rare; comprising a circular closed depression (compare *crater*) with a raised margin; typically of low to high relief and having a large range of slope values, without stream channels, or with a peripheral integrated pattern of centrifugal tributary streams. The pattern is excavated, heaved up and built up by meteor impact. Typical elements are crater, scarp, talus, footslope, plain, hillcrest, hillslope.
- **mountains**: moderate to precipitous slopes of very high relief with fixed erosional stream channels which are closely to very widely spaced and form a non-directional or diverging integrated tributary network. There is continuously active erosion by collapse, landslide, sheet flow, creep, and channelled stream flow. Typical elements are hillcrest, hillslope (dominant), stream bed. Also includes talus, landslide, alcove, valley flat, scarp, cirque, footslope (compare *hills*, *low hills*, *rises*, *plain*).
- **parabolic dunefield**: dunefield characterised by sand dunes with a long, scoop-shaped form, convex in the downwind direction so that its trailing arms point upwind; the ground plan, when developed, approximates the form of a parabola. Where many parabolic dunes have been active, the trailing arms give the impression of a longitudinal dunefield. Typical elements include dune, swale and blow out.
- **pediment**: gently inclined to level feature of extremely low relief; typically with numerous, rapidly migrating, very shallow, incipient stream channels which form a centrifugal to diverging integrated reticulated pattern. Underlain by bedrock, eroded and locally aggraded by frequently active channelled stream flow or sheet flow with subordinate wind erosion. Characteristically lies downslope from adjacent hills with markedly steeper slopes. Typical elements are pediment, plain stream bed (compare *sheet-flood fan*, *alluvial fan*).
- **pediplain**: level to very gently inclined with extremely low relief and no stream channels, eroded by barely active sheet flow and wind. Largely relict from more effective erosion by stream flow in incipient stream channels as on a pediment. Typical element is plain.
- **peneplain**: level to gently undulating with extremely low relief and sparse, slowly migrating stream channels which form a non-directional integrated tributary pattern. It is eroded by barely active sheet flow, creep, and channelled and overbank stream flow. Typical elements are plain (dominant), stream channel.
- **plain**: level to undulating or, rarely, rolling with extremely low relief.
- **plateau**: level to rolling with plains, rises or low hills standing above a cliff, scarp or escarpment that extends around a large part of its perimeter. A bounding scarp or cliff may be included or excluded; a bounding escarpment would be an adjacent pattern. Typical elements are plain, summit surfaces, cliff. Also includes hillcrest, hillslope, drainage depression, rock flat, scarp, stream channel.
- **playa plain**: level with extremely low relief, typically without stream channels; aggraded by rarely active sheet flow and modified by wind, waves, and soil phenomena. Typical elements are playa, lunette, plain.

- **rise**: very gentle to steep slopes. Very low relief. The fixed erosional stream channels are closely to very widely spaced and form a non-directional to convergent, integrated or interrupted tributary pattern. The pattern is eroded by continuously active to barely active creep and sheet flow. Typical elements are hillcrest, hillslope (dominant), footslope, drainage depression. Also includes valley flat, stream channel, gully, tor, fan (compare *mountains*, *hills*, *low hills*, *plain*).
- **sand plain**: level to gently undulating with extremely low relief and without channels; formed possibly by sheet flow or stream flow but now relict and modified by wind action. Typical element is plain. Also includes dune, playa, lunette.
- **sheet-flood fan**: level to very gently inclined with extremely low relief and numerous, rapidly migrating, very shallow incipient stream channels forming a divergent to unidirectional, integrated or interrupted reticulated pattern. Aggraded by frequently active sheet flow and channelled stream flow with subordinate wind erosion. Typical elements are plain, stream bed (compare *alluvial fan*, *pediment*).
- **stagnant alluvial plain**: an alluvial plain on which erosion and aggradation by channelled and overbank stream flow are barely active or inactive because of reduced water supply, without apparent incision or channel enlargement that would lower the level of stream action. Typical elements are stream channel, plain (dominant). Also includes bar, scroll, levee, backplain, swamp, ox bow, flood out, lake (compare *floodplain*, *terrace*).
- **terrace**: a former floodplain on which erosion and aggradation by channelled and overbank stream flow are either barely active or inactive because deepening or enlargement of the stream channel has lowered the level of flooding. Typical elements are plain (dominant), scarp, channel bench. Also includes stream channel, scroll, levee.
- **terraced land**: landform pattern including one or more terraces and often a floodplain. Relief is low or very low (9–90 m). Terrace plains or terrace flats occur at stated heights above the top of a streambank. Typical elements include terrace plain, terrace flat, scarp, scroll plain, stream channel, scroll and levee.
- **tidal flat**: level with extremely low relief and slowly migrating deep alluvial stream channels which form non-directional integrated tributary patterns. Aggraded by frequently active tides. Typical elements are plain (dominant), stream channel. Also includes lagoon, dune, beach ridge, beach.
- **volcano**: very rare; typically, very high and very steep, without stream channels, or with erosional stream channels forming a centrifugal interrupted tributary pattern. Built up by volcanism and modified by erosional agents. Typical elements are cone, crater. Also includes scarp, hillcrest, hillslope, stream bed, lake, maar.

10.6.7 Landform element

The specific landform element for a site may be defined in terms of its shape (site morphology), slope and primary geomorphic activity (site process) responsible for its development.

Available values are:

- **alcove**: moderately inclined to very steep, short open depression with concave cross-section, eroded by collapse, landslides, creep or surface wash.
- **backplain**: large flat resulting from aggradation by overbank stream flow at some distance from the stream channel and, in some cases, having biological (peat) accumulations; often characterised by a high watertable and the presence of swamps or lakes; part of a covered plain.
- **bank**: very short but laterally extensive slope, moderately inclined to precipitous, forming the margin of a stream channel and resulting from erosion or aggradation by channelled stream flow; part of a stream channel.
- **bar**: elongated, gently to moderately inclined low ridge built up by channelled stream flow; part of a stream bed.
- **beach ridge**: elongated, nearly straight, low ridge built up by waves and usually modified by wind; often a relict feature remote from the beach.
- **beach**: short, low, laterally extensive slope, gently or moderately inclined, built up or eroded by waves, forming the shore of a lake or sea.
- **bench**: short, gently or very gently inclined minimal midslope or flat, eroded or aggraded by any agent.
- **berm**: short, very gently inclined to level minimal midslope in an embankment or cut face, eroded or aggraded by human activity; or a flat built up by waves above a beach.
- **blow out**: a usually small, open or closed depression excavated by wind.
- **channel bench**: a flat at the margin of a stream channel aggraded and, in part, eroded by overbank and channelled stream flow; an incipient floodplain; is sometimes referred to as 'low terrace', but the term 'terrace' should be restricted to **landform patterns** above the influence of active stream flow.
- **cirque**: precipitous to gently inclined and typically closed depression of concave cross-section and profile excavated by ice; the closed part of the depression may be shallow, the larger part being an open depression like an alcove.
- **cliff**: high, laterally extensive, maximal slope (greater than 72° slope gradient), usually eroded by gravitational fall as a result of erosion of the base by various agencies; sometimes built up by marine organisms (compare *scarp*).
- **cliff/scarp**: very wide steep to precipitous maximal slope, possibly formed as a direct result of a fault, eroded by gravity, water aided mass movement or sheet flow (compare *cliff*).
- **cone:** hillock with a circular symmetry built up by volcanism; the crest may form a ring around a crater.
- **crater**: steep to precipitous closed depression excavated by explosions due to volcanism, human action, or impact of an extraterrestrial object.
- **cut face**: slope eroded by human activity.
- **cut over surface**: a flat eroded by human activity.
- **dam**: a ridge built up by human activity so as to close a depression.

- **drainage depression**: a level to gently inclined, long, narrow, shallow, open depression with smoothly concave cross-section, rising to moderately inclined sideslopes, eroded or aggraded by sheetwash.
- **dune**: moderately inclined to very steep ridge or hillock built up by wind.
- **embankment**: slope or ridge built up by human activity.
- **estuary**: a stream channel close to its junction with a sea or lake, where the action of channelled stream flow is modified by tides and waves; width typically increases downstream.
- **fan**: large, gently inclined to level element with a radial slope inclined away from a point, resulting from aggradation or occasionally from erosion by channelled, often braided stream flow, or possibly by sheet flow.
- **fill top**: a flat aggraded by human activity.
- **flood out**: a flat, inclined radially away from a point on the margin or at the end of a stream channel, aggraded by overbank stream flow or by channelled stream flow associated with channels developed within the overbank flow; part of a covered plain.
- **footslope**: moderately to very gently inclined waning lower slope resulting from aggradation or erosion by sheet flow, earth flow or creep (compare *pediment*).
- **foredune**: elongated, nearly straight, moderately inclined to very steep ridge, built up by the wind from material from an adjacent beach.
- **gully**: an open depression with short, precipitous walls and moderately inclined to very gently inclined floor or small stream channel, eroded by channelled stream flow and consequent gravitational fall and water aided movement.
- **hillcrest**: very gently inclined to steep smoothly convex crest, standing above a hillslope, eroded mainly by creep and sheetwash (overland flow).
- **hillslope**: gently inclined to precipitous slope, commonly simple and maximal and eroded by sheetwash, creep or water aided mass movement; part of mountains, hills, low hills and rises.
- **lagoon**: a closed depression filled with water that is typically salty or brackish, bounded at least in part by forms aggraded or built up by waves or reef-building organisms.
- **lake**: water-filled closed depression.
- **landslide**: moderately inclined to very steep slope, eroded in the upper part and aggraded in the lower part by water aided mass movement, characterised by irregular hummocks.
- **levee**: very long, very low, nearly level sinuous ridge, immediately adjacent to a stream channel, built up by overbank flow. Levees often occur in pairs bounding the 2 sides of a stream channel at the level reached by frequent floods; part of a covered plain (compare *embankment*).
- **lunette**: elongated, gently curved, low ridge, built up by wind on the margin of a playa, or intermittent lake, typically with a moderately inclined wave modified slope towards the playa, and a gentle outer slope gradient.

- **maar**: a level-floored, commonly water filled closed depression with a nearly circular steep rim, excavated by volcanism.
- **mound**: a hillock built up by human activity.
- **ox bow**: long, curved, commonly water filled closed depression, eroded by channelled stream flow, but closed as a result of aggradation by channelled or overbank stream flow during the formation of a meander plain; the floor may be more or less aggraded by overbank stream flow, wind, and biological (peat) accumulation.
- **pan/playa**: large, shallow, level-floored closed depression, intermittently water filled, but mainly dry due to evaporation, generally bounded by flats, aggraded by sheet flow and channelled stream flow.
- **pediment**: large gently inclined to level waning lower slope, with slope lines inclined in a single direction, or somewhat convergent or divergent, eroded or sometimes slightly aggraded by sheet flow; underlain by bedrock (compare *footslope*).
- **pit**: a closed depression excavated by human activity.
- **plain**: large, very gently inclined or level element of unspecified geomorphological origin.
- **prior stream**: long, generally sinuous low ridge built up from materials originally deposited by channelled stream flow along the line of a former stream channel; may include a depression marking the old stream bed and relict levees.
- **rock flat**: a flat of bare consolidated rock usually eroded by sheetwash.
- **rock platform**: a flat of consolidated rock eroded by waves.
- **scald**: a flat, bare of vegetation, from which soil has been eroded or excavated by surface wash or wind; or a bare surface caused by salting.
- **scree**: a sheet of any loose, fragmental material, lying on or mantling a slope. (Some authorities regard scree as the material that makes up the sloping land feature known as *talus*.)
- **scroll**: long curved very low ridge, built up by channelled stream flow and left relict by channel migration; part of a meander plain.
- **sinkhole/doline**: steep-sided closed depression, eroded by solution, directed towards an underground drainage way, or by collapse consequent on such solution; typical of karst terrain.
- **stream bed**: linear, generally sinuous, open depression forming the bottom of a stream channel eroded and locally excavated, aggraded or built up by channelled stream flow; parts that are built up include bars; part of a stream channel.
- **stream channel**: linear, generally sinuous, open depression, in parts eroded, excavated and aggraded by channelled stream flow; may include stream bed, banks and bars.
- **summit surface**: very wide, level to gently inclined crest with abrupt margins, commonly eroded by water aided mass movement or sheetwash.

- **swale**: linear, level-floored depression excavated by wind, or a relict feature between ridges built up by wind or waves or built up to a lesser height than them; or a long curved relict open or closed depression between scrolls built up by channelled stream flow.
- **swamp**: almost level, closed or almost closed depression with a seasonal or permanent watertable at or above the surface, commonly aggraded by overbank stream flow and sometimes biological accumulation.
- **talus**: moderately inclined to steeply waning lower slope, aggraded by gravity, usually formed from an accumulation of rock fragments and other soil material at the foot of a cliff or steep slope.
- **tidal creek**: intermittently water-filled open depression, in parts eroded, excavated and aggraded by channelled tide-water flow; type of stream channel characterised by a rapid increase in width downstream.
- **tidal flat**: large flat subject to inundation by water that is usually salty or brackish, eroded and aggraded by tidal processes.
- **tor**: steep to precipitous hillock, typically convex, with a surface mainly of bare rock, either coherent or comprising sub-angular to rounded boulders, eroded by sheetwash or mass movement.
- **trench**: an open depression excavated by human activity.
- **valley flat**: small, gently inclined to level flat, aggraded or sometimes eroded by channelled or overbank stream flow, enclosed by hillslopes; a miniature alluvial plain located on a narrow valley floor.

10.6.8 Position in landform element

Refers to the position of the soil **profile site** within the **landform element** in which it occurs – that is, whether it is in the upper part, middle or lower part of the **landform element**.

10.6.9 Microrelief

Microrelief refers to small-scale variations in relief up to a few metres above and below the general land surface, within a radius of 10 m of the profile.

Available values are:

- none
- normal gilgai: irregularly distributed small mounds and subcircular depressions varying in size and spacing. The vertical interval is usually <0.3 m, and the horizontal interval is usually 3–10 m. The surface is almost level.
- crabhole gilgai: irregularly distributed small depressions and mounds separated by a more or less continuous shelf. The vertical interval is usually <0.3 m and the horizontal interval is usually 3–20 m. The surface is almost level.
- linear gilgai: long, narrow, parallel, elongate mounds and broader elongate depressions more or less at right angles to the contour. They usually occur on

sloping land. The vertical interval is usually <0.3 m, and the horizontal interval is usually 5–8 m.

- lattice gilgai: discontinuous elongate mounds and/or elongate depressions more or less at right angles to the contour. They usually occur on sloping land, and commonly between linear gilgai on lower slopes and plains.
- melonhole gilgai: irregularly distributed large depressions, usually >3 m in diameter, or greatest dimension, sub-circular or irregular and varying from closely spaced in a network of elongate mounds to isolated depressions set in an undulating shelf with occasional small mounds. Some depressions may also contain sinkholes. The vertical interval is usually >0.3 m, and the horizontal interval is usually 6–50 m. The surface is almost level.
- biotic: examples of biotic microrelief include termite mounds, rabbit warrens, wombat burrows, pig wallows, man-made terraces, stump holes and coppice mounds such as dillon bush mounds.
- terracettes: small terraces on sideslopes resulting from soil creep and/or trampling by hoofed animals.
- **other**.

10.6.10 Gilgai microrelief depth

Describe the depth of gilgai microrelief features using the threshold values defined by the Interim protocol for site verification and mapping of biophysical strategic agricultural land (NSW Government 2013) as being significant for determination of BSAL. This field is paired with **microrelief extent**.

Available values are:

- **≤500 mm depth**: the gilgai microrelief features observed at the site are ≤500 mm deep beneath the prevailing land surface at their deepest point.
- **>500 mm depth**: the gilgai microrelief features observed at the site are >500 mm deep beneath the prevailing land surface at their deepest point.

10.6.11 Gilgai microrelief extent

Describe the extent of gilgai microrelief features using the threshold values defined by the Interim protocol for site verification and mapping of biophysical strategic agricultural land (NSW Government 2013) as being significant for determination of BSAL. This field is paired with **microrelief depth**.

Available values are:

- **≤50% area**: the gilgai microrelief features observed at the site cover ≤50% of the land surface.
- **>50% area**: the gilgai microrelief features observed at the site cover >50% of the land surface.

10.6.12 Soil landscape geomorphic class

- **Residual Landscapes**: dominated by sites where deep soils have formed from in situ weathering of parent materials. (This has presumably taken place over long periods

where the rate of soil formation has been greater than rate of erosion.) Residual soil landscapes typically have level to undulating elevated topography. Landform elements include some summit surfaces, plateaux, terrace plains, peneplains and old ground surfaces. Stream channels are usually poorly defined.

- **Vestigial Landscapes**: dominated by sites where shallow soils have formed from in situ weathering of typically resistant parent materials. Vestigial soil landscapes typically have level to undulating elevated topography. Landform elements include summit surfaces, plateaux and old ground surfaces. Rock outcrop may be common.
- **Karst Landscapes**: dominated by solutional processes, particularly on limestone and related rock types. Soil parent materials include accumulations of less soluble minerals. Drainage patterns are deranged and solution hollows are common. Landform patterns may include tors, hillslopes and dolines.
- **Colluvial Landscapes**: affected by mass movement. Soil parent material mostly consists of colluvial mass movement debris including scree and talus along with other landslide, mudflow and creep deposits. Colluvial soil landscapes usually include alcoves, cliffs, cliff-foot slopes, scarps, landslides, talus, some moderately inclined to precipitous hillslopes and areas of commonplace evidence of mass movement.
- **Erosional Landscapes**: primarily sculpted by erosive action of running water. Streams are well defined and competent to transport their sediment load. Soil depth is usually shallow (with occasional deep patches) and mode of origin is variable and complex. Soils may be either absent, derived from water washed parent materials or derived from in situ weathered bedrock. Erosional soil landscapes usually consist of steep to undulating hillslopes and may include tors, benches, and areas of rock outcrop. Evidence of mass movement is rare.
- **Transferral Landscapes**: deep deposits of mostly eroded parent materials washed from areas directly upslope. Stream channels are often discontinuous and slopes are generally concave. Transferral landscapes include footslopes, valley flats, fans, bajadas and piedmonts.
- **Alluvial Landscapes**: formed by deposition along rivers and streams. Soil parent material is alluvium. Alluvial soil landscapes include floodplains and alluvial deposits. Typical landform elements include those found on meander plains; including bars, backplains, scrolls, scroll plains, flood-outs, ox bows, levees, terraces, prior and current stream channels.
- **Estuarine Landscapes**: occur where rivers and streams enter large bodies of water such as the sea or inland lakes. Channel flow is dissipated and is also modified by wave and/or tidal action. Soil materials may be influenced by saline conditions. Estuarine soil landscapes include estuaries, deltas, tidal creeks and tidal flats.
- **Lacustrine Landscapes**: result from infilling of lakes with sediments deposited in still water. Soil parent materials are usually fine grained, well-sorted and often varved. Ground surfaces are level to gently inclined and slightly concave. Landform elements include lakes, playas, some ox bows and some lagoons.

- **Beach Landscapes**: have ground surfaces and soil parent materials which have been deposited by wave action. Beach soil landscapes typically occur near sandy coastlines and near lake edges. Typical landform elements include beaches, berms, beach ridges, and some plains. Due to map scale limitations, associated foredunes and windblown soils are included.
- **Aeolian Landscapes**: have accumulated by deposition of sand-sized particles by wind action. Aeolian soil landscapes include dunefields, dunes, blow-outs, sand sheets and lunettes.
- **Swamp Landscapes**: dominated by ground surfaces and soils which are at least seasonally wet. Soil parent material includes large amounts of accumulated decayed organic matter. Watertables are frequently close to the surface. Landform elements may include swamps and some relic ox bows, abandoned channels, lagoons and swales.
- **Disturbed Landscapes**: dominated by ground surfaces arising from human activity. Soil parent materials have been moved, accumulated, removed or replaced (with soil or other items). Landform elements include fill-tops, embankments, cut faces, cut over surfaces, dams, mounds and pits.

10.7 Land use

10.7.1 Site

The present land use at the site is recorded so that the degree of disturbance of the soil's morphological properties can be determined (see also **Site Disturbance**). Describe the land use within a radius of 10 m of the profile or to the edge of the landform element or until there is a change in land use, whichever is the lesser distance.

Available values are:

- **national/state parks**: land in public ownership which is in a relatively undisturbed condition.
- **timber/scrub/unused**: unlogged State and private forests and partially cleared land which is not grazed or is being allowed to regenerate. Does not include land which is currently being used for agricultural, pastoral or forestry production.
- **logged native forest**: stands of native forest that show evidence of having been or being logged.
- **hardwood plantation**: land where the vegetation has been cleared and replaced with a plantation of native hardwood species – for example, *Eucalyptus* spp.
- **softwood plantation**: land where the vegetation has been cleared and replaced with a plantation of softwood species – for example, *Pinus radiata*.
- **voluntary/native pasture**: cleared land to woodland with a ground cover of grasses and/or legumes which are either native species or naturalised (self-sown) exotic species; generally lower productivity and nutrient status than improved pastures.
- **improved pasture**: cleared to lightly wooded land with a ground cover of grasses and/or legumes which are generally exotic species; the grazing productivity has been raised by the use of fertilisers and/or cultivation.

- **cropping**: land normally cultivated for agricultural production – for example, for grain and fodder production, rice, cotton, etc., but not for improved pasture or for vegetables, flowers or trees. Note: irrigation may be recorded under **Site Disturbance**.
- **orchard/vineyard**: land used for the production of fruit trees and/or vines.
- **vegetables/flowers**: land used for the production of vegetables and/or flowers.
- **urban**: land associated with cities or towns; includes residential, commercial and recreational areas and their associated infrastructure; allotment sizes are generally less than one hectare.
- **industrial**: land used for the manufacture of goods; includes factories, warehouses, sawmills, refineries, etc., and their grounds.
- **quarrying/mining**: land used for an extractive industry including spoil dumps, infrastructure and rehabilitated areas.
- **other**: for any land use not adequately covered by the other values, select other and record the appropriate description in the text box provided.

10.7.2 General area

Describe the main forms of **land use** within a distance of 300 m from the **profile** or to the edge of the **landform element**, whichever is the lesser distance. The list of available values is the same as those used for **Land use, site**.

10.7.3 Land use vegetation species

This notes field allows the surveyor to record the names of vegetation species typical of the **land use** carried out in the general area as well as their condition.

10.7.4 Prior land use, site

Describe what is believed to be the previous **land use** within a radius of 10 m of the **profile** or to the edge of the **Landform element**, whichever is the lesser distance.

Available values are:

- **dense timber**
- **wooded**
- **cleared land**
- **shrub/heathland**
- **rehabilitated**
- **standing dead timber**
- **unlogged/uncleared**
- **dense timber regenerating**
- **scattered timber**
- **natural woodland**
- **unimproved pasture**
- **irrigated non legume pasture**

- **rain fed non legume pasture**
- **irrigated legume pasture**
- **rain fed legume pasture**
- **irrigated continuous cropping**
- **rain fed continuous cropping**
- **irrigated non continuous cropping**
- **rain fed non-continuous cropping**
- **unknown**
- **other**

10.8 Lithology

Indicate the lithology of the solum parent material and substrate separately. The major lithological divisions of unconsolidated sediments, sedimentary rocks, metamorphic rocks and igneous rocks have been included for use if the specific lithology cannot be identified. If a lithology is required and is not listed, record the major division – for example, sedimentary division – and record 'other', then record in the text field provided.

10.8.1 Solum parent material

Solum parent material refers to the material from which the solum (A and B horizons) of the soil have developed. The **solum parent material** may be identified by loose stones present on, or in, the soil. The solum parent material may be the same as or different to the substrate. Solum layer may have different parent materials in a number of situations, including:

- a lithological boundary occurring at or immediately below the upper solum
- solum layers may have formed from colluvium and be derived from contrasting upslope material
- the solum layers may have formed from depositional material such as alluvium or windblown sand.

Available values are:

- **not identified.**
- **adamellite:** coarse-acidic igneous rock.
- **aeolian:** material that has been transported and deposited by wind; composed of well-sorted medium to fine sand, silt or clay; often found as dunes or sand sheets.
- **aeolianite (eolianite):** a consolidated sedimentary rock consisting of clastic material deposited by the wind.
- **agglomerate:** chaotic assemblage of coarse angular pyroclastic material.
- **alluvium:** unconsolidated detrital material transported by water.
- **amphibolite:** crystalloblastic rock consisting mainly of amphibole and plagioclase with little or no quartz.

- **andesite:** dark coloured fine-grained intermediate extrusive rock.
- **aplite:** light coloured, intrusive, acidic igneous rock characterised by fine-grained texture.
- **arkose:** coarse-grained sandstone, typically pink or red, of quartz and >25% feldspar in clay and iron oxide matrix.
- **ash:** fine (usually <4.0 mm) pyroclastic material; usually unconsolidated.
- **basalt:** dark to medium dark coloured fine-grained extrusive mafic basic igneous rock.
- **breccia:** coarse-grained clastic rock of angular, broken rock fragments in a fine-grained matrix or held together with mineral cement.
- **calcareous:** sedimentary rocks formed from chemical and detrital sediments containing a high proportion (>50%) of calcium carbonate, such as limestone, chalk, tufa, or shelly sandstone.
- **calcareous sand:** material with the particle size range of 0.02–2 mm containing <50% calcium carbonate.
- **calcrete:** calcareous duricrust; a conglomerate of sand and gravel cemented by calcium carbonate into a hard mass.
- **chert:** hard, dense sedimentary rock of interlocking quartz crystals, often white or coloured; also called flint.
- **clay:** fine-grained material, <0.002 mm; composed normally of hydrated aluminium silicate minerals and plastic when moist.
- **claystone:** compacted, non-fissile, fine-grained sedimentary rock composed mainly of clay-sized particles <0.004 mm.
- **coarse-acidic:** igneous rock type with >20% free quartz and containing the feldspars orthoclase and/or plagioclase; grain size is normally >5 mm but may include medium-grained rocks with grain sizes >3 mm; includes granite and adamellite.
- **coarse-basic:** quartz-free igneous rock type containing >50% ferromagnesian minerals; calcic-plagioclase is the dominant feldspar; common ferromagnesian minerals are olivine and pyroxene; grain size is >3 mm; includes gabbro.
- **coarse-intermediate:** feldspathic igneous rock type with <10% free quartz and <50% ferromagnesian minerals; grain size is >3 mm; includes granodiorite, diorite, monzonite and syenite.
- **colluvium:** heterogeneous rock and soil detritus transported by downslope processes.
- **conglomerate:** detrital sedimentary rock substantially composed of rounded particles which are >2 mm diameter.
- **diorite:** group of intrusive intermediate igneous rocks; intrusive equivalent of andesite.
- **dolerite:** intrusive igneous rock with lath-shaped plagioclase crystals included in pyroxene crystals; also called diabase.

- **dolomite:** sedimentary rock containing >90% dolomite and <10% calcite; often associated and interbedded with limestone.
- **ferricrete:** hard, resistant sedimentary rock, typically consisting of sand, gravel, conglomerate or breccia that has been cemented by iron oxides.
- **fill:** man-made deposits of rock, soil, tailings, etc.
- **fine-acidic:** igneous rock type with >20% free quartz, >20% ferromagnesian minerals and containing the feldspars orthoclase and plagioclase; grain size is normally >1 mm but may include medium-grained rocks with grain sizes <3 mm and the acid porphyries; includes rhyolite, quartz porphyry and quartz-orthoclase porphyry.
- **fine-basic:** quartz-free igneous rock type containing >50% ferromagnesian minerals; calcic-plagioclase is the dominant feldspar; grain size is >3 mm; includes basalt, latite and dolerite.
- **fine-intermediate:** feldspathic igneous rock with <10% free quartz and <50% ferromagnesian minerals; grain size is >3 mm; includes trachyte, trachyandesite and andesite.
- **gabbro:** a group of dark-coloured basic intrusive igneous rocks; the approximate intrusive equivalent of basalt.
- **gneiss:** coarse-grained banded crystalline rock formed during high-grade regional metamorphism; most have a granitic composition with minerals separating into schistose bands of micas and amphiboles and granulose bands of quartz and feldspar.
- **granite:** coarse-acidic plutonic igneous rock.
- **granodiorite:** coarse-intermediate intrusive igneous rock; the intrusive equivalent of rhyodacite; contains quartz, oligoclase or andesine, potassium feldspar and mafic minerals.
- **gravel:** loose detrital material composed mainly of small pebbles or rock fragments, >2 mm and <60 mm; may be mixed with other unconsolidated material.
- **greenstone:** any compact dark green metamorphosed basic igneous rock.
- **greywacke:** dark grey firmly indurated sandstone with poorly sorted quartz and feldspar with dark rock and mineral fragments in a clayey matrix.
- **hornfels:** tough, fine-grained granulose rock produced by the thermal metamorphism of argillaceous or calcareo-argillaceous rock; no cleavage, schistosity or parallel alignment of materials.
- **igneous:** rocks which have solidified from molten magma at or below the earth's surface; grains are characteristically crystalline and interlocking; crystal size decreases with increasing rate of cooling of the molten rock material.
- **ironstone:** sedimentary rock, either deposited directly as a ferruginous sediment or created by chemical replacement, containing >15% of iron that is present as variable proportions of iron oxide or carbonate-bearing minerals.
- **jasper:** red chert, usually associated with iron ores.

- **lacustrine:** deposits in or pertaining to lakes; typically fine-grained laminated sediments predominate; may contain evaporates such as salts; coarser sediments may be found on lake margins.
- **limestone:** non-clastic sedimentary rock consisting essentially of the carbonate minerals calcite and dolomite; may be organic, detrital or chemically precipitated.
- **marble:** limestone which has been recrystallised by heat and pressure during metamorphic processes.
- **marine:** sediment that has been transported and deposited by marine processes; includes beach sands and the fine sand, silt and mud of tidal flats.
- **metamorphic:** rocks that have been changed in their mineralogical, textural or small-scale structural compositions by the action of heat and/or pressure.
- **metasediment:** sedimentary rock that has undergone metamorphism, involving changes in mineralogy, texture and structure through the action of heat and/or pressure.
- **monzonite:** granular, plutonic igneous rock intermediate in composition between syenite and diorite, with a moderate silica content but rich in alkali metal oxides.
- **mud:** mixture of water with silt or clay-sized particles.
- **mudstone:** fine-grained, non-fissile, non-laminated sedimentary rock, composed of particles <0.063 mm in size, that was originally formed from clays or muds.
- **obsidian:** black or dark coloured volcanic glass.
- **organic material:** a deposit composed of plant remains at various stages of decomposition.
- **peridotite:** dense, coarse-grained, ultramafic igneous rock consisting mainly of olivine and pyroxene, with <45% silica.
- **porphyry:** igneous or granitic rock with coarse-grained crystals of feldspar and/or quartz dispersed in a fine-grained silicate-rich groundmass.
- **quartz porphyry:** extrusive or intrusive rock containing larger crystals of quartz set in a finer groundmass.
- **quartzite:** regionally or thermally metamorphosed rock in which quartz is the primary constituent; grains have recrystallised into an interlocking mosaic texture with little or no trace of cementation.
- **rhyolite:** fine-grained porphrytic acidic extrusive igneous rock; exhibits flow texture; consists of quartz and feldspar in a glassy to cryptocrystalline groundmass.
- **sand:** material with the particle size range of 0.02–2 mm; commonly quartz grains.
- **sandstone:** a clastic sedimentary rock composed mainly of sand-sized particles (0.0625–2 mm), compacted and cemented by another mineral.
- **sandstone-lithic:** detrital sedimentary rock with predominantly sand-sized particles including rock fragments, quartz and feldspar set in a fine-grained matrix.
- **sandstone-quartz:** detrital sedimentary rock with predominantly sand-sized quartz particles cemented by silica or carbonates with little fine-grained matrix material.

- **sandstone-quartz lithic:** detrital sedimentary rock consisting of quartz grains mixed with >5% of unstable (lithic) rock fragments such as shale, basalt or schist.
- **schist/phyllite:** schists are largely or completely recrystallised during moderately intense regional metamorphism; characterised by a parallel arrangement and fine scale foliation of lamellar minerals, particularly micas. Phyllites are low temperature regionally metamorphosed, fine-grained rocks which have a distinctive shiny surface caused by the reorientation of mica minerals along cleavage planes.
- **sedimentary:** rocks resulting from the consolidation of sediment, including organic accumulations and chemical precipitates; distinguished from loose sediments by the degree of lithification.
- **serpentinite:** rock consisting almost wholly of serpentine-group minerals; includes antigorite, chrysotile.
- **shale:** fine-grained detrital sedimentary rock which is laminated and easily split into layers.
- **silcrete:** hard, resistant duricrust formed when surface soil, sand and gravel is cemented by dissolved silica.
- **silt:** material within the particle size range of 0.002–0.02 mm. Non-plastic when moist and not deposited by floods (see *alluvium*).
- **siltstone:** fine-grained sedimentary rock composed mainly of silt-sized particles (0.004–0.063 mm).
- **siltstone/mudstone:** fine-grained detrital sedimentary rock composed mainly of silt or clay respectively and is not easily split into layers.
- **slate:** fine-grained regionally metamorphosed argillaceous rock which has a well-developed cleavage and splits readily into thin plates.
- **syenite:** coarse-intermediate plutonic igneous rock; the intrusive equivalent of trachyte; usually contains orthoclase, microcline or perthite, a small amount of plagioclase, hornblende and other mafic minerals but little or no quartz.
- **scoria:** vesicular cindery crust on the surface of andesitic or basaltic lava; usually heavier, darker and more crystalline than pumice.
- **till:** unstratified drift, deposited directly by a glacier without reworking by meltwater and consisting of a mixture of clay, silt, sand, gravel and boulders ranging widely in size and shape.
- **tuff:** consolidated volcanic ash; water-laid tuffs generally show excellent bedding and may appear similar to shales or sandstones; pyroclastic fragments are <20 mm in diameter.
- **trachyte:** fine-grained porphrytic intermediate extrusive rock; main components are alkali feldspar and minor mafic minerals.
- **ultrabasic:** igneous or meta-igneous rock containing <45% silica.
- **unconsolidated:** a range of materials, usually forming surface layers or deposits and not compacted or cemented into rock.

- **other:** when values listed are inadequate to describe lithology, this may be used in conjunction with either *unconsolidated*, *sedimentary*, *metamorphic* or *igneous*.

10.8.2 Substrate

Substrate refers to the bedrock or strata underlying the soil. This may be identified from an exposure or outcrop. Select values from the list of available values used in **solum parent material**.

10.8.3 Substrate (major categories)

Substrate refers to the bedrock or strata underlying the soil. This may be identified from an exposure or outcrop. This field includes only the major categories of lithology, for use in the more basic templates.

Available values are:

- **alluvium**: unconsolidated detrital material transported by water.
- **aeolian**: material that has been transported and deposited by wind; composed of well-sorted medium to fine sand, silt or clay; often found as dunes or sand sheets.
- **calcareous**: sedimentary rocks formed from chemical and detrital sediments containing a high proportion (>50%) of calcium carbonate, such as limestone, chalk, tufa, or shelly sandstone.
- **igneous**: rocks which have solidified from molten magma at or below the earth's surface; grains are characteristically crystalline and interlocking; crystal size decreases with increasing rate of cooling of the molten rock material.
- **metamorphic**: rocks that have been changed in their mineralogical, textural or small-scale structural compositions by the action of heat and/or pressure.
- **sedimentary**: rocks resulting from the consolidation of sediment, including organic accumulations and chemical precipitates; distinguished from loose sediments by the degree of lithification.

10.8.4 Identification method

Indicate the method used to identify the **lithology**.

10.8.5 Rock outcrop

Rock in this context refers specifically to outcrop of the in situ rock material – that is, substrate – within a radius of 10 m from the profile, and not to loose rocks (or ‘floaters’) which may be of a colluvial origin. Partially buried boulders and other stones are identified in **coarse fragments**.

10.8.6 Rock outcrop (BSAL)

Rock in this context refers specifically to outcrop of the in situ rock material – that is, substrate – within a radius of 10 m from the profile, and not to loose rocks (or ‘floaters’) which may be of a colluvial origin. Surficial rock fragments, partially buried boulders and other stones are identified in **coarse fragments**. Additional values have been added to this field to match the threshold values of rock outcrop for definition of BSAL as

defined by the *Interim protocol for site verification and mapping of biophysical strategic agricultural land* (NSW Government 2013).

10.8.7 Profile fragment amount

Provides a general measure of the amount of coarse fragments within the **profile**, measured in a similar way to **coarse fragment amount** in layers but averaging the fragment content of the **profile** as a whole.

10.8.8 Outcrop same as

Describe the **lithology** of the rock outcrop by indicating the relationship of the rock outcrop to the solum parent material and/or the substrate.

10.8.9 Substrate material

Indicate the relationship of the substrate with the soil materials that overlie it.

10.8.10 Substrate strength

Indicate the average substrate strength assessed using a knife, pick or hammer.

Available values are:

- **weak**: knife easily cuts or scratches; pick blow crumbles or indents deeply; hammer blow shatters rock to many small fragments or powder (<50 MPa pressure).
- **moderate**: knife makes slight or no mark; pick blow indents shallowly; hammer blow breaks rock readily into a few large and some small fragments (50–100 MPa pressure).
- **strong**: knife makes no mark; pick blow makes no mark; hammer blow breaks rock into 1 or 2 large fragments or does not break it at all (>100 MPa pressure).

10.8.11 Weathering and alteration

Substrate materials may be so extensively weathered and/or altered that it may be difficult or impossible to determine their original nature. Describe the weathering and/or alteration that has occurred.

Available values are:

- **ferruginised**: iron enriched.
- **kaolinised**: clay enriched, usually pale coloured.
- **silicified**: silica enriched.
- **calcified**: calcium carbonate enriched.
- **fresh rock**: no earth material, original rock structure preserved, no decay of feldspars.
- **faintly weathered rock**: rusty stain on cracks, trace of earth material, original rock structure preserved, 75–99% of original **substrate strength**, no decay of feldspars.
- **slightly weathered rock**: slight rusty stain, trace of earth material, interlocked rectangular corestones (if present), original rock structure preserved, 75–100% of original **substrate strength**, feldspars partly decayed, few microfractures.

- **moderately weathered rock**: strong rusty stain, <50% earth material, interlocked rectangular corestones (if present), original rock structure preserved, 40–75% of original **substrate strength**, most of feldspars decayed, microfractures present throughout.
- **highly weathered rock**: strong rusty stain, >50% earth material, corestones free and rounded (if present), original rock structure preserved, 15–40% of original **substrate strength**, nearly all feldspars decayed, numerous microfractures.
- **structured saprolite**: strong rusty stain, may be pallid, 100% earth material, corestones rare and rounded if present, original rock structure preserved, <15% of original **substrate strength**, all feldspars decayed, numerous microfractures.
- **massive saprolite**: strong rusty stain, may be mottled, 100% earth material, no corestones, original rock structure lost, <15% of original **substrate strength**, all feldspars decayed.
- **other**: deeply weathered but no specific weathering nature apparent. Further information should be entered in **Site field notes**.

10.8.12 Spacing of discontinuities

Describes the integrity and continuousness of the substrate immediately underlying the soil profile. This is described both in terms of the size of individual continuous rock fragments and in the amount of jointing or fracturing of the rock mass as a whole.

10.9 Site condition

Site condition describes the surface condition characteristics which extend from the soil profile to a radius of 10 m or the edge of the landform element, whichever is the lesser.

10.9.1 Site disturbance

Describe any land use activities that may have affected soil properties. More detail is provided under **Land use**.

Available values are:

- **natural disturbance**: no disturbance other than from native fauna; no hoofed animal grazing.
- **no effective disturbance**: no disturbance is evident other than grazing by hoofed animals.
- **limited clearing**: clearing has been limited or the land has been selectively logged.
- **extensive clearing**: clearing has been extensive although not complete; the land may or may not be pasture improved but not cultivated.
- **cleared, no cultivation**: clearing has been complete; the land may or may not be pasture improved but not cultivated.
- **occasional cultivation**: clearing has been extensive to complete; the land has been cultivated at some stage.

- **rain-fed cultivation**: the land has been cultivated at some stage; but no irrigation has occurred.
- **irrigated cultivation**: irrigation has occurred, either past or present.
- **highly disturbed**: for example, quarrying, road works, mining, landfill, urban development, etc.

10.9.2 Ground cover

Indicate the percentage of the ground surface that is covered by material that may act to reduce the erosion hazard. Exclude any canopy which does not affect rate of overland flow and/or does not provide protection against raindrop impact. Materials may include surface rock, mulch, gravel, living vegetation, etc. Figure 12 may be used in the visual estimation of ground cover percentage.

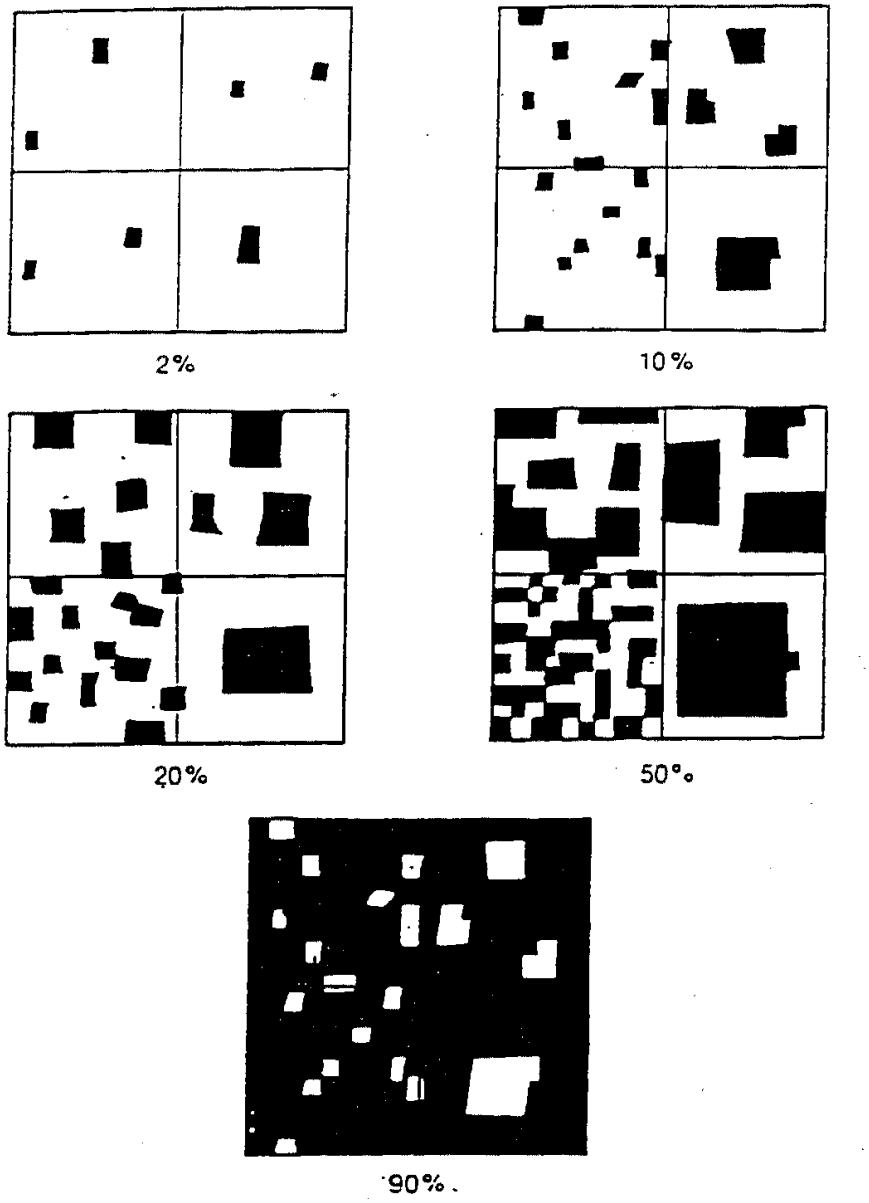


Figure 12 Chart for visually estimating percentage of abundance of an attribute

10.9.3 Current condition

Describe the current condition of the surface soil.

Available values are:

- **gravelly**: the amount of surface gravel (particles between 2–60 mm in diameter) is >60% of ground cover percentage.
- **cracked**: cracks ≥6 mm wide penetrating to ≥0.3 m depth and at least 1 crack per square metre. Cracks may lie below a thin massive surface layer.
- **self-mulched**: soil surface layer is highly pedal and loose, forming a mulch.
- **loose**: incoherent mass of individual particles or aggregates forms the soil surface. The surface is easily disturbed by pressure of forefinger.
- **soft**: coherent mass of individual particles or aggregates forms the soil surface. The surface may be easily disturbed by pressure of forefinger.
- **firm**: coherent mass of individual particles or aggregates forms the soil surface. The surface may be disturbed or indented by moderate pressure of forefinger.
- **hard set**: soil surface layer is compact, hard and apparently apedal. A surface seal may or may not occur.
- **surface crust**: thin surface layer or flake, usually <10 mm thick, can be separated from and lifted off the soil below, and often seals the surface from penetration by moisture.
- **trampled**: soil surface has been extensively disturbed under dry conditions by hoofed animals.
- **poached**: soil surface has been extensively disturbed under wet conditions by hoofed animals.
- **recently cultivated**: series of furrows or other cultural marks are visible on the surface, indicating that the surface soil has been recently cultivated or otherwise disturbed.
- **water repellent**: water is not readily absorbed into the surface layer. The degree of water repellence can be recorded in **Profile notes**.
- **other**: record the type of condition – for example, cryptogam – in the text box provided when 'other' is selected.

10.9.4 Expected - wet

The surface condition of a soil may have a characteristic appearance when wet: this expected wet condition may affect the use of the soil and is diagnostic of particular soil characteristics.

Available values are:

- **cracked**: cracks ≥6 mm wide penetrating to ≥0.3 m depth and at least 1 crack per square metre. Cracks may lie below a thin massive surface layer.
- **self-mulched**: soil surface layer is highly pedal and loose, forming a mulch.

- **loose**: incoherent mass of individual particles or aggregates forms the soil surface. The surface is easily disturbed by pressure of forefinger.
- **soft**: coherent mass of individual particles or aggregates forms the soil surface. The surface may be easily disturbed by pressure of forefinger.
- **firm**: coherent mass of individual particles or aggregates forms the soil surface. The surface may be disturbed or indented by moderate pressure of forefinger.
- **surface crust**: thin surface layer or flake, usually <10 mm thick, can be separated from and lifted off the soil below, and often seals the surface from penetration by moisture.
- **poached**: soil surface has been extensively disturbed under wet conditions by hoofed animals.
- **other**: record the type of condition – for example, cryptogam – in the text box provided when 'other' is selected.

10.9.5 Expected - dry

The surface condition of a soil may have a characteristic appearance when dry: this expected dry condition may affect the use of the soil and is diagnostic of particular soil characteristics.

Available values are:

- **cracked**: cracks ≥6 mm wide penetrating to ≥0.3 m depth and at least 1 crack per square metre. Cracks may lie below a thin massive surface layer.
- **self-mulched**: soil surface layer is highly pedal and loose, forming a mulch.
- **loose**: incoherent mass of individual particles or aggregates forms the soil surface. The surface is easily disturbed by pressure of forefinger.
- **soft**: coherent mass of individual particles or aggregates forms the soil surface. The surface may be easily disturbed by pressure of forefinger.
- **firm**: coherent mass of individual particles or aggregates forms the soil surface. The surface may be disturbed or indented by moderate pressure of forefinger.
- **hard set**: soil surface layer is compact, hard and apparently apedal. A surface seal may or may not occur.
- **surface crust**: thin surface layer or flake, usually <10 mm thick, can be separated from and lifted off the soil below, and often seals the surface from penetration by moisture.
- **trampled**: soil surface has been extensively disturbed under dry conditions by hoofed animals.
- **water repellent**: water is not readily absorbed into the surface layer. The degree of water repellence can be recorded in **Profile notes.**
- **other**: record the type of condition – for example, cryptogam – in the text box provided when 'other' is selected.

10.9.6 Estimated effective rooting depth

Estimated effective rooting depth indicates the depth to which the roots of plants have penetrated the soil profile, recorded in metres to the nearest centimetre.

10.9.7 Soil condition for root growth

Describes the general soil conditions for plant root growth, which can be adversely affected by a variety of factors including depth to impenetrable substrate, presence of pans or abundant coarse fragments, or hardsetting or chemically inhospitable soil layers.

Available values are:

- **good rooting conditions**
- **moderate rooting conditions**
- **poor rooting conditions**

10.9.8 Cryptogam mat occurrence

Record the amount of cryptogam mat occurrence using the reference list below. A cryptogam surface is a thin, more or less continuous crust of biologically stabilised soil material usually due to algae, liverworts and mosses (NCST 2009).

Available values are:

- **none**
- **sporadic:** <20% by area
- **patchy:** 20–70% by area
- **thick:** >70% by area.

10.9.9 Surface organic matter estimate

Use this field to record the reduction in the amount of organic matter on the soil surface compared to a completely natural, undisturbed site.

Available values are:

- **as unused state**
- **slightly to moderately reduced**
- **less than half**
- **less than one-quarter**
- **virtually or totally absent**.

10.9.10 Surface soil types (2002)

Records the class of surface soil type present in the **profile** using the second edition of the classification introduced in *On the Surface, What Kind of Soil Are You Farming?* (Lawrie, J., Murphy, B. and Packer, I. 2002).

Available values are:

- **Type 1 - Loose sand: Low organic carbon (<2%)**: soils formed from wind deposits (levees and mallee soils), granites and sandstone.
- **Type 2a - Fragile coarse (light) textured surface (Low OM)**: low organic carbon (<2%); soils are formed mostly from sandstones, granites and weathered shales.
- **Type 2b - Fragile medium-textured surfaces (Low OM)**: low organic carbon (<2%); soils are formed mostly from shales, limestone, andesites and loamy alluvium.
- **Type 3a - Acid sodic topsoil**: acid soils with pH <7 (1:5 soil:water). Soils are mostly formed from rhyolitic volcanics, marine sediments, ancient alluvium.
- **Type 3b - Alkaline sodic topsoil:** alkaline soils with pH ≥7 (1:5 soil:water). Soils formed on recent alluvium.
- **Type 4 - Coarse structured clayey surfaces:** soils formed on/from ancient and recent alluvium.
- **Type 5 - Friable surfaces**: soils formed mainly from basalt, limestone, andesite and associated shales.
- **Type 6 - Self-mulching clays**: soils formed on recent alluvium especially those derived from basalt.
- **Type 7 - Surfaces high in organic matter**: alpine areas, swamps, and undisturbed native vegetation including grasslands and forests.

10.9.11 Erosion hazard

The **erosion hazard** of a parcel of land refers to its susceptibility to the prevailing agents of erosion. It is dependent upon a number of factors including climate, landform and geomorphic activity, soil erodibility and land use. However, this definition is modified to allow for possible changes to the level of land management. Where necessary, erosion hazard may be described in terms of special conditions applying at the time of the soil survey – for example, at varying stocking rates, or disturbance during highway construction. These terms of reference should be defined in the **profile notes**.

Available values are:

- **slight**: the combination of slope, runoff/run-on and soil erodibility is such that no appreciable erosion damage is likely to take place.
- **moderate**: significant short-term soil erosion may occur as a result of the combination of steep slope gradient, high soil erodibility and adverse runoff/run-on factors. Control can be obtained with such management techniques as topsoiling, vegetative techniques, phasing development and the implementation of structural works.
- **high**: major soil erosion, in some cases long-term, can be expected to occur. Control of this risk will require the adoption of appropriate management techniques or intensive soil conservation works.
- **very high**: major short-term and long-term erosion damage can be expected on this land. The combination of slope, soil erodibility and runoff/run-on ratings makes intensive soil conservation works necessary.

- **extreme**: even with intensive short-term and long-term soil conservation works, significant soil erosion is likely to occur on this class of land.

10.9.12 Wind exposure

Describes the relative exposure of the **site** to strong winds, which may cause desiccation (drying) of soil and vegetation.

Available values are:

- **low exposure**
- **moderate exposure**
- **high exposure**.

10.9.13 Revised Universal Soil Loss Equation (RUSLE)

Originally developed in the USA, the RUSLE is an empirical model used to predict the long-term, average annual soil loss from sheet and rill erosion caused by rainfall and runoff.

Rainfall erosivity factor (R)

- **R**: rainfall erosivity factor, calculated as the long-term average annual sum of Erosion Index (EI) where EI is the product of storm energy and the maximum 30-minute intensity.

Soil erodibility factor (K)

- **K**: soil erodibility factor, typically sourced from soil laboratory test results that, in turn, source values of K using particle size analysis and organic matter information from a soil erodibility nomograph developed in the USA. If particle size analysis information is not available, estimates of K derived from soil texture or soil type may be used.

Topographic factor (LS)

- **LS**: topographic factor, combining slope length (L) and slope steepness (S).

Support practice factor (P)

- **P**: support practice factor, representing the effect of erosion control practices such as contour cultivation or contour banking.

Cover and crop management factor (C)

- **C**: cover and crop management factor, which measures the combined effect of all cover and crop management variables; defined as the ratio of soil loss from land maintained under specified conditions to the corresponding loss from continuous tilled bare fallow.

Average annual soil loss (A)

- **A**: average annual soil loss, produced using the following formula:

  $A = R \times K \times LS \times P \times C$ (tonnes/ha/year)

10.9.14 Existing erosion (by type)

Erosion is the detachment and transport of soil from a site. Assisting processes may include physical and chemical weathering. Record details of **erosion** observable within a 20 m radius from the profile. This is an assessment of the degradation status of the site, which is its condition compared with essentially undisturbed land. You must record a **type** before recording the details of other related attributes. The **type** selected also restricts the valid values possible for the other related attributes. These possible values are presented for each erosion **type**. Record the **type** by selecting an erosion severity value (can be none if erosion of specified **type** is not present).

None

- **none**: no appreciable erosion of any **type** is evident at the site.

Wind

Detachment and transport of soil from the land surface by the action of the wind. The soils most susceptible to wind erosion tend to either be single grained or have poor aggregate stability and have a predominance of fine sand particles. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of wind erosion.
- **susceptible**: no appreciable form of wind erosion is observed, but the site is susceptible.
- **minor**: finer soil particles have been removed resulting in a marked increase in the coarse fraction of the soil surface to a depth of about 10 mm.
- **moderate**: gross movement of the coarser particles has occurred; hummocks and drift banks are evident in the lee of nearby vegetation and other obstacles.
- **severe**: significant deflation of the soil surface has occurred leaving hard material.
- **very severe**: soil surface is completely removed exposing deeper layers and leaving a hard compact surface – for example, subsoil, weathered country rock or pans.

Sheet

Removal of a relatively uniform layer of soil from the land surface by raindrop splash and/or runoff. No perceptible channels are formed. Indicators include soil deposits in downslope sediment traps such as fence lines, logs or farm dams, pedestalling and exposure of subsoils or roots. In many situations, local knowledge of an area must be used to provide the correct interpretation. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of sheet erosion.
- **susceptible**: no appreciable form of sheet erosion is observed, but the site is susceptible.
- **minor**: often very difficult to assess because evidence may be lost as a result of revegetation or cultivation; indicators include such factors as shallow soil deposits in downslope sediment traps.

- **moderate**: indicators include partial exposure of roots, substantial quantities of sediment in downslope traps (farm dams, fence lines, etc.) and shallow A1 horizons.
- **severe**: indicators include lack of surface soil layers, exposure of subsoil layers, pedestalling, root exposure, and substantial soil deposits in downslope sediment traps.

Rill

Removal of soil from the land surface by the formation of numerous small channels <0.3 m deep. It typically occurs on recently cultivated or disturbed soil. Sheet erosion grades into rill erosion or, if very severe, into gully erosion. It is very difficult to assess rill erosion unless the site is observed immediately after the erosion event as the rills are eventually lost due to revegetation or cultivation and the evidence indicates a sheet process. Indicators include rill frequency and depth, lack of topsoil layer, exposure of subsoils or roots, etc. Local knowledge of an area is necessary for correct interpretation. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of rill erosion.
- **minor**: occasional rills.
- **moderate**: rills common
- **severe**: numerous rills forming corrugated ground surface.

Gully

A complex process whereby the removal of soil is characterised by large (>0.3 m deep) channels cut into slopes or in drainage lines. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of gully erosion.
- **minor**: gullies are isolated, linear and discontinuous, and are restricted to the primary or minor drainage lines.
- **moderate**: gullies are continuous and linear and are restricted to the primary or minor drainage lines.
- **severe**: gullies are either continuous or discontinuous and either tend to branch away from the primary drainage lines into minor drainage lines and onto footslopes or have multiple branches within primary drainage lines.

Gully depth

Gully depth is used only with the **type** *gully*, and indicates the range of the maximum depth of gullies occurring at a site.

Available values are:

- **<1.5 m**
- **1.5–3.0 m**
- **>3.0 m**

Scald

Where surface soil is removed by wind and/or water, often exposing a more clayey subsoil which is bare and relatively impermeable to water. Scalds are a typical erosion type on duplex soils in arid or semi-arid regions and are generally associated with alluvial plains or prior streams. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of scald erosion.
- **minor**: <5% of the site is scalded.
- **moderate**: 5–50% of the site is scalded.
- **severe**: >50% of the site is scalded.

Tunnel

Removal of subsurface soil by the action of water while the surface soil remains relatively intact. It is an erosion process resulting from soil dispersion and/or slaking after water seepage. The tunnels so formed normally have outlets in a gully side, batter or earth wall, or at the ground surface further downslope. They normally collapse initiating gully erosion (Crouch 1976). **Severity** values for this **type** are as follows:

- **none**: no appreciable form of tunnel erosion.
- **not evident**: no appreciable form of tunnel erosion is observed, but the site may be susceptible.
- **evident**: tunnel erosion is observed.

Stream bank

Removal of soil from a stream bank by the direct action of stream flow. It typically occurs during periods of high stream flow. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of stream bank erosion.
- **susceptible**: no appreciable form of stream bank erosion is observed, but the site is susceptible.
- **evident**: stream bank erosion is observed.

Wave

Progressive removal of soil or sand from the margins of beaches, beach ridges, dunes, dams or lakes by the action of waves. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of wave erosion.
- **susceptible**: no appreciable form of wave erosion is observed, but the site is susceptible.
- **evident**: wave erosion is observed.

Mass movement

Downslope displacement of unstable soil material on slopes. Its occurrence depends on profile drainage, soil mineralogy and slope morphology. It may occur as a catastrophic

event – for example, mud slides, landslides – or as a slow incipient process – for example, creep. **Severity** values for this **type** are as follows:

- **none**: no appreciable form of mass movement erosion.
- **evident**: mass movement erosion is observed.

10.10 Hydrology

Hydrology describes the surface and subsurface water regime at the profile and site.

10.10.1 Presence of free water

Indicate the presence of free water or watertable as observed and its relationship to the ground surface.

10.10.2 Free water depth

Record free water depth in metres to the nearest centimetre, either above or below the soil surface, if it is exposed at the time of description.

10.10.3 Free water pH

The acidity of free water in the soil body is measured in the field using a properly calibrated pH meter and recorded to one decimal place.

10.10.4 Free water electrical conductivity

The salinity of free water in the soil body is measured in the field using a properly calibrated electrical conductivity (EC) meter and recorded in decisiemens (dS) correct to one decimal place.

10.10.5 Site exposure

Indicate the relative exposure of the site to drying conditions, such as sunlight or winds.

10.10.6 Run-on

This is a subjective assessment of the amount and rate at which water is likely to enter the site by overland flow.

Available values are:

- **none**: water does not enter the site by overland flow – for example, crests.
- **low**: small volumes of overland flow occur – for example, upper slopes and spurs.
- **moderate**: significant overland flow occurs – for example, some midslopes and some lower slopes.
- **high**: areas where concentrated overland flow occurs – for example, some lower slopes and drainage depressions.
- **very high**: large volumes of water enter the site by channelised flow – for example, gullies and major drainage lines.

10.10.7 Run-off

This is a subjective assessment of the amount and rate of water that is likely to leave the site by overland flow. The source of water may be run-on, runoff from another site,

and/or precipitation excess at the site during rainfall. Runoff is modified by landform element, soil type and ground cover, especially vegetation.

Available values are:

- **none**: water does not leave site as surface flow. Free water lies on the surface for long periods or enters the soil immediately. The site is usually level and/or the soil is loose and porous.
- **low**: water remains ponded on the surface for significant periods or enters the soil fairly quickly. The site is usually either nearly level or gently sloping or the soil is relatively porous.
- **moderate**: water lies on the surface for short periods only. A moderate amount of water may enter the soil.
- **high**: most of the water rapidly leaves the site as surface flow, with little entering the soil. The site usually has moderate to steep slope and/or the soil has a low infiltration rate or capacity.
- **very high**: water very rapidly leaves the site as surface flow. The site usually has a steep to very steep slope, and the soil has a low infiltration rate or capacity.

10.10.8 Profile drainage

Profile drainage controls local soil moisture conditions. It provides a statement about soil and site drainage that is likely to occur in most years. It is affected by a number of attributes, both internal and external, that may act separately or together. Internal attributes include soil structure, texture, cracks and macropores, hydraulic conductivity, and water-holding capacity, while external attributes are source and quality of water, evapotranspiration, slope length and gradient and position in the landscape.

Available values include:

- **very poorly drained**: water is removed from the soil so slowly that the watertable remains at or near the surface for most of the year. Surface flow, ground water and subsurface flow are major sources of water, although precipitation may be important where there is a perched watertable and precipitation exceeds evapotranspiration. Very poorly drained soils vary widely in texture and depth and often occur in depressed sites. Strong gleying and accumulation of surface organic matter are usually features.
- **poorly drained**: water is removed very slowly in relation to supply. Subsurface and/or ground water flow, as well as precipitation, may be a significant water source. Seasonal ponding resulting from run-on and insufficient outflow also occurs. A perched watertable may be present. Poorly drained soils vary widely in texture and depth; many have layers that are gleyed, mottled, or possess orange or rusty linings of root channels. All layers remain wet for periods of several months.
- **imperfectly drained**: water is removed only slowly in relation to supply. Precipitation is the main source if available water storage capacity is high, but subsurface flow and/or ground water contribute as available water storage capacity decreases. Imperfectly drained soils range widely in texture and depth. Some layers

may be mottled and/or have orange or rusty linings of root channels and are wet for periods of several weeks.

- **moderately well drained**: water is removed from the soil somewhat slowly in relation to supply due to low permeability, shallow watertable, lack of gradient, or some combination of these. Moderately well drained soils are usually medium to fine in texture. Significant additions of water by subsurface flow are necessary in coarse-textured soils. Some layers may remain wet for as long as a week after addition of water.
- **well drained**: water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying moderately permeable material or laterally as subsurface flow. Well drained soils are often medium in texture. Some layers may remain wet for several days after addition of water.
- **rapidly drained**: water is removed from the soil rapidly in relation to supply. Excess water flows downward rapidly if underlying, material is highly permeable. There may be rapid subsurface lateral flow during heavy rainfall provided there is a steep gradient. Rapidly drained soils are usually coarse textured or shallow or both. No layer is normally wet for more than several hours after addition of water.

10.10.9 Profile permeability

Permeability is an intrinsic property of the soil profile, independent of climate and drainage. It is the measure of a profile's potential to transmit water (saturated hydraulic conductivity, K_{sat}) and is controlled by the least permeable layer in the profile. It is inferred from attributes of the soil such as structure, texture, porosity, cracks and macropores, and shrink-swell properties.

Available values are:

- **very slowly permeable**: vertical transmission of water in the least permeable layer is very slow in that the profile would take periods of a month or more after thorough wetting to reach field capacity if there were no obstructions to movement from the profile. Structure may vary, but cracks and macropores between peds close on wetting. Texture is usually clay or silty clay, and there is an absence of visible (hand lens) pores that could conduct water when wet.
- **slowly permeable**: vertical transmission of water in the least permeable layer is slow in that the profile would take a week or more after thorough wetting to reach field capacity if there were no obstructions to movement from the profile. Structure may vary, usually from massive to moderate. Texture is usually clay or silty clay, and there will be few visible (hand lens) pores that conduct water when wet. If texture is coarser, the inter-particle voids are filled with fine minerals.
- **moderately permeable**: vertical transmission of water in the least permeable layer is such that such that the profile would take no more than a few (1–5) days after a thorough wetting to reach field capacity if there were no obstructions to water movement from the profile. The soil may vary in structure, but grade is usually at least moderate and blocky, or polyhedral peds are common. If massive, the soil

material is always porous. The pores and channels which remain open when wet are clearly visible with a hand lens.

- **highly permeable**: vertical transmission of water in the least permeable layer is such that the profile would take no more than 1–12 hours after a thorough wetting to reach field capacity if there were no obstructions to water movement from the profile. Layers have large, continuous and clearly visible connecting pores and cracks that do not close with wetting. Texture is usually sandy, and nodules or gravels are commonly present. Soil layers are usually apedal, but some medium to fine-textured soils with strong granular structure or cementation of aggregates can be highly permeable.

10.10.10 Flood hazard

Describes the susceptibility to flooding of the site, describing both the amount of run-on and how long the water lies around on the site.

Available values are:

- **not flooded**
- **rarely flooded**
- **local run-on**
- **subject to intensive floodwater passage**
- **subject to inundation for extended periods**
- **isolated by floodwaters**
- **not flooded; subject to intense floodwater passage**
- **local run-on; subject to intense floodwater passage**
- **passive floodwater passage and inundation for extended periods**
- **intense floodwater passage and inundation for extended periods**
- **subject to intense floodwater passage; not flooded**
- **not flooded; isolated by floodwaters**
- **subject to inundation for extended periods; local run-on**
- **intense and passive floodwater passage and inundated for periods**
- **rarely flooded; isolated by floodwaters**
- **subject to intense and passive floodwater passage**
- **run-on; passive floodwater passage and inundated for periods**.

10.11 Salinity

10.11.1 Salinity

Saline soils often have ground cover percentage equal to or nearly zero. Where vegetation is present, it is usually stunted with deep blue-green foliage and has considerable variability in size. These features, however, are not invariable indicators of salinity as they may be caused by inadequate nutrition or uneven irrigation. Further, some plant species are more tolerant of saline conditions than others and may be used

to reclaim affected areas. Such species (ordered from highly tolerant to moderately tolerant) are *Puccinellia* spp., tall wheat-grass, couch, wimmera ryegrass, rhodes grass, phalaris, strawberry clover and lucerne. The presence of **salinity** is often reflected in the **vegetation** and **site condition**. The layer attribute **silver nitrate test** under **chemical tests** may be used to record the results of a diagnostic test of the **salinity** status of layers in the profile.

Available values are:

- **no salting evident**: effect of salting is not apparent in the vegetation or on the soil surface.
- **salting evident**: growth of salt sensitive plants is inhibited but that of salt-tolerant plants is not affected; patches of bare ground may occur.
- **salting strongly evident**: only a few species of salt-tolerant plants survive and much of the ground is bare, with a surface crust; free salts are often visible on the ground surface.

10.11.2 Salt outbreak mapping

This field allows the surveyor to record a **salt outbreak mapping** for the site.

Available values are:

- **non-saline wet site**: the site is affected by high groundwater or a localised perched water table. No evidence of salt-tolerant vegetation species is observed at the site, although species tolerant of permanently or seasonally moist conditions are observed. In localities where dryland salinity is already an acknowledged problem, these sites have the potential to become saline over time
- **confirmed sub-surface salt store**: no surface expression of salinity is observed at the site. The presence of sub-surface salt is confirmed by electromagnetic induction survey and soil sampling.
- **outbreak, salt-tolerant plants**: early phase of dryland salinity outbreak with salt-tolerant plant species present. Salt-tolerant vegetation occupies most of the site and can include *Typhus* spp. (cumbungi), *Juncus acutus* (spiny rush), *Cynodon dactylon* (couch) and *Hordeum marinum* (sea barley grass). Bare patches of ground <1 m^2 in size occupying <25% of the total surface area of the site occur in small, discrete patches. Salt crystals can be observed on the bare surfaces at certain times. Salt sensitive vegetation species are entirely absent or restricted to slightly raised areas within the overall site.
- **outbreak, low-moderate sheet erosion:** dryland salinity outbreak affected by low to moderate levels of sheet erosion. The site is affected by high, saline groundwater. **Salt**-tolerant vegetation occupies most of the site and can include *Typhus* spp. (cumbungi), *Juncus acutus* (spiny rush), *Cynodon dactylon* (couch) and *Hordeum marinum* (sea barley grass). Bare patches of ground <1 m^2 in size and occupying <25% of the total surface area of the site occur in small, discrete patches. Salt crystals can be observed on the bare surfaces at certain times. Salt sensitive

vegetation species are entirely absent or restricted to slightly raised areas within the overall site.

- **outbreak, severe rill/sheet erosion:** dryland salinity outbreak affected by severe to extreme rates of rill and sheet erosion. The site affected by high, saline groundwater and is almost completely bare of vegetation, including most salt-tolerant species. Salt crystals can be observed on the bare surfaces at certain times. Salt-tolerant vegetation species are usually restricted to slightly raised areas within the overall site.
- **minor gully erosion, salt discharges**: minor gully erosion is classified as isolated, discontinuous linear gullies, confined to primary or minor drainage lines. Salt discharges occur within gully floor or from banks of gully.
- **moderate gully erosion, salt discharges**: moderate gully erosion is classified as continuous linear gullies, confined to primary or minor drainage lines. Salt discharges occur within gully floor or from banks of gully.
- **severe gully erosion, salt discharges**: severe gully erosion is classified as discontinuous or continuous gullies, branching into minor drainage lines or multiple branching within primary drainage lines. Salt discharges occur within gully floor or from banks of gully.
- **extreme gully erosion, salt discharges**: extreme gully erosion is classified as discontinuous or continuous multiple branching gullies or sub-parallel gullies in dispersible soils. Salt discharges occur within gully floor or from banks of gully.
- **irrigation outbreak, salt-tolerant plants:** early phase of salinity development caused by irrigation practices with salt-tolerant plant species present. The site is affected by high, saline groundwater caused by irrigation practices. Salt-tolerant vegetation occupies most of the site and can include *Typhus* spp. (cumbungi), *Juncus acutus* (spiny rush), *Cynodon dactylon* (couch), *Hordeum marinum* (sea barley grass) or *Trifolium fragiferum* (strawberry clover). Salt sensitive vegetation species are entirely absent or restricted to slightly raised areas within the overall site. <5% of the total area of the site is bare of vegetation.
- **irrigation outbreak, low-moderate sheet erosion**: salinity site caused by irrigation practices and associated with low to moderate levels of sheet erosion. Site affected by high, saline groundwater caused by irrigation practices. Salt-tolerant vegetation occupies most of the site and can include *Typhus* spp. (cumbungi), *Juncus acutus* (spiny rush), *Cynodon dactylon* (couch), *Hordeum marinum* (sea barley grass). Bare patches of ground <1 m^2 in size and occupying <25% of the total surface area of the site occur in small, discrete patches. Salt crystals can be observed on the bare surfaces at certain times. Salt sensitive vegetation species are entirely absent or restricted to slightly raised areas within the overall site.
- **irrigation outbreak, severe rill/sheet**: salinity site caused by irrigation practices and associated with severe to extreme rates of rill and sheet erosion. Site is affected by high, saline groundwater caused by irrigation practices. The site is almost completely bare of vegetation, including most salt-tolerant species. Salt crystals

can be observed on the bare surfaces at certain times. Salt-tolerant vegetation species are usually restricted to slightly raised areas within the overall site.

- **marine-derived salinity**: soil salinity due to marine influences. Includes areas of mangroves, brackish coastal swamps.

10.11.3 Salt outbreak vegetation species

This notes field allows the user to record the names of vegetation species present at any surface outbreak of salinity that may occur at the site as well as their condition.

10.11.4 Electromagnetic measurement

Measurement type

Allows the user to record an electromagnetic induction measurement at the site. This field allows the surveyor to record the identifying number of the geophysical electromagnetic (EM) instrument being used for the first set of measurements. To add additional types of meters to the list of values, please contact the SALIS administrator.

Horizontal

Record the electromagnetic reading in millisiemens per m (mS/s) with the EM instrument on or very close to the ground surface in horizontal dipole mode (that is, with the flat sides of the instrument facing vertically).

Vertical

Record the vertical electromagnetic reading in millisiemens per m (mS/m) with the EM instrument on or very close to the ground surface in vertical dipole mode (that is, with the flat sides of the instrument facing horizontally).

10.12 Vegetation

Vegetation describes the vegetative characteristics generally extending from the soil profile to a radius of 10 m or the edge of the landform element, whichever is less. Structural formation classes used are equivalent to Specht *et al.* 1974.

10.12.1 Vegetation formation

Describe the original, or native, vegetation if any remains.

Available values are:

- **unknown**: impossible to ascertain native vegetation.
- **rainforest**: canopy cover >70%, maximum height >10 m; structurally complex (more than one stratum) and floristically diverse with dense crowns; emergents, vines, ferns and epiphytes present.
- **wet sclerophyll**: canopy cover 30–70%, maximum height >10 m; sclerophyllous trees; at least one moist stratum of mesophytic shrubs; ferns are frequently present.
- **dry sclerophyll**: canopy cover 30–70%, maximum height >10 m; sclerophyllous trees; a single lower stratum of xerophytic shrubs and herbs.

- **woodland grass understorey**: canopy cover <30%, maximum height >5 m; lower stratum of sod or tussock grass; grades into dry sclerophyll or grassland.
- **woodland-shrub understorey**: canopy cover <30%, maximum height >5 m; lower stratum characterised by shrubs; grades into dry sclerophyll or shrubland.
- **tall shrubland**: canopy cover <70%, maximum height >2 m.
- **low shrubland**: anopy cover <30%, maximum height <2 m; sparse upper stratum with a lower stratum of grasses and forbs.
- **heath**: canopy cover <30%, maximum height <2 m; dense upper stratum with a sporadic lower stratum of forbs.
- **grassland/herbland**: grasses, single stratum of grasses and forbs.
- **swamp complex**: mixed growth forms; low shrubs, heath, swamp grasses, sedges, rushes and forbs.
- **littoral complex**: mixed growth forms; mosaic of mangroves, low shrubs, forbs, sedges and swamp grasses adjacent to estuarine or tidal areas.
- **no vegetation**: bare, mainly due to extreme moisture stress, high salinity or lack of suitable rooting material.

10.12.2 Growth forms

Record up to 4 growth forms which dominate the site. Consider growth forms in each stratum: the upper stratum, the mid stratum and the lower stratum.

Available values are:

- **tree**: woody plant >2 m tall with a single stem or branches well above the base.
- **mallee tree**: woody perennial plant usually of the genus *Eucalyptus*; multi-stemmed with fewer than 5 trunks of which at least 3 are >100 mm in diameter at breast height; usually ≥8 m tall.
- **shrub**: woody plant, multi-stemmed at the base (or within 200 mm from ground level) or, if single-stemmed, <2 m tall.
- **mallee shrub**: commonly <8 m tall, usually with 5 or more trunks, of which at least 3 of the largest trunks are ≤100 mm in diameter at breast height.
- **heath shrub**: shrub, usually <2 m tall, commonly with ericoid leaves.
- **chenopod shrub**: xeromorphic single or multi-stemmed halophyte exhibiting drought and salt tolerance.
- **hummock grass**: coarse xeromorphic grass with a mound-like form often dead in the middle; genera are *Triodia* and *Plectrachne*. These differ from sedges in that the leaf sheath is always split, ligules are present, the leaf is usually flat, the stem cross-section is circular, and evenly spaced internodes.
- **tussock grass**: forms discrete but open tussocks, usually with distinct individual shoots or, if not, then not forming a hummock. These are the common agricultural grasses. These differ from sedges in that the leaf sheath is always split, ligules are present, the leaf is usually flat, the stem cross-section is circular, and evenly spaced internodes.

- **sod grass**: grass of short to medium height forming compact tussocks in close contact at their base and uniting as a densely interfacing leaf canopy. These differ from sedges in that the leaf sheath is always split, ligules are present, the leaf is usually flat, the stem cross-section is circular, and evenly spaced internodes.
- **sedge**: herbaceous, usually perennial, erect plant; generally with a tufted habit and of the families *Cyperaceae* and *Restionaceae*. These differ from grasses in that the leaf sheath is never split (except *Restionaceae*), there is usually no ligule, the leaf is not always flat, the stem cross-section is circular, triangular or polygonal, and there is an extended internode below the inflorescence.
- **rush**: herbaceous, usually perennial, erect plant. Rushes are grouped in the families *Juncaceae*, *Typhaceae*, *Restionaceae* and the genus *Lomandra*.
- **forb**: herbaceous or slightly woody annual or sometimes perennial plant; not a grass.
- **fern/cycad**: characterised by large and usually branched leaves (fronds), herbaceous to arborescent and terrestrial to aquatic; spores in sporangia on the leaves or separate sporophylls.
- **moss**: small plant usually with a slender leaf bearing stem with no true vascular tissue.
- **lichen**: composite plant consisting of a fungus living symbiotically with algae; without true roots, stems or leaves.
- **liverwort**: often moss-like in appearance or consisting of a flat, ribbon like green thallus.
- **vine**: climbing, twining, winding or sprawling plant usually with a woody stem.

10.12.3 Crown separation ratio

The crown separation ratio is the average distance between crowns, divided by the average diameter of crowns.

Describe the **crown separation ratio** for the upper stratum and, if relevant, record in **site field notes** the **crown separation ratio** for the mid stratum within the complete vegetation unit.

10.12.4 Upper stratum height

Describe the mean upper stratum height in metres.

10.12.5 Vegetation species

To add a plant species, click or tap on the 

+ Add button.

To edit an existing species record, click or tap on its row in the table (web app) or click or tap on the row's  **Edit** button. To delete a species record, click or tap on its  **Delete** button.

Code

A list of 4-character numerical codes has been compiled from Government staff, Leigh and Mulham (1965), Beadle, Evans and Carolin (1982) and other reliable sources for

plant species in New South Wales. This list is not exhaustive, and codes will be added as required. New codes will be provided by the SALIS Administrator on request. Enter part or all of a code or species name to select a species.

Common name

Typically, each plant species has one or more common names, being names widely and/or frequently used to describe that species. While some common names are universally applicable, others are used only within certain regions or localities. Common names do not necessarily reliably correspond to individual species – for example, the common name 'narrow-leaved stringybark' is commonly used to refer to both *Eucalyptus oblonga* and *Eucalyptus sparsifolia*, which are distinct species of eucalypt.

Scientific name

A species' scientific (binomial) name is made up of its genus name (a group of species associated by similarity, ancestry and relation, distinctiveness and utility) and its species name (a group of plants capable of interbreeding and producing fertile offspring). For example, the river red gum is part of the genus *Eucalyptus* and has the species name *camaldulensis*, thus, its scientific (binomial) name is *Eucalyptus camaldulensis*.

Stratum

For each species code entered, a stratum should be recorded.

Available values are:

- **upper stratum**: tallest stratum, canopy
- **mid stratum**: second tallest stratum
- **lower stratum**: third tallest stratum.

Dominance

For each species code entered, a code may be entered which identifies whether the species is dominant, co-dominant or subdominant within the association.

Available values are:

- **dominant**: most abundant or physically predominant species in the stratum.
- **co-dominant**: 2 or more species are said to be co-dominant where their combined abundance is significantly greater than the combined abundance of all other species in the association. It is also important for the relative abundance of the co-dominant species to be relatively similar. If one species is significantly more abundant than another, this species is said to be dominant and the other sub-dominant.
- **subdominant**: less abundant than either co-dominant or dominant species.

11. Layer attributes

11.1 Base of observation

Use this field to record the status of the profile at the lowest point of the observations. Where bedrock is not reached you can record that either the soil, or, more specifically, the layer continues.

Available values are:

- **layer continues**: bedrock is not reached. The soil surveyor is certain that the underlying material is identical to that of the lowest layer recorded.
- **soil continues**: bedrock is not reached. The soil surveyor is uncertain of the nature of the underlying soil material.
- **equipment refusal**: the soil is too hard, tough, stony, unconsolidated or deep for further exploration – for example, a rock 'floater' has been encountered, or the soil incorporates saturated sands which are too fluid to be withdrawn from the observation hole.
- **bedrock reached**: bedrock has been reached. This will be confirmed by the recording of a **substrate layer**.

11.2 Layer status

11.2.1 Horizon code

Prefix

A **prefix** numeral (for example, 2B2) indicates buried soils, or soils below lithological discontinuities, or layers with obvious difference(s) in lithology. These layers are numbered from the surface downwards, although the upper or modern soil is not numbered '1', this being assumed. Buried soil layers should also be given the horizon suffix 'b'. Prefix numerals of 2, 3 or 4 may be used with any horizon code and a prefix of 5 with the D horizon only.

Division

Each layer can be allocated a **horizon code**. **Horizon codes** are deduced from the profile description data (NCST 2009) and should be allocated only after completing the other attributes for the profile.

Available values at the **division** level are:

- **O**: horizon dominated by organic materials, forming layer(s) above the mineral soil surface; may be subdivided into O1 or O2.
- **P**: layer(s) of organic debris in various stages of decomposition that have accumulated under water or in excessive wetness.

- **A**: surface mineral horizon(s) with some organic accumulation; either darker in colour than underlying horizons, or lighter in colour but with a lower silicate clay/sesquioxide content.
- **B**: subsoil horizon(s) characterised by one or more of the following: concentration of silicate clay, iron, aluminium, and/or organic material; different structure and/or consistence to adjacent horizons; and/or stronger colours than adjacent horizons.
- **C**: layer(s) of consolidated or unconsolidated, generally partially weathered material showing lack of pedological development and/or presence of remnant geological structure or organisation - for example, sedimentary laminae, 'ghost' rock structures such as saprolite.
- **AB**: transition from A to B but not dominated by properties characteristic of either horizon.
- **AC**: transition from A to C but not dominated by properties characteristic of either horizon; B horizon not present.
- **BC**: transition from B to C but not dominated by properties characteristic of either horizon.
- **D**: layer(s) showing contrast in pedological organisation to overlying A and/or B horizons but is not C or buried soil.
- **F**: fill layers; mineral layers of materials imported by human activity, recent sedimentation, etc., and numbered from the surface downwards.
- **R**: continuous masses of moderately strong to strong, non-displaced bedrock; underlies the solum or other unconsolidated surficial material; very few cracks or joints allowing penetration of roots.

Subdivision

Each layer can be allocated a **horizon code**. **Horizon codes** are deduced from the profile description data (NCST 2009) and should be allocated only after completing the other attributes for the profile. A layer may be given a general designation – for example, A – or a more detailed classification – for example, A1 or A2 – depending upon the characteristics evident. Where a broad horizon – for example, B2 – has been subdivided into narrower layers – for example, B21, B22, and B23 – these are numbered downwards from the surface.

Available values are:

- **O**: horizon dominated by organic materials, forming layer(s) above the mineral soil surface; may be subdivided into O1 or O2.
- **O1**: undecomposed organic debris – for example, leaves or twigs – whose original form can be recognised with the naked eye.
- **O2**: organic debris in various stages of decomposition. The original form of most of the debris cannot be recognised with the naked eye.
- **P**: layer(s) of organic debris in various stages of decomposition that have accumulated under water or in excessive wetness.

- **P1**: relatively undecomposed material whose original form can be recognised with the naked eye.
- **P2**: moderately to completely decomposed organic material whose original form of material can generally not be detected with the naked eye. Can be further divided into P21, P22.
- **A**: surface mineral horizon(s) with some organic accumulation; either darker in colour than underlying horizons, or lighter in colour but with a lower silicate clay/sesquioxide content.
- **Ap**: ploughing, tillage practices or other human disturbance – for example, deep ripping; used only with A horizons; where the plough layer clearly includes what was once B horizon and it is no longer possible to infer with any reliability what the texture and depth of the A horizon where the plough layer is designated Ap; may be subdivided into subhorizons – for example, Ap1, Ap2. Note: an Ap2 horizon is different from an A2 horizon, but a subdivision equivalent to A12.
- **A1**: mineral horizon at or near surface and containing some humified organic matter; usually darker than underlying horizons, and with maximum biologic activity for any given soil profile. Can be further divided into A11, A12, A13, A14, A15 and A16.
- **A11**: darker, uppermost section of A1.
- **A12**: usually lighter in colour than A11 but not pale enough to qualify as an A2. Can be divided into A13.
- **A2**: mineral horizon(s) characterised by one or more of the following: less organic matter, sesquioxides and/or organic material than adjacent horizons; different structure and/or consistence to adjacent horizons; and/or paler colours than adjacent horizons. Further division is possible into A21, A22, A23, A24, A25 and A26.
- **A3**: transitional horizon(s) from A to B but with properties more like A. Further division is possible into A31, A32, A33, A34, A35 and A36.
- **B**: subsoil horizon(s) characterised by one or more of the following: concentration of silicate clay, iron, aluminium, and/or organic material; different structure and/or consistence to adjacent horizons; and/or stronger colours than adjacent horizons.
- **B1**: transition from A to B but with properties more like the underlying B2. Further division is possible into B11, B12, B13, B14, B15 and B16.
- **B2**: horizon(s) dominated by one or more of the following: an illuvial, residual or other concentration of silicate clay, iron, aluminium and/or humus; maximum pedological organisation as indicated by a different structure and/or consistence, and/or a stronger colour. Further division is possible into B21, B22, B23, B24, B25 and B26.
- **B3**: transition from B to C with properties more like B2 but intergrading to the properties of the C horizon below. Further division is possible into B31, B32, B33, B34, B35 and B36.
- **C**: layer(s) of consolidated or unconsolidated, generally partially weathered material showing lack of pedological development and/or presence of remnant geological

structure or organisation – for example, sedimentary laminae, ‘ghost’ rock structures such as saprolite.

- **C1**: can be further subdivided into C11, C12, C13, C14, C15 and C16.
- **C2**: can be further subdivided into C21, C22, C23, C24, C25 and C26.
- **C3**: can be further subdivided into C31, C32, C33, C34, C35 and C36.
- **AB**: transition from A to B but not dominated by properties characteristic of either horizon.
- **AB1**: can be further subdivided into AB11, AB12, AB13, AB14, AB15 and AB16.
- **AB2**: can be further subdivided into AB21, AB22, AB23, AB24, AB25 and AB26.
- **AB3**: can be further subdivided into AB31, AB32, AB33, AB34, AB35 and AB36.
- **AC**: transition from A to C but not dominated by properties characteristic of either horizon; B horizon not present.
- **AC1**: can be further subdivided into AC11, AC12, AC13, AC14, AC15 and AC16.
- **AC2**: can be further subdivided into AC21, AC22, AC23, AC24, AC25 and AC26.
- **AC3**: can be further subdivided into AC31, AC32, AC33, AC34, AC35 and AC36.
- **BC**: transition from B to C but not dominated by properties characteristic of either horizon.
- **BC1**: can be further subdivided into BC11, BC12, BC13, BC14, BC15 and BC16.
- **BC2**: can be further subdivided into BC21, BC22, BC23, BC24, BC25 and BC26.
- **BC3**: can be further subdivided into BC31, BC32, BC33, BC34, BC35 and BC36.
- **D**: layer(s) showing contrast in pedological organisation to overlying A and/or B horizons but is not C or buried soil.
- **D1**: can be further subdivided into D11, D12, D13, D14, D15 and D16.
- **D2**: can be further subdivided into D21, D22, D23, D24, D25 and D26.
- **D3**: can be further subdivided into D31, D32, D33, D34, D35 and D36.
- **F**: fill layers; mineral layers of materials imported by human activity, recent sedimentation, etc., and numbered from the surface downwards.
- **F1**: can be further subdivided into F11, F12, F13, F14, F15 and F16.
- **F2**: can be further subdivided into F21, F22, F23, F24, F25 and F26.
- **F3**: can be further subdivided into F31, F32, F33, F34, F35 and F36.
- **R**: continuous masses of moderately strong to strong, non-displaced bedrock; underlies the solum or other unconsolidated surficial material; very few cracks or joints allowing penetration of roots.

11.2.2 Horizon suffix

Horizon suffixes allow additional summary information about a layer to be recorded. They should be allocated only after completing the other attributes for the profile.

Available values are:

- **buried soil horizon** (**b**): used in mineral soils only. See references to buried soil layers above.
- **concretions or nodules** (**c**): horizons with accumulation of concretions or nodules of iron and/or aluminium and/or manganese.
- **concretions or nodules >50%** (**cc**): horizons with accumulation of >50% concretions or nodules of iron and/or aluminium and/or manganese.
- **densipan** (**d**): very fine sandy earthy pan.
- **conspicuously bleached horizon** (**e**): ≥80% of the horizon is white, near white or much paler than adjacent horizons; Munsell Notations for dry soil for all hues, value 7 or greater, with chroma 4 or less, and where adjacent horizons have hues 5YR or redder, value 6 or greater, with chroma 4 or less (Northcote 1979); most common in A2 horizons.
- **faunal accumulation** (**f**): where faunal accumulation, such as worm casts, dominates certain A1 horizons.
- **strong gleying** (**g**): indicative of permanent or periodic intense reduction due to wetness and characterised by greyish, bluish or greenish colours, generally of low chroma; mottles may be prominent and may have reddish hues and higher chromas if oxidising conditions occur periodically; roots may have rusty or yellowish outlines.
- **organic-Al complexes** (**h**): accumulation of amorphous organic matter-aluminium complexes in which iron contents are very low; the dominantly organic-aluminium complexes occur as discrete pellets between clean sand grains or completely fill the voids, occasionally they may coat sand grains; *h* is often combined with *s* where both organic and iron components are significant; *h* and *hs* horizons may be soft or cemented and form the characteristic B horizons of poorly drained Podzols or Spodosols.
- **sporadically bleached** (**j**): sporadically bleached horizon; bleached material is white, near white or much paler than adjacent horizons; Munsell Notations for dry soil for all hues, value 7 or greater, with chroma 4 or less, and where adjacent horizons have hues 5YR or redder, value 6 or greater, with chroma 4 or less; bleach occurs irregularly as blotches at the interface of horizons, or as nests of bleached grains at the interface of A and B horizons where no other evidence of an A2 occurs (Northcote 1979); most common in A2 horizons.
- **carbonates** (**k**): Accumulation of carbonates, commonly calcium carbonate.
- **strong cementation** (**m**): strong cementation or induration; confined to irreversibly cemented horizons which are essentially continuous (>90%) though they may be broken.
- **changed properties due to fire** (**n**): horizons that have changed properties (primarily changed to an orange/red colour) as a result of heat (fire).
- **ploughing or tillage practices** (**p**): ploughing, tillage practices or other human disturbance, for example, deep ripping; used only with A horizons; where the plough layer clearly includes what was once B horizon and it is no longer possible to infer with any reliability what the texture and depth of the A horizon was, the plough

layer is designated Ap; may be subdivided into subhorizons by using the *Ap* horizon code (see above).

- **secondary silica** (**q**): accumulation of secondary silica; if cementation is continuous or nearly continuous, this information should be recorded in layer field notes and the suffixes *q* and *m* used.
- **weathered rock** (**r**): layers of weathered rock (including saprolite) that, although consolidated, can be dug with hand tools.
- **illuvial sesquioxides** (**s**): accumulation of sesquioxide-organic matter complexes in which iron is dominant relative to aluminium; may form coating on sand grains, occur as discrete pellets or, with moderate amounts of iron, may fill voids forming cemented patches; organic matter content is variable and distribution often irregular; *s* is often combined with *h* where both organic and iron components are significant; *s* and *sh* horizons may be soft or hard and form the characteristic B horizons of free-draining Podzols or Spodosols.
- **silicate clay** (**t**): accumulation of silicate clay; different mechanisms (such as illuviation, formation in situ) may be responsible for the clay accumulation, but these may be difficult to confirm; used only with B horizons.
- **colour/structure development** (**w**): development of colour and/or structure in B horizon with little or no accumulation of clay.
- **fragipan/earthy pan** (**x**): fragipan or earthy pan; A horizon with high bulk density relative to the horizon above, seemingly cemented when dry but when moist showing a moderate to weak cementation.
- **gypsum** (**y**): accumulation of calcium sulphate (gypsum).
- **salts** (**z**): accumulation of salts more soluble than calcium sulphate and calcium carbonate.
- **other:** used where doubt is associated with the nomenclature of the horizon; details should be recorded in the text box provided when 'other' is selected.

11.2.3 Soil material code

You can record an identifying code for a soil material – for example, for use in soil survey reports, or for analysis of soil attributes. Up to 4 characters may be used, in any combination of letters, both upper and lower case, and numerals.

11.2.4 Impeding

Describe whether the **layer** provides an impediment to the movement of water or plant roots downwards through the **profile**.

11.2.5 Sample taken

Refers to soil samples taken from a layer for further testing and investigation. The purpose of this field is to assist in the tracking of samples for laboratory testing and the correct assignment of the results.

Record the value that best describes the type of samples taken. You can select up to 3 values. If required, values not listed and more detailed descriptions can be recorded in layer field notes.

Available values are:

- **none**: no sample taken for this layer.
- **unspecified**: type of sample not identified.
- **disturbed**: sample taken from single profile; structure of the soil not retained in the sample; larger roots and coarse fragments may be removed.
- **undisturbed**: sample taken from single profile using wide bore corer or similar equipment; structure is still evident and all roots and coarse fragments are retained.
- **micromorphological**: sample taken from single profile and prepared at the site using resin or similar material so that all micromorphological structures are retained for examination and the sample can be cut for microscopic analysis.
- **bulked**: sample taken from the equivalent layer within the radius of the site; any number of smaller samples are brought together to provide a large sample for laboratory analysis. It is recommended that at least 12 sub-samples be used to build up a bulked sample.
- **bulk density**: samples of the equivalent layer taken in as intact a state as possible – for example, using bulk density rings.

11.2.6 Dent's classification for Acid Sulfate Soils (Dent 1986)

Allows classification of **layers** in acid sulfate soils according to their level of development of acid sulfate characteristics, either in unoxidised or oxidised state, using a horizon classification introduced by Dent (1986). The class may be prefixed by a number identifying the second or subsequent **horizon** of the same type in a profile – for example, the second (deeper) occurrence of a GBj horizon in a **profile** would be classified as 2GBj, while the third would be classified as 3GBj.

Horizons of unripe saline clay soils

- **Gr**: practically unripe or half ripe; permanently reduced and accumulating pyrite.
- **Gro**: half ripe; partly oxidised; iron pipes and ped coatings.
- **Go**: nearly ripe; oxidised; mottles; nodules, pipes and coatings of iron or iron oxide, not potentially acid.
- **Gj**: severely acid; black, dark grey or pinkish brown, usually with pale yellow jarosite mottles; practically unripe or half ripe; reserve of pyrite present.
- **G**: undifferentiated, unripe surface layer.

Horizons developing after drainage

- **GBj**: severely acid; grey with pale yellow jarosite mottles; half ripe or nearly ripe; reserve of pyrite present.
- **Bj**: severely acid; strongly mottles grey with reddish iron oxide and yellow jarosite mottles; ripe.

- **Bg**: not severely acid; strongly mottled grey with reddish iron oxide mottles and nodules; ripe.
- **Hj**: severely acid peat.
- **A**: surface mineral horizon distinguished by a concentration of organic matter, not severely acid.

Number of occurrence

The class may be prefixed by a number identifying the second or subsequent **horizon** of the same type in a **profile** – for example, the second (deeper) occurrence of a GBj horizon in a **profile** would be classified as 2GBj, while the third would be classified as 3GBj.

11.3 Boundary

11.3.1 Distinctiveness

For each layer, record one value to describe the **distinctiveness** of the boundary with the layer below.

Available values are:

- **not evident**: for layers extending beyond the maximum depth of the profile description.
- **sharp (<5 mm)**
- **abrupt (5–20 mm)**
- **clear (20–50 mm)**
- **gradual (50–100 mm)**
- **diffuse (>100 mm)**.

11.3.2 Shape

For each layer, record one value to describe the shape of the boundary with respect to the layer below.

Available values are:

- **smooth**: almost a planar surface.
- **wavy**: undulating with troughs relatively wider than they are deep.
- **irregular**: undulating with troughs relatively deeper than they are wide.
- **tongued**: tongues, considerably deeper than they are wide, into an adjacent layer.
- **broken**: discontinuous.

11.4 Colour

11.4.1 Moist Munsell

Dry samples should be moistened and the colour recorded when the visible moisture film disappears from the aggregate surface. With most soils, dry samples will change

colour with the addition of water, usually a decrease of 1.5–2 in **value** and an increase of 1.5–2 in **chroma**.

The Munsell colour notation consists of 3 dimensions:

- **hue**: the dominant spectral colour
- **value**: a number representing the lightness or darkness, from 0 (black) to 10 (white)
- **chroma**: a number representing the saturation or purity of the colour, from 0 (neutral) to 8 (highly saturated).

For the purpose of ease of recording, the eDIRT app splits the **hue** (for example, 5YR) into its leading value (5) and its hue (YR). All 4 elements are required to generate a valid colour.

A reference list of values can be found by using Munsell Soil Colour Charts (Munsell Colour 2009). More information can be found at **Munsell Color Systems**.

Hue value

Used in conjunction with **hue**, **hue value** describes the dominant spectral colour of the soil. **Value** and **chroma** must also be recorded.

Hue

Used in conjunction with **hue value**, **hue** describes the dominant spectral colour of the soil. **Value** and **chroma** must also be recorded.

Value

The **value** indicates the lightness or darkness of the soil. **Hue**, **hue value** and **chroma** must also be recorded to deliver a description of the soil colour using the Munsell system.

Chroma

The **chroma** indicates the intensity or brightness of the colour of the soil. **Hue**, **hue value** and **value** must also be recorded to deliver a description of the soil colour using the Munsell system.

11.4.2 Dry Munsell

Dry soil colour is recorded using the same methodology as for Moist Munsell Notation, above. Dry soil colour measurements should be made on the surface of a freshly broken aggregate of dry soil.

In this system, colour is defined with respect to 3 independent coordinates as defined in **colour – moist Munsell**. A reference list of values will be found by using Munsell Soil Colour Charts (Munsell Colour 2009). More information can be found at **Munsell Color Systems**.

Hue value

Used in conjunction with **hue**, **hue value** describes the dominant spectral colour of the soil. **Value** and **chroma** must also be recorded.

Hue

Used in conjunction with **hue value**, **hue** describes the dominant spectral colour of the soil. **Value** and **chroma** must also be recorded.

Value

The **value** indicates the lightness or darkness of the soil. **Hue**, **hue value** and **chroma** must also be recorded to deliver a description of the soil colour using the Munsell system.

Chroma

The **chroma** indicates the intensity or brightness of the colour of the soil. **Hue**, **hue value** and **value** must also be recorded to deliver a description of the soil colour using the Munsell system.

11.4.3 General colour

Record a general indication of the colour of a soil layer at its current moisture condition, as a less accurate alternative to Munsell notation.

Available values are:

- **dark**: V/C 1 for all hues.
- **red**: V/C 2b, 3b or 4 for hues as red as or redder than 2.5YR.
- **orange**: V/C 4 for hues 5YR, 7.5YR or 10YR.
- **yellow**: V/C 3b or 4 for hues as yellow as or yellower than 2.5Y.
- **brown**: V/C 5 for all hues; or V/C 2b for hues as yellow as or yellower than 5YR; or V/C 3b for hues 5YR, 7.5YR, 10YR.
- **pale**: V/C 3a for all hues.
- **grey**: V/C 2a for all hues.
- **gley**: Any colour on the Munsell 'gley' charts.

11.4.4 Modifier with General colour

Qualifies the specified value for **general colour** or **Isbell colour**. Use this attribute, where necessary, to specify if the colour recorded in these attributes is *dark* or *light*.

11.4.5 Isbell colour

Record a general indication of the visible colour of a soil layer, using the set of values defined for the Australian Soil Classification (Isbell 2002).

Available values are:

- **black**: the dominant colour (moist) for all hues has a value of 3 or less and a chroma of 2 or less.

- **red**: the dominant colour (moist) has a hue of 5YR or redder and a chroma of 3 or more.
- **brown**: the dominant colour (moist) has a hue yellower than 5YR and a value of 5 or less and a chroma of 3 or more.
- **yellow**: the dominant colour (moist) has a hue yellower than 5YR and a value of 6 or more and a chroma of 4 or more.
- **grey**: the dominant colour (moist) for all hues has a value of 4 or more and chroma 2 or less; for hues yellower than 5YR values of 6 or more and chromas of 3 are allowed.

11.5 Mottles

Mottles are masses, blotches or streaks of sub-dominant colours within the soil. They do not include the glaze or colour skin which may occur on the outside of some peds (see **ped coatings - coating type**). Northcote (1979) defines mottles as colours which differ from the dominant colour by 5 units in hue and/or 2 units in value or 4 units in chroma and affect ≥10% of the soil mass. Only the extreme colours of the mottle need to be described. Provision is made for recording descriptions under the headings of dominant mottle and subdominant mottle.

Mottle dominance and type are key **attributes** and require **values** before **values** for the related **attributes** can be recorded. The mottle type must be provided if related **attributes** are to be described.

11.5.1 Dominant

Mottle type

Describes the general nature or likely cause of the colour patterns for the dominant mottle in each layer.

Available values are:

- **not evident**: no dominant mottles observed in layer.
- **unspecified**: dominant mottles observed but type not identified.
- **biological**: colour patterns due to biological mixing of soil material from other horizons – for example, earthworm casts.
- **mechanical**: colour patterns due to mechanical mixing of soil material from other horizons – for example, inclusions of B horizon material in Ap horizons.
- **weathered**: colour patterns due to inclusions of weathered substrate material and includes patterns due to chemical reactions – for example, fluctuating watertable.

Mottle abundance

Describe the proportion of the soil mass that can be described as dominant mottles.

Available values are:

- **not evident**
- **<2%**

- **2–10%**
- **10–20%**
- **20–50%.**

Munsell colour

Dominant mottle colour may be measured using the Munsell Soil Colour Charts (Munsell Colour 2009). More information can be found at **Munsell Color Systems**. In this system, colour is defined with respect to 3 independent coordinates as defined in **colour – moist Munsell**. Soil colour measurements should be made on the surface of a freshly broken aggregate of moist soil. Dry samples should be moistened, and the colour recorded when the visible moisture film disappears from the aggregate surface. With most soils, dry samples will change colour with the addition of water, usually a decrease of 1.5 to 2 units of value.

Hue value

Used in conjunction with **hue**, **hue value** describes the dominant spectral colour of the dominant mottle. **Value** and **chroma** must also be recorded.

Hue

Used in conjunction with **hue value**, **hue** describes the dominant spectral colour of the dominant mottle. **value** and **chroma** must also be recorded.

Value

The **value** indicates the lightness or darkness of the dominant mottle. **Hue**, **hue value** and **chroma** must also be recorded to deliver a description of the dominant mottle colour using the Munsell system.

Chroma

The **chroma** indicates the intensity or brightness of the colour of the dominant mottle. **Hue**, **hue value** and **value** must also be recorded to deliver a description of the dominant mottle colour using the Munsell system.

General colour

Alternate to or in conjunction with Munsell notation, values from colour can be recorded to describe the colour of the dominant mottle.

Available values are:

- **dark**: V/C 1 for all hues.
- **red**: V/C 2b, 3b or 4 for hues as red as or redder than 2.5YR.
- **orange**: V/C 4 for hues 5YR, 7.5YR or 10YR.
- **yellow**: V/C 3b or 4 for hues as yellow as or yellower than 2.5Y.
- **brown**: V/C 5 for all hues; or V/C 2b for hues as yellow as or yellower than 5YR; or V/C 3b for hues 5YR, 7.5YR, 10YR.

- **pale**: V/C 3a for all hues.
- **grey**: V/C 2a for all hues.
- **gley**: any colour on the Munsell ‘gley’ charts.

General colour modifier

Qualifies the specified value for the dominant **mottle colour**. Use this attribute, where necessary, to specify if the colour recorded in these attributes is dark or light.

Contrast

Describe the contrast of the boundary between the dominant mottle and the remainder of the soil.

Available values are:

- **faint**: indistinct; evident only on close examination.
- **distinct**: readily evident although not striking.
- **prominent**: striking and conspicuous.

11.5.2 Subdominant

Mottle type

Describes the general nature or likely cause of the colour patterns for each subdominant mottle in each layer.

Available values are:

- **not evident**: no subdominant mottles observed in layer.
- **unspecified**: subdominant mottles observed but type not identified.
- **biological**: colour patterns due to biological mixing of soil material from other horizons – for example, earthworm casts.
- **mechanical**: colour patterns due to mechanical mixing of soil material from other horizons – for example, inclusions of B horizon material in Ap horizons.
- **weathered**: colour patterns due to inclusions of weathered substrate material and includes patterns due to chemical reactions – for example, fluctuating watertable.

Mottle abundance

Describe the proportion of the soil mass that can be described as subdominant mottles.

Available values are:

- **Not evident**
- **<2%**
- **2–10%**
- **10–20%**
- **20–50%**.

Munsell colour

Subdominant mottle colour may be measured using the Munsell Soil Colour Charts (Munsell Colour 2009). More information can be found at **Munsell Color Systems**. In this system, colour is defined with respect to 3 independent coordinates as defined in **colour – moist Munsell**. Soil colour measurements should be made on the surface of a freshly broken aggregate of moist soil. Dry samples should be moistened, and the colour recorded when the visible moisture film disappears from the aggregate surface. With most soils, dry samples will change colour with the addition of water, usually a decrease of 1.5–2 units of value.

Hue value

Used in conjunction with **hue**, **hue value** describes the dominant spectral colour of the subdominant mottle. **Value** and **chroma** must also be recorded.

Hue

Used in conjunction with **hue value**, **hue** describes the dominant spectral colour of the subdominant mottle. **Value** and **chroma** must also be recorded.

Value

The **value** indicates the lightness or darkness of the subdominant mottle. **Hue**, **hue value** and **chroma** must also be recorded to deliver a description of the subdominant mottle colour using the Munsell system.

Chroma

The **chroma** indicates the intensity or brightness of the colour of the subdominant mottle. **Hue**, **hue value** and **value** must also be recorded to deliver a description of the subdominant mottle colour using the Munsell system.

General colour

Alternate to or in conjunction with Munsell notation, values from colour can be recorded to describe the colour of the subdominant mottle.

Available values are:

- **dark**: V/C 1 for all hues.
- **red**: V/C 2b, 3b or 4 for hues as red as or redder than 2.5YR.
- **orange**: V/C 4 for hues 5YR, 7.5YR or 10YR.
- **yellow**: V/C 3b or 4 for hues as yellow as or yellower than 2.5Y.
- **brown**: V/C 5 for all hues; or V/C 2b for hues as yellow as or yellower than 5YR; or V/C 3b for hues 5YR, 7.5YR, 10YR.
- **pale**: V/C 3a for all hues.
- **grey**: V/C 2a for all hues.
- **gley**: any colour on the Munsell ‘gley’ charts.

General colour modifier

Qualifies the specified value for subdominant **mottle colour**. Use this attribute, where necessary, to specify if the colour recorded in these attributes is dark or light.

Contrast

Describe the contrast of the boundary between the subdominant mottle and the remainder of the soil.

Available values are:

- **faint**: indistinct; evident only on close examination.
- **distinct**: readily evident although not striking.
- **prominent**: striking and conspicuous.

11.6 Field texture

Field texture is determined on soil material that is < 2 mm diameter, in other words only material that after crushing will pass through a 2 mm sieve. Take a sample of soil sufficient to fit comfortably into the palm of the hand. Moisten the soil with water, a little at a time, and knead until the ball of soil just fails to stick to the fingers. More soil or water may be added to maintain this condition, which is known as sticky point. This approximates field moisture capacity for the soil. Continue kneading and moistening until there is no apparent change in the soil ball. This usually takes 1–3 minutes, but identification of possible texture modifiers requires a longer period of kneading. The soil ball, or bolus, is now ready for shearing manipulation. The behaviour of the bolus and of the ribbon produced by shearing (pressing out) between thumb and forefinger and the feel of the material between the fingers characterises the **texture**.

11.6.1 Texture grade

Twenty texture grades are recognised. Definitions of grades are from *A factual key for the recognition of Australian soils* (Northcote 1979) and the *Australian soil and land survey field handbook* (NCST 2009).

Available values are:

- **sand**: coherence nil to very slight; cannot be moulded; single sand grains adhere to fingers; approximate clay content <5%.
- **loamy sand**: slight coherence; will form minimal ribbon of ≈ 5 mm; clay content ≈ 5%, some organic matter; discolours fingers with dark stain.
- **clayey sand**: slight coherence; sticky when wet; many sand grains stick to fingers; will form minimal ribbon 5–15 mm; little or no organic matter; clay content ≈ 5–10%; discolours fingers with clay stain.
- **sandy loam**: bolus coherent but very sandy to touch; will form ribbon of 15–25 mm; sand grains readily visible; clay content ≈ 10–20%.
- **loam**: bolus coherent and rather spongy; smooth feel when manipulated but with no obvious sandiness or silkiness; may be somewhat greasy to the touch if much organic matter present; will form ribbon ≈ 25 mm long; clay content ≈ 25%.

- **silty loam**: coherent bolus, very smooth to silky when manipulated; will form ribbon of about 25 mm; approximately clay content 25% and with ≥25% silt.
- **sandy clay loam**: strongly coherent bolus, sandy to touch; sand grains visible in finer matrix; will form ribbon of 25–40 mm; clay content ≈ 20–30%.
- **clay loam**: coherent plastic bolus; smooth to manipulate; will form ribbon of 40–50 mm; clay content ≈ 30–35%.
- **clay loam sandy**: coherent plastic bolus; sand grains visible in finer matrix; will form ribbon of 40–50 mm; clay content ≈ 30–35%.
- **silty clay loam**: coherent smooth bolus; plastic and often silky to the touch; will form ribbon of 40–50 mm; clay content ≈ 30–35% and with silt ≥25%.
- **sandy clay**: plastic bolus; sand grains can be seen, felt or heard in clayey matrix; will form ribbon of 50–75 mm; clay content ≈ 35–40%.
- **silty clay**: plastic bolus; smooth and silky to manipulate; will form ribbon of 50–75 mm; clay content ≈ 35–40%, with silt ≥25%.
- **clay**: smooth plastic bolus; slight to firm resistance to shearing between thumb and forefinger; handles like plasticine; will form ribbon of 50–75 mm or more; clay content ≈ 35–≥50%.
- **fibric peat (fibrous peat)**: undecomposed or weakly decomposed organic material. Plant fibres (other than living roots) are distinct, readily identifiable and make up >2/3 of the material.
- **hemic peat (semi-fibrous peat)**: moderately to well decomposed organic material. Plant remains vary from most being difficult to identify to being unidentifiable. It is intermediate in degree of decomposition between the less decomposed fibric peat and the more decomposed sapric peat.
- **sapric peat (humified peat)**: strongly to completely decomposed organic material. Fibres make up <1/3 of the material; plant remains vary from few being identifiable to being completely amorphous.
- **sandy peat**: undecomposed to strongly decomposed organic material in which the bolus is sandy to touch.
- **loamy peat**: undecomposed to strongly decomposed organic material in which the bolus has obvious mineral particle content but no obvious sandiness to touch, is smooth, non-sticky when wet and weakly coherent.
- **clayey peat**: undecomposed to strongly decomposed organic material in which the bolus has obvious fine mineral particle content, is sticky when wet and is coherent.
- **granular peat**: dominantly decomposed organic material that has dried irreversibly to fine granules through exposure and drying and/or cultivation. Granules are ≈ 1–2 mm diameter and have granular or sub-angular blocky **structure**.

11.6.2 Sand fraction

In soils where the texture grade is sandy, the diameters of those particles is defined as medium. If the average diameter of the sand particles is subjectively assessed as not being medium, then one value from sand fraction can recorded for each texture grade.

Available values are:

- **coarse**: mainly 0.2–2.0 mm; they are easily observed with the naked eye.
- **fine**: mainly 0.02–0.20 mm; they are difficult to see with the naked eye but are clearly visible with a hand lens. The grains can be felt and heard when rubbed between the fingers.

11.6.3 Clay fraction

The non clay texture grades (clay loams and coarser) may be qualified according to whether they are at or near the light (lower clay content) or heavy (higher clay content) end of the range for that texture grade. Note that light medium, medium and medium heavy qualifiers can be applied only to texture grades as fine as or finer than sandy clay. It is strongly recommended that this attribute be used only when essential. If used too freely, it can lead to excessive, unnecessary detail of doubtful usefulness.

Available values are:

- **light**: nearer the lower end of the clay content range; when used with texture grade clay, bolus will form a ribbon of 50–75 mm and has a clay content of 35–40%.
- **light medium**: between the lower end and the middle of the clay content range; when used with texture grade clay, bolus will form a ribbon of 75 mm and has a clay content of
  40–45%.
- **medium**: near the middle of the clay content range; when used with texture grade clay, bolus will form a ribbon of 75 mm or more and has a clay content of 45–55%.
- **medium heavy**: between the middle and the higher end of the clay content range.
- **heavy**: nearer the higher end of the clay content range; when used with texture grade clay, bolus will form a ribbon of ≥75 mm and has a clay content of ≥50%. Generally difficult to work at sticky point.

11.6.4 Organic fraction

Soils that contain an appreciable amount of organic matter can have their texture grade qualified by organic fraction.

Available values are:

- **sapric**: organic and non-fibrous; dark organic stain discolours fingers; greasy feel in clayey textures and coherence in sandy textures. Fibres (excluding living roots) or plant tissue remains are not visible to naked eye, and little or none are visible with ´10 hand lens.
- **fibric**: organic and fibrous; dark organic stain discolours fingers; greasy feel in clayey textures and coherence in sandy textures. Fibres (excluding living roots) or plant tissue remains are visible to naked eye or easily visible with ´10 hand lens.
- **hemic**: organic and semi-fibrous; dark organic stain discolours fingers; greasy feel in clayey textures and coherence in sandy textures; it is intermediate in decomposition between sapric and fibric; fibres excluding living roots vary from most being difficult to identify to being unidentifiable.

11.7 Structure

Structure refers to the distinctness, size, shape and condition of natural, or artificially produced soil aggregates (peds). It can be reliably described only in a relatively fresh vertical exposure or a relatively undisturbed soil core and cannot be described fully from an auger boring. Sections which have been exposed for a long time (road cuttings, gullies) are unsuitable for the determination of **structure** unless the section is cut back 0.3–0.5 m to expose fresh soil; surface exposures may alter significantly due to daily or seasonal moisture and temperature changes.

11.7.1 Grade of pedality

Describes the relative proportion of peds in the soil. It may vary with the soil water status.

Available values are:

- **single grained**: soil occurs as a loose incoherent mass of individual particles (as in sands).
- **massive**: soil occurs as a coherent mass showing no evidence of any distinct arrangement of soil particles.
- **weak pedality**: in an undisturbed soil, peds are indistinct and barely observable. When displaced, <30% of the soil material consists of peds (Northcote 1979).
- **moderate pedality**: although not distinct in an undisturbed soil, peds are well formed and evident. When displaced, 30–70% of the soil material consists of peds (Northcote 1979).
- **strong pedality**: peds are quite distinct in an undisturbed soil. When displaced, >70% of the soil material consists of peds (NCST 2009).

11.7.2 Fabric

Describes the appearance of the soil material as expressed by the spatial arrangement and nature of the solid particles and associated voids when observed with a ´10 hand lens. Differences in fabric are associated with the presence or absence of peds; the lustre or lack thereof on the ped surfaces; and the presence, size and arrangement of pores (voids) in the soil mass. Available values are defined by Northcote (1979) and are:

- **sandy**: soil material is commonly single grained. The closely packed sand grains provide the characteristic appearance of the soil mass.
- **earthy**: soil material is porous, coherent, massive to weakly pedal, characterised by the presence of pores (voids) and generally a massive appearance. Ultimate soil particles (such as sand grains) are coated with oxides and/or clays and are arranged (clumped) around the pores.
- **rough-faced peds**: peds have relatively porous surfaces with a generally aggregated appearance, and are non-lustrous and non-shiny. <50% of the peds are rough-faced. They usually have less clearly defined faces than smooth-faced peds and the pedality of the soil may be questioned. However, after gentle pressure is applied to the soil mass, the characteristic size and shape of the soil aggregates

confirm its pedality. Granular peds with common or many macropores are always rough-faced, but this condition varies in other ped forms.

- **smooth-faced peds**: peds have clearly defined faces. Characteristically, >50% of the ped surfaces are smooth matt. They have a generally lacquered surface appearance although the degree of lustre, or shininess, may be variable.

11.7.3 Ped shape

You can describe the shape of both dominant and subdominant peds.

Dominant peds are the most obvious peds observed in an undisturbed soil sample. The relative difference between the strength of cohesion within peds and the strength of adhesion between peds is greater for dominant peds than for subdominant peds. Ped dominance is assessed in a different way to the primary and compound ped concepts used in NCST (1990).

Subdominant peds may form when dominant peds either pack together to form larger compound entities or break into simpler units. Subdominant peds are less conspicuous than dominant peds. In many cases, subdominant peds can be identified only by gently probing an in situ soil section in an attempt to identify zones or planes of weakness (planar voids). Other ped types, which are weaker than the subdominant peds, may occur and provision is made to describe them in the field layer notes.

Recording of compound pedality is possible by recording the primary ped details as the dominant ped, the next most conspicuous ped as the first subdominant ped, the third most conspicuous as the second subdominant ped, and any remaining peds in the field layer **notes**.

Available values are:

- **platy**: oil particles are arranged around a horizontal plane and bounded by relatively flat horizontal faces with accommodation to the faces of surrounding peds.
- **lenticular**: soil particles are arranged around an elliptical or circular plane and are bounded by curved faces with considerable accommodation to the faces of surrounding peds; most vertices between adjoining faces are angular and acute.

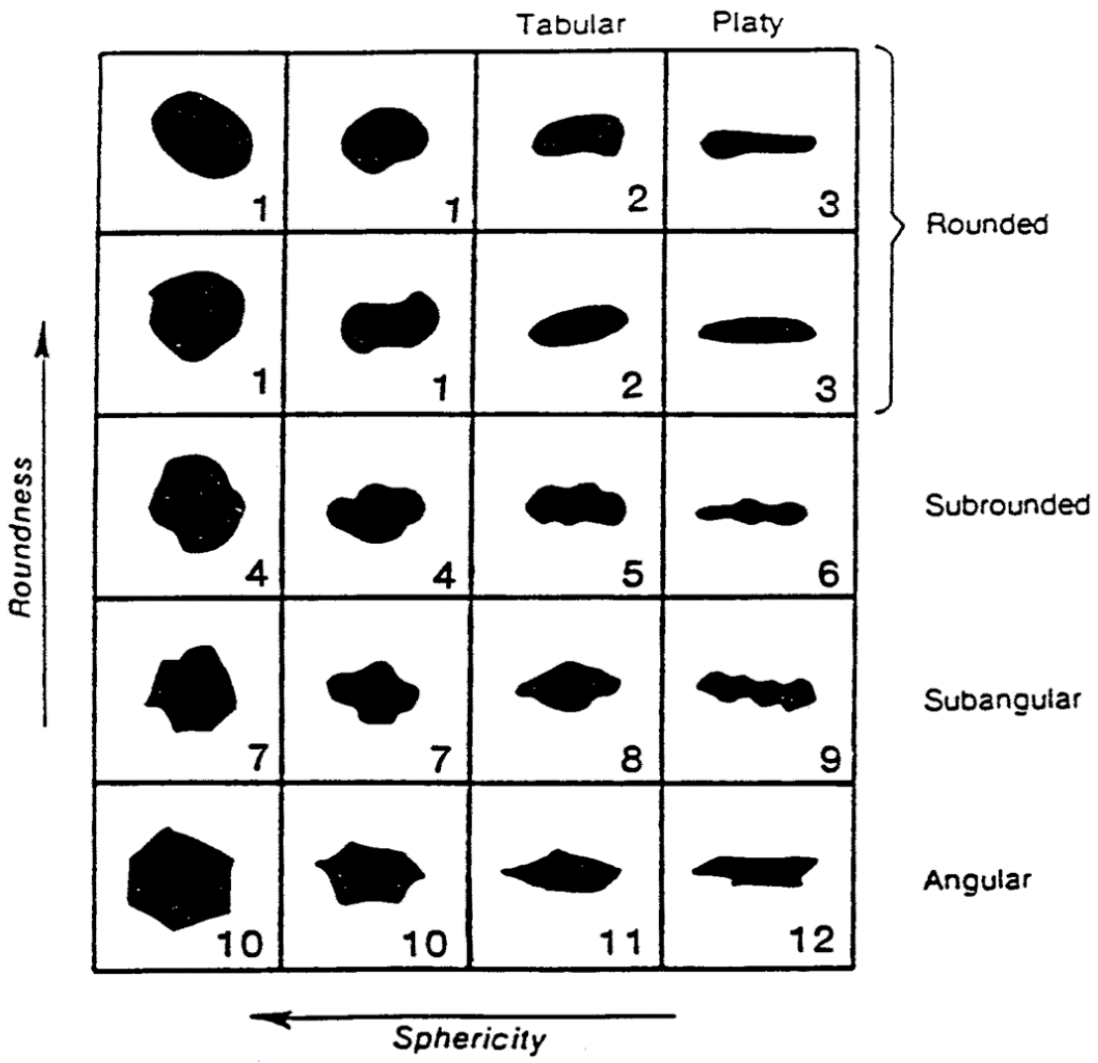


Figure 13 Ped shapes

- **prismatic**: soil particles are arranged around a vertical axis and are bounded by well defined, relatively flat faces with considerable accommodation to the faces of surrounding peds; vertices between adjoining faces are usually angular.
- **columnar**: similar to prismatic, but the peds are usually larger and have domed tops.
- **angular blocky**: soil particles are arranged around a point and bounded by 6 relatively flat, roughly equal faces with re-entrant angles between adjoining faces few or absent. There is usually considerable accommodation of ped faces to the faces of surrounding peds. Most vertices between adjoining faces are angular.
- **sub-angular blocky**: similar to angular blocky except peds are bounded by flat and rounded faces with limited accommodation to the faces of surrounding peds. Many vertices are rounded.
- **polyhedral**: soil particles are arranged around a point and bounded by more than 6 relatively flat, unequal, dissimilar faces. Re-entrant angles between adjoining faces are a feature. There is usually considerable accommodation of ped faces to the faces of surrounding peds. Most vertices are angular.

- **granular**: peds are spheroidal or polyhedrons having planar or curved surfaces which have slight or no accommodation to faces of surrounding peds. Peds are relatively non-porous.
- **crumb**: similar to granular but more porous and usually <5 mm diameter.
- **round**: soil particles are arranged in a spheroidal shape. There are no planar faces. There is slight or no accommodation to faces of surrounding peds.

Figure 13 (above) can help you select the most appropriate value.

11.7.4 Ped size

You can describe the size of both dominant and subdominant peds.

Dominant peds are the most obvious peds observed in an undisturbed soil sample. The relative difference between the strength of cohesion within peds and the strength of adhesion between peds is greater for dominant peds than for subdominant peds. Ped dominance is assessed differently from the primary and compound ped concepts used in NCST (1990).

Subdominant peds may form when dominant peds either pack together to form larger compound entities or break into simpler units. Subdominant peds are less conspicuous than dominant peds. In many cases, subdominant peds can be identified only by gently probing an in situ soil section in an attempt to identify zones or planes of weakness (planar voids). Other ped types, which are weaker than the subdominant peds, may occur and provision is made to describe them in the **layer notes**.

Recording of compound pedality is possible by recording the primary ped details as the dominant ped, the next most conspicuous ped as the first subdominant ped, the third most conspicuous as the second subdominant ped, and any remaining peds in the **layer notes**.

Peds are placed in size classes depending upon their average least dimension (in millimetres). This is the minimum horizontal dimension of the ped for all ped shapes except platy and lenticular. For platy and lenticular ped shapes, the minimum dimension is the ped's vertical measurement.

Available values are:

- **<1 mm**
- **1–2 mm**
- **<2 mm**
- **2–5 mm**
- **5–10 mm**
- **10–20 mm**
- **20–50 mm**
- **50–100 mm**
- **100–200 mm**
- **200–500 mm**

- **>500 mm**.

11.7.5 Artificial aggregates

Some soil layers consist of artificial aggregates formed by cultivation or work being done on the soil. The distinction between artificial aggregates and peds can be difficult. In cultivated layers, where the surveyor is not confident the aggregates are natural peds, they should be recorded as clods or fragments.

Available values are:

- **clods**: artificial aggregates with a diameter of ≥100 mm comprise a greater proportion of the structure of the layer.
- **fragments**: artificial aggregates with a diameter of <100 mm comprise the greater proportion of the structure of the layer.

11.7.6 SOILpak score

Details given here about SOILpak are taken from *SOILpak for dryland farmers on the red soil of Central Western NSW* (NSW Agriculture 1999).

The SOILpak scoring system is a semi-quantitative system of assessing structural form. Each structural factor is scored on a scale of 0–2, with 0 being the worst score and 2 being the best. A soil with an overall score >1.5 has relatively good structure while a soil with a score of <0.5 has a compaction or hardsetting problem and methods to improve it should be implemented.

For more detailed information about SOILpak scores, refer to the various SOILpak guides at SOILpak.

11.7.7 Vesicles

Describe the presence and abundance of small, non-connected spherical soil pores.

Available values are:

- **not vesicular**
- **very slightly vesicular**
- **slightly vesicular**
- **moderately vesicular**
- **very vesicular**.

11.7.8 Ped porosity

Describe the relative porosity of the soil aggregates.

Available values are:

- **porous**
- **dense**.

11.8 Ped coating

Refers to coatings (cutans) resulting from the concentration of particular soil constituents of the in situ modification of the soil material.

11.8.1 Coating amount

Refers to coatings (cutans) resulting from the concentration of particular soil constituents or the in situ modification of the soil material. Coatings include clay, sesquioxide, manganese, ferromanganese, organic matter or carbonate coatings. If required, attributes or values not listed or more detailed descriptions can be recorded in the text box provided when 'other' is selected.

- **none**: no ped coatings are observed in layer.
- **few (<10%)**: <10% of the ped faces or pore linings are coated.
- **common (10–50%)**: 10–50% of the ped faces or pore linings are coated.
- **many (>50%)**: >50% of the ped faces or pore linings are coated.

11.8.2 Coating type

Observe possible coatings with a ´10 hand lens. Record the value which best describes the type of **ped coating**. For each layer, record only one value.

Available values are:

- **clay**: coatings of clay often differ in colour from the matrix of the ped. They are frequently difficult to distinguish from stress cutans which are not true coatings.
- **mangan**: coating contains manganese oxides or hydroxides. May have glazed appearance. Very dark brown to black.
- **stress cutans**: in situ modifications of natural surfaces in soil materials due to differential forces such as shearing. They are not true coatings.
- **slickensides**: stress cutans with smooth striations or grooves.
- **topsoil**: coating formed from soil material from upper layers.
- **organic**: coating composed of organic material.
- **other**: **c**oating composed of iron oxide, calcium carbonate, sodium carbonate or gypsum, that is not described by any other value. A description should be entered in the text box provided when 'other' is selected.
- **unspecified**: nature of coatings cannot be determined.

11.8.3 Coating distinctiveness

Record the value which best describes the ease and certainty with which a coating is identified. This attribute relates to the thickness and to the colour contrast with the adjacent material and may change markedly with moisture content.

Available values are:

- **faint**: coating is evident only on close examination with ´10 magnification. Little contrast occurs with adjacent material.

- **distinct**: coating can be detected without magnification. Contrast with adjacent material is evident in colour, texture or other properties.
- **prominent**: coating is conspicuous without magnification when compared with a surface broken through the soil. Colour, texture or some other property contrasts sharply with properties of the adjacent material, or the feature is thick enough to be conspicuous.

11.9 Consistence

A statement of the strength and nature of cohesion of a hand sample of soil material as it occurs in the field (Butler 1955; Butler and Hubble 1977). Like **field texture** it is determined by manipulation. It varies considerably according to the moisture content of the sample, so it is important to also record a value for **soil water status** at the time of testing.

11.9.1 Disruptive test

The compressive strength of the soil in its field condition is judged from the force required to cause a 20 mm cube (aggregate or sample) of the soil to just break or deform when a compressive force is applied between the thumb and forefinger.

Available values are:

- **loose**: no force required. Separate particles such as loose sands.
- **very weak force**: very small or almost nil force is required.
- **moderately weak force**: small but significant force is required.
- **moderately firm force**: moderate to firm force is required.
- **very firm force**: strong force but within power of thumb and forefinger.
- **moderately strong force**: the force required is beyond the capability of the thumb and forefinger.

11.9.2 Degree of plasticity

A plastic soil is one in which an applied stress may produce continuous, permanent deformation without rupture. It becomes evident within a particular water content range. It should be distinguished from the plasticity index, which is defined numerically as the liquid limit minus the plastic limit which are measured as laboratory tests.

The degree of plasticity is determined at the soil moisture content used for field texture – that is, just below sticky point. The soil is rolled between the palms of the hand and, if possible, 40 mm long rolls are formed. The rolls are dangled from the thumb and forefinger.

Available values are:

- **non-plastic**: rolls 40 mm long and 6 mm in diameter will not form.
- **slightly plastic**: rolls 40 mm long and 6 mm in diameter will form and support their own weight; rolls 40 mm long and 4 mm in diameter will form but will not support their own weight.

- **moderately plastic**: rolls 40 mm long and 4 mm in diameter will form and will support their own weight; rolls 40 mm long and 2 mm in diameter will form but will not support their own weight.
- **very plastic**: rolls 40 mm long and 2 mm in diameter will form and will support their own weight.

11.9.3 Texture modifier

Many soils contain texture modifiers. These modifiers affect the degree to which the **consistence** and/or **field texture** properties of soils suggests the amount of clay-sized particles they contain (Butler 1955). The presence of texture modifiers may be identified by determining 2 **texture grades**: one after an initial 1–2-minute working of the soil sample, and another after a prolonged 10-minute kneading. For example, a soil sample which might initially appear to be a clay loam is eventually classed as a medium clay. Other soils appear to decrease in **texture grade** as they are worked (Northcote 1979). NCST (2009) refers to this as **plasticity type**.

Available values are:

- **decrease ≥1 grade**: bolus decreases one or more **texture grades** (becomes lighter in texture) as it is worked. This occurs, for example, in the presence of large amounts of fine-grained calcium and/or magnesium carbonates with clays and clay loams. These soils have previously been termed superplastic. Record the original **texture grade**.
- **no change**: bolus does not change in texture grade as it is worked.
- **increase <2 grades**: bolus increases one **texture grade** (becomes heavier in texture) as it is worked. These soils have been frequently termed subplastic and are usually red in colour; peds have been generally stabilised by iron and the fine peds take time to break down. Record the final **texture grade**.
- **increase ≥2 grades**: bolus increases 2 or more texture grades (becomes heavier in texture) as it is worked. These soils have previously been termed strongly subplastic. Record the final texture grade.

11.9.4 Shearing test

With a 20 mm cube (aggregate or sample) of the soil and maintaining the same force, subject the sample to 2 seconds of rotational shearing between the thumb and forefinger and observe the effect upon the material.

Available values are:

- **no change**: no more than a slight rounding of the cube occurs.
- **brittle**: there is a sudden disintegration into fractured fragments.
- **crumbly**: some disintegration occurs where the cube readily breaks into discreet natural aggregates which do not deform.
- **labile**: the cube fractures and fragments are easily deformed.
- **plastic**: the cube does not fracture but is readily remoulded.

11.9.5 Stickiness

Determined on a wet bolus (beyond 'sticky point', which equates to field capacity). Press the wet sample into the upward facing palm and invert the hand. Observe the adherence of the soil to the palm.

Available values are:

- **non-sticky**: soil does not feel sticky and falls.
- **slightly sticky**: soil feels sticky but comes cleanly off the skin and falls.
- **moderately sticky**: soil adheres to the palm, falling only after gentle shaking of the hand in a vertical motion.
- **very sticky**: soil adheres strongly to the palm, requiring vigorous shaking in a vertical motion to remove it from the hand.

11.9.6 Toughness

A measure of the consistency of the soil near its plastic limit. A small sample of soil without coarse fragments is moulded to the consistency of putty. This specimen is then rolled out into a thread
≈ 3 mm diameter. The thread is then folded and re-rolled repeatedly. During this manipulation, the moisture content is gradually reduced, and the specimen stiffens, finally loses its plasticity and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together, and a slight kneading action should be continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin type clays and organic clays.

Available values are:

- **high**: the lump is stiff and tough with disruption ranging from moderately to very firm force or strong force.
- **medium**: the lump is somewhat stiff and tough with disruption ranging from moderately weak to moderately strong.
- **weak**: the lump is weak and crumbly with disruption being very weak. Non-plastic soils have a loose crumbly reaction.

11.10 Chemical tests

11.10.1 pH method

Several methods are used to record the acidity or alkalinity of the soil layers in the field. This is a key attribute since interpretation of the pH value recorded is dependent upon knowing which method was used to determine it.

Available values are:

- **Raupach**: the soil pH is determined using the method developed by Raupach and Tucker (1959). In this test, a small sample of soil is mixed with a few drops of Raupach Indicator on a spot plate to form a paste. The sample is then sprinkled with neutral barium sulphate powder and, after 2 minutes, its colour is compared with a standard colour chart to determine the pH to the nearest half unit. This test is known to be inaccurate, especially if poorly maintained or out-of-date testing kits and/or reagents are used. Results should only be used for comparative purposes on the same soil profile.
- **pH meter**: the soil pH is determined on a 1:5 soil:water mixture using a correctly calibrated field pH meter. Please note that inaccuracies will occur when de-ionised water is not used to make the sample.
- **test strip**: the soil pH is determined on a moist bolus using a test strip. Ideally, de-ionised water should be used but this is generally unimportant since the buffering capacity of soil is much greater than water.

11.10.2 Field pH

The pH of any layer is determined using one of the methods described in **pH method**.

11.10.3 Field EC measurement units

In this field, the surveyor must record the units in which the electrical conductivity (EC) results recorded in the **EC** fields have been measured.

11.10.4 Field EC

The salinity of each layer can be measured by mixing a small sample of soil with distilled water and testing it using a properly calibrated EC meter. The result should be recorded in either decisiemens (dS) or millisiemens (mS), depending on the value selected in the **field EC measurement units** field. Decisiemens (dS) is the international standard unit for these measurements, so its use is preferred.

11.10.5 Hydrochloric acid test

The presence of carbonate in soils can be tested by adding several drops of 1 M hydrochloric acid to a small soil sample. Effervescence will occur if carbonate is present.

Available values are:

- **no effervescence**: no effervescence occurs.
- **audible/slight effervescence**: an audible and/or a slightly visible effervescence occurs.
- **strong effervescence**: a strong audible and visible effervescence occurs.

11.10.6 Silver nitrate test

The presence of chloride ions can be tested by mixing a small sample of soil with distilled water in a test tube and adding a few drops of a 5% solution of silver nitrate ($AgNO_3$). A white precipitate of silver chloride will form in the presence of chloride ions. The soil water mixture should be filtered (if it is cloudy) prior to adding the silver nitrate.

Available values are:

- **no precipitate**: the test is negative (no white precipitate).
- **light precipitate**: a light precipitate forms.
- **conspicuous white precipitate**: a conspicuous white precipitate forms.

11.10.7 Hydrogen peroxide test

The presence of manganese dioxide can be tested by adding 2 or 3 drops of a 10% hydrogen peroxide (H_2O_2) solution to a small soil sample on a spot plate. Effervescence will occur if manganese dioxide is present. Note: the presence of organic matter or iron pyrite may also give a positive reaction.

Available values are:

- **no effervescence**
- **effervescence**.

11.11 Erodibility tests

11.11.1 Crumb test, modification of EAT

This test is a modification of the Emerson Aggregate Test (Emerson 1967). It provides a simple field assessment of aggregate stability or dispersibility from similar EAT 2-hour classes, which are based on a 2-hour testing period. Describe the behaviour of a natural aggregate or worked bolus when placed in distilled water. Failure to respond within 3 minutes does not necessarily mean that no response will be measurable within 2 hours. The Emerson Aggregate Test is defined as ‘a classification of soil aggregates based on their coherence in water. Small aggregates are placed in dishes of distilled water and their behaviour observed. The conditions under which they slake, swell and disperse allow the different aggregates to be separated into 8 different classes’ (Charman and Murphy 1991).

Available values are:

- **no change**
- **aggregates slake:** aggregate breaks down into macroscopic fragments but does not significantly disperse
- **aggregates disperse:** aggregate breaks down into microscopic fragments (individual clay particles) that disperse into the water, producing a milky cloud or ring of dispersed clay.
- **worked bolus disperse:** worked bolus breaks down into microscopic fragments (individual clay particles) that disperse into the water, producing a milky cloud or ring of dispersed clay.

11.11.2 Bolus formation test

Dry or moderately moist samples of some dispersible soils are very difficult to wet. When water is added to such materials in the process of bolus formation, the surface deflocculates, preventing further infiltration of water. This produces a very slimy surface on an essentially unwetted soil ball and is rather like trying to grip a handful of

ball-bearings or gravel. A knife or fingernail will cut through each of these ball-bearings to expose the dry interior. In extreme circumstances, the soil material will not form into a smooth bolus unless it is ground to a powder prior to adding water.

This test provides a field assessment of aggregate dispersibility. Describe the behaviour of the bolus during bolus formation.

Available values are:

- **no deflocculation**: deflocculation does not occur. Particles remain flocculated and structure persists at the surface, allowing infiltration.
- **deflocculation**: deflocculation occurs. Pores are clogged at the surface, making a relatively impenetrable barrier to further water entry.

11.11.3 Field dilatency test

This test assists in identifying the character of the fine fraction of the soil material. A small sample of soil, without coarse fragments, is prepared with additional water if necessary to approximately sticky point (the sample is soft but not sticky).

The resulting soil pat is placed in the palm of one hand and is shaken rapidly horizontally, which can be done by striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat, which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and the gloss disappear from the surface.

Available values are:

- **none**: no noticeable sheen appears on the surface after 30 seconds.
- **very slow**: a barely noticeable reaction occurs after <10 seconds.
- **slow**: a noticeable reaction occurs within 5–10 seconds.
- **rapid**: a very noticeable reaction occurs within a few seconds.

11.11.4 Soil erodibility class

This is a function of a soil's susceptibility to detachment and transport of its constituent particles by erosive agents. It is a function of mechanical, chemical and physical characteristics and is independent of factors such as topography, rainfall intensity, plant cover, etc. (see **Erosion Hazard**). The upper layers are termed 'topsoil', and the lower layers are termed 'subsoil'.

The assignment of a value of **erodibility** to a layer is subjective, but the following rules apply.

Texture. Very fine sands (0.02–0.20 mm) and silts (0.002–0.020 mm) are more erodible than other texture grades.

Aggregate stability. Topsoils low in organic matter or subsoils low in sesquioxides tend to be structurally unstable. Structurally unstable soils generally slake or disperse in water, breaking up into smaller aggregates or individual particles. Where these are mainly <2 mm in size, they can be readily transported by water. Soils with unstable aggregates tend to be more erodible than soils with stable aggregates.

Infiltration. Soils with slow infiltration rates tend to be more erodible than soils with rapid internal drainage rates.

Existing erosion. The level of existing erosion is likely to be worse in areas with a high soil erosion hazard and high soil erodibility.

Record the value which best describes the degree of erodibility for each layer.

Table 4 Erodibility available values

Erodibility	Topsoil	Subsoil
Low	High organic matter (>3%) (soils have a dark colour and feel greasy when textured). Cemented layers including iron, manganese and silicon pans – for example, silcrete, ortstein and laterite.	Cemented layers including iron, manganese and silicon pans – for example, silcrete, ortstein and laterite.
Low	High coarse sand.	High coarse sand.
Low	Well-structured, non-dispersible clay loams and clays having aggregates which do not slake in water to particles less than 2 mm (Emerson Aggregate Classes 4, 6, 7 and 8) – for example, red, smooth and rough ped earths (Gn3, Gn4 soils), some cracking clays (Ug5.1, Ug5.2, Ug5.3 soils), some structured loams (Um6.1 soils), and friable duplex soils (Dr4, Db3 soils).	Well-structured, non-dispersible clay loams and clays having aggregates which do not slake in water to particles less than 2 mm (Emerson Aggregate Classes 4, 6, 7 and 8) – for example, red, smooth and rough ped earths (Gn3, Gn4 soils), some cracking clays (Ug5.1, Ug5.2, Ug5.3 soils), some structured loams (Um6.1 soils), and friable duplex soils (Dr4, Db3 soils).
Moderate	Moderate organic matter (2–3%). Moderate fine sand and silt – for example, hard, pedal red duplex soils (Dr2 soils). Well-structured clay loams and clays which slake in water to particles less than 2 mm (Emerson Aggregate Classes 3 to 6) – for example, black cracking clays (Ug5.1, Ug5.2 and Ug5.3 soils).	Stable non-dispersible loams and clay loams – for example, red and yellow massive earths (Gn2.1 and Gn2.2 soils). Non-dispersible or slightly dispersible clays with particles that slake to finer than 2 mm (Emerson Aggregate Classes 3 to 6) – for example, non-sodic, red, brown and yellow duplex soils (Dr, Db and Dy soils).
High	Low (1–2%) to very low (<1%) organic matter – for example, soils with bleached A2 horizons. High to very high silt and fine sand (>65%).	Dispersible clays (Emerson Aggregate Classes 1 and 2) – for example, sodic, yellow and red soils, (Dy3.4, Dr3.4, Dr2.3 soils). Unstable, dispersible clayey sands and sandy clays. For example, yellow and grey massive earths formed on sandstone and some granites (Gn2.3, Gn2.8, Gn2.9, Dy5.8 soils). Unstable silty and sandy materials, such as unconsolidated sediments and alluvium.

11.12 Mechanical tests

11.12.1 Compressive strength

Record the compressive strength (kPa) of the soil measured with the aid of a penetrometer, ASAE S313.2-1985.

11.12.2 Shear strength

Record the peak shear strength (kPa) measured with the aid of a shear vane.

11.13 Layer hydrology

11.13.1 Soil water status

Describe the soil **water status** of the layer at the time of description.

Note the following general guidelines: dry is below permanent wilting point; material becomes darker when moistened; moderately moist is the drier half of the available moisture range; moist is the wetter half of the available moisture range; and wet is at, or exceeding, field capacity.

However, these guidelines may not apply to sodic 2:1 clays, which may appear moderately moist even when their soil moisture status is below wilting point.

Available values are:

Sands and sandy loams

- **dry**: will flow through the fingers or fragments will powder.
- **moderately moist**: appears dry; bolus will not hold together.
- **moist**: forms a weak ball but breaks easily; broadly equivalent to sticky point or field capacity.
- **wet**: leaves a wet outline on the hand when squeezed or is wetter; bolus is sticky.

Loams

- **dry**: will not form a ball when squeezed in the hand; fragments will powder.
- **moderately moist**: forms a crumbly ball on squeezing in the hand.
- **moist**: will ball; will not ribbon.
- **wet**: leaves a wet outline on the hand when squeezed or is wetter; bolus is sticky.

Clay loams and clays

- **dry**: will not ball when squeezed in the hand; fragments will break to smaller fragments or peds.
- **moderately moist**: will ball but will not ribbon.
- **moist**: will ball and ribbon easily.
- **wet**: leaves a wet outline on the hand when squeezed or is wetter; bolus is sticky.

11.13.2 Layer permeability

Permeability is an intrinsic property of the soil profile, independent of climate and drainage. It is the measure of a profile's potential to transmit water (saturated hydraulic conductivity, K_{sat}) and is controlled by the least permeable layer in the profile. It is inferred from attributes of the soil such as structure, texture, porosity, cracks and macropores, and shrink-swell properties.

Available values are:

- **very slowly permeable**: vertical transmission of water in the least permeable layer is very slow in that the profile would take periods of a month or more after thorough wetting to reach field capacity if there were no obstructions to movement from the profile. Structure may vary, but cracks and macropores between peds close on wetting. Texture is usually clay or silty clay, and there is an absence of visible (hand lens) pores that could conduct water when wet.
- **slowly permeable**: vertical transmission of water in the least permeable layer is slow in that the profile would take a week or more after thorough wetting to reach field capacity if there were no obstructions to movement from the profile. Structure may vary, usually from massive to moderate. Texture is usually clay or silty clay, and there will be few visible (hand lens) pores that conduct water when wet. If texture is coarser, the inter-particle voids are filled with fine minerals.
- **moderately permeable**: vertical transmission of water in the least permeable layer is such that the profile would take no more than a few days (1–5) after a thorough wetting to reach field capacity if there were no obstructions to water movement from the profile. The soil may vary in structure, but grade is usually at least moderate and blocky, or polyhedral peds are common. If massive, the soil material is always porous. The pores and channels which remain open when wet are clearly visible with a ´10 hand lens.
- **highly permeable**: vertical transmission of water in the least permeable layer is such that the profile would take no more than 1–12 hours after a thorough wetting to reach field capacity if there were no obstructions to water movement from the profile. Layers have large, continuous and clearly visible connecting pores and cracks that do not close with wetting. Texture is usually sandy, and nodules or gravels are commonly present. Soil layers are usually apedal, but some medium to fine-textured soils with strong granular structure or cementation of aggregates can be highly permeable.

11.14 Coarse fragments

Coarse fragments refer to all particles >2 mm in size. Included are rock fragments inferred to be not continuous with underlying bedrock and other fragments such as charcoal and shells, but not segregations of pedogenic origin (see **Segregations**). More than one type of **Coarse fragments** may occur in a soil layer; up to 3 separate types may be recorded.

To add a **coarse fragment**, click or tap on the 

+ Add button.

Each **coarse fragment record** is defined by its type. Record the most important coarse fragment type first. If the value of 'other' is selected as the 'Type' then please enter an appropriate description in the text field provided.

All coarse fragment information added and saved is displayed in a summary table for comparison. To edit an existing coarse fragment, click or tap on its row in the table (web app) or click or tap on the row's **Edit** button (mobile app). To delete a coarse fragment, click or tap on its **Delete** button.

The amount expressed as a percentage is visually estimated using ***Figure 8*** as a guide. A **coarse fragment type** must always have an **amount**.

11.14.1 Type

Describe the source or type of **coarse fragments**.

Available values are:

- **not evident**
- **not identified**
- **as substrate**
- **as rock outcrop**
- **as parent material**
- **quartz**
- **feldspar**
- **silcrete**
- **ironstone**
- **bauxite**
- **shells**
- **charcoal**
- **pumice**
- **opalised wood**
- **sedimentary**
- **metamorphic**
- **igneous**
- **other**.

11.14.2 Amount

Describe the amount of **coarse fragments** within the **layer**, using Figure 14 (below) as a visual guide.

Values available are:

- **very few (<2%)**
- **few (2–10%)**
- **common (10–20%)**

- **many (20–50%)**
- **abundant (50–90%)**
- **very abundant (>90%).**

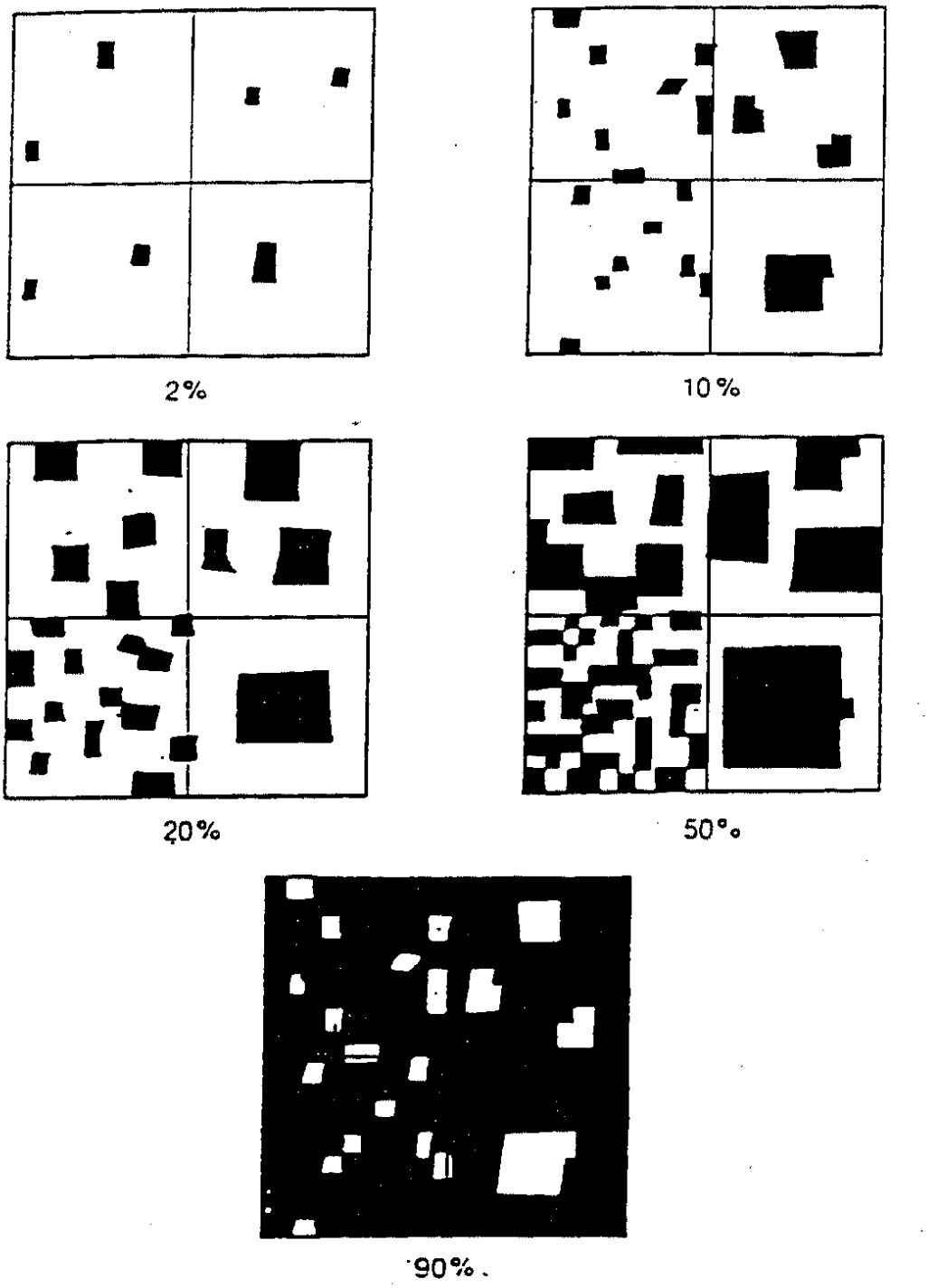


Figure 14 Chart for visually estimating percentage of abundance of an attribute

11.14.3 Distribution

Describe the distribution of **coarse fragments** within the **layer**.

Available values are:

- **stratified**: occur in recognisable bands, usually parallel with the soil surface.
- **dispersed**: tend to be randomly scattered throughout the layer.

11.14.4 Orientation

Describe the orientation of **coarse fragments** within the **layer**.

Available values are:

- **undisturbed**: all fragments are remnants of the underlying substrate; general orientation closely parallels that of the joint/bedding planes within the substrate.
- **reoriented**: orientation is not related to the joint/bedding plane patterns of the underlying substrate.

11.14.5 Weathering

Assess the degree of weathering of **coarse fragments** by comparing the appearance of the exposed face with a freshly broken surface.

Available values are:

- **non weathered**: little difference between the exposed surface of the rock and a freshly broken surface.
- **weakly weathered**: the rock has a weathered surface layer so that it is necessary to break it open to identify its lithology accurately.
- **strongly weathered**: sufficiently weathered so as not to contain any surfaces similar in colour or texture to an unweathered surface; often easily broken.

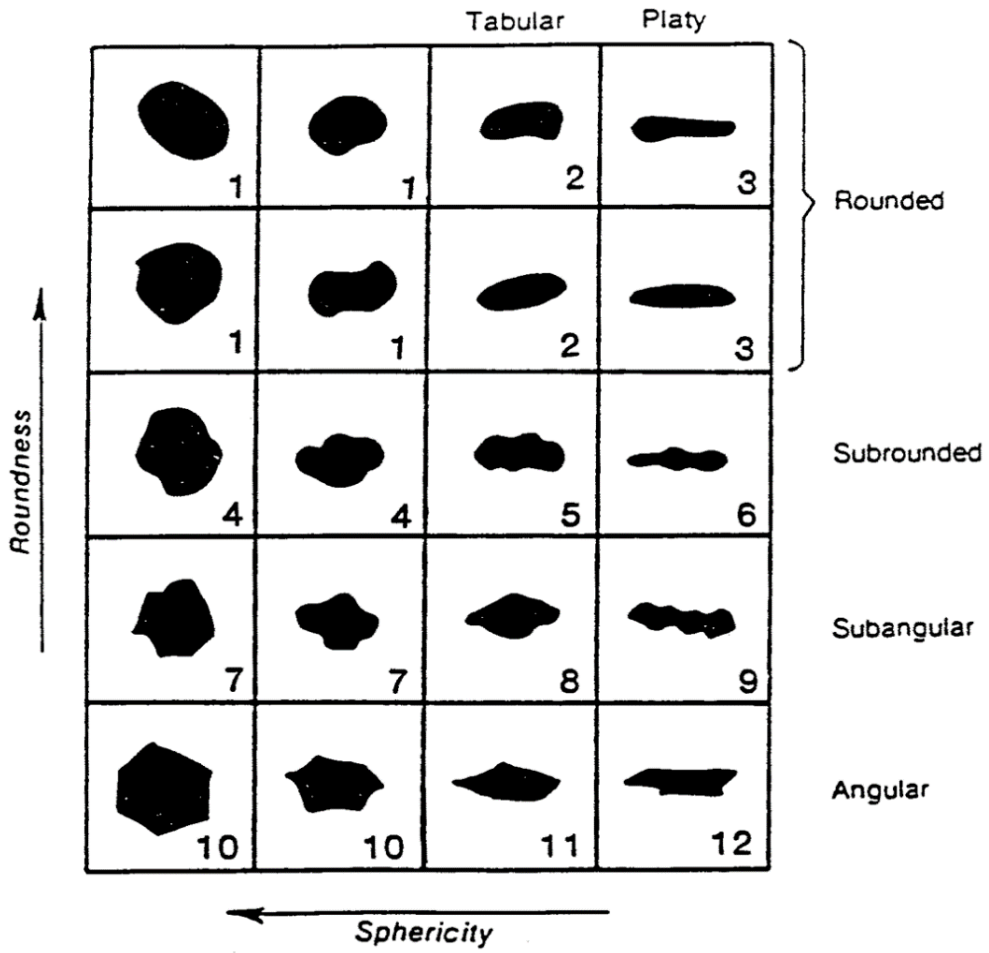


Figure 15 Fragment shapes

11.14.6 Shape

Describe the shape of each type, using Figure 15 (above) as a visual guide.

Available values are:

- **angular**
- **angular tabular**
- **angular platy**
- **sub-angular**
- **sub-angular tabular**
- **sub-angular platy**
- **sub-rounded**
- **sub-rounded tabular**
- **sub-rounded platy**
- **rounded**
- **rounded tabular**
- **rounded platy**.

11.14.7 Size

Describe the average size range of each type of **coarse fragment**, considering the maximum dimension of the fragments.

Available values are:

- **fine gravel (2–6 mm)**
- **gravel (6–20 mm)**
- **coarse gravel (20–60 mm)**
- **cobbles (60–200 mm)**
- **stones (200–600 mm)**
- **boulders (>600 mm)**.

11.15 Segregations

Segregations are discrete accumulations of material in the soil resulting from the concentration of some constituent, usually by chemical or biological action. **Segregations** may be formed in situ by current or relic pedogenic processes or derived from older soils or material. They are distinguished from **ped coatings** at the macroscale because they occur within the body of the aggregate rather than at a surface. More than one type of **segregations** may occur in a soil layer; up to 3 separate types may be recorded.

To add a **segregation**, click or tap on the 

+ Add button.

Each **segregation** record is defined by its type. Record the most important **segregation** type first. If the value of 'other' is selected as the 'Type' then please enter an appropriate description in the text field provided.

All **segregation** information added and saved is displayed in a summary table for comparison. To edit an existing **segregation**, click or tap on its row in the table (web app) or click or tap on the row's  **Edit** button (mobile app). To delete a **segregation**, click or tap on its  **Delete** button.

11.15.1 Type

Describe the types of **segregations** observed. If value of 'other' is selected as the 'Type' then please enter an appropriate description in the text field provided.

Available values are:

- **not evident**: no segregation observed in the layer.
- **calcareous**: calcium and/or magnesium carbonates, detectable, when not visible, by the application of 2 or 3 drops of 1 M hydrochloric acid to a sample of the soil.
- **gypseous**: gypsum (calcium sulfate) usually occurring as transparent or near-white crystals which may be so fine as to seem powdery; alternatively, may appear in a fine, thread-like form, or as beards or pendants; nests of larger gypsum crystals <5 mm in size may also occur; crystals are soft, may be broken between the thumb and fingernail and do not effervesce when treated with HCl; more extensive deposits,

from finely crystalline powdery forms (kopi) to large arrowhead and oyster crystals, <150 mm or larger, are associated with geological formations and may occur below some modern soils; dunes of kopi occur in arid areas marginal to salt lake systems (Northcote 1979).

- **manganiferous**: manganese oxides.
- **ferruginous**: ironstone gravels; may be localised within or scattered throughout the soil profile.
- **ferromanganiferous**: ironstone gravels containing oxides of manganese; may be localised within or scattered throughout the soil profile.
- **organic**: inclusions from an organic source. This is not intended to include living organic matter.
- **not identified**: segregations observed but not identified.
- **other**: used when none of the above descriptions suit the observation; further comments should be entered into the adjacent text field.

11.15.2 Amount

The volume of soil occupied by concretions may be visually estimated using Figure 14 as a guide.

11.15.3 Strength

Strength is used to qualify the **form** – for example, when hard nodules are observed, the **strength** is recorded as strong and the **form** as nodules. Similarly, if soft nodules are observed, the **strength** is recorded as weak and the **form** as nodules.

Available values are:

- **weak**: can be broken between thumb and forefinger.
- **strong**: cannot be broken between thumb and forefinger.

11.15.4 Form

Describe the dominant form in which the **segregations** occur.

Available values are:

- **soft segregations**: finely divided material which contrast with the soil matrix in both colour and composition but not easily separated as discrete bodies; outline or boundary may be clearly defined or diffuse.
- **nodules**: irregular rounded mineral aggregate; no concentric or symmetric interior fabric but may have hollow interior; usually easily separated from the soil matrix; if nodules are soft, then strength 1 (weak) should also be entered; if nodules are hard, then strength 2 (strong) should also be entered.
- **fragments**: broken pieces of segregations.
- **crystals**: crusts or coatings on the soil surface, within the soil and along fissures, or as crystal chambers and crystal tubes filling or partly filling voids; frequently composed of carbonates, bicarbonates, sulfates and chlorides of calcium, magnesium and sodium.

- **veins**: fine (<2 mm wide) linear segregations.
- **concretions**: spheroidal mineral aggregates; crudely concentric internal fabric can be seen with naked eye; includes pisoliths and ooliths.
- **root linings**: linings of former or current root channels.
- **tubules**: medium to coarse (>2 mm wide) tube-like segregations which may or may not be hollow.

11.15.5 Size

Describe the average size range of each type of **segregations**, considering the maximum dimension of the **segregations**.

Available values are:

- **fine (<2 mm)**
- **medium (2–6 mm)**
- **coarse (6–20 mm)**
- **very coarse (20–60 mm)**
- **extremely coarse (>60 mm)**.

11.16 Pans

A **pan** is an indurated and/or cemented soil **layer** that is denser and less permeable than the **layers** above and below it and more or less impenetrable to plant roots. More than one type of **pan** may occur in a soil **layer**.

To add a **pan**, click or tap on the + Add **+ Add** button.

Each **pan** record is defined by its type. Record the most important **pan** type first. If value of 'other' is selected as the 'Type' then please enter an appropriate description in the text field provided.

All **pan** information added and saved is displayed in a summary table for comparison. To edit an existing **pan**, click or tap on its row in the table (web app) or click or tap on the row's **Edit** button (mobile app). To delete a **pan**, click or tap on its **Delete** button.

11.16.1 Type

Describe the types of **pan** observed. If the value of 'other' is selected as the type then please enter an appropriate description in the text field provided.

- **not evident**: no pans observed in the layer.
- **calcrete**: hardened layer of calcium or magnesium carbonates; may be referred to by various names including calcareous pan, caliche, carbonate, kunkar, travertine, and secondary limestone; all show some effervescence when treated with dilute hydrochloric acid.
- **silcrete**: hard to very hard siliceous material composed almost entirely of secondary silica.
- **earthy**: this value should be used only if the pan cannot be assigned to either *duripan*, *fragipan*, *densipan* or *red-brown hardpan*.

- **duripan**: an earthy pan so cemented by silica that dry fragments do not slake in water and are always brittle, even after prolonged wetting (described by Soil Survey Staff 1975).
- **fragipan**: an earthy pan which is usually loamy; dry fragments slake in water; wet fragments do not slake in water but have moderate or weak brittleness. Fragipans are more stable on exposure than overlying or underlying horizons (described by Soil Survey Staff 1975) – for example, protruding from adjacent layers when exposed in road batters.
- **densipan**: a very fine sandy (0.02–0.05 mm) earthy pan. Fragments, both wet and dry, slake in water. Densipans are less stable on exposure than overlying or underlying horizons (described by Smith, Ayra and Stark 1975).
- **red-brown hardpan**: an earthy pan which is normally red with a dense yet porous appearance; very hard (cannot be penetrated by a soil auger), with an irregular laminar cleavage and some vertical fissures; thickness may vary from >0.3 m to <3 m; other variable features include bedded and unsorted sand and gravel lenses, wavy black veinings, probably manganiferous, and off-white veins of calcium carbonate (calcium carbonate is not common and the red-brown hardpan in which it occurs may be relatively brittle and finely laminar); usually present below the soil profile and is not a feature of any particular soil group.
- **thin ironpan**: commonly thin (2–10 mm) black to dark reddish pan cemented by iron, iron and manganese or iron-organic matter complexes; has wavy or convoluted form and usually occurs as a single pan; described as a placic horizon by the Soil Survey Staff (1975).
- **ferricrete**: indurated material rich in hydrated oxides of iron (usually goethite and hematite) occurring as cemented nodules and/or concentrations, or as massive sheets; may be referred to as laterite, duricrust or ironstone.
- **alcrete**: indurated material rich in aluminium hydroxides; commonly consists of cemented pisoliths and usually known as bauxite.
- **manganiferous**: indurated material dominated by oxides of manganese.
- **ortstein**: layer strongly cemented by iron and organic matter marked by local colour variability, both laterally and vertically; may occur in the B horizons of Podzols.
- **organic**: a layer relatively high in organic matter but low in iron; relatively thick and weakly to strongly cemented by aluminium, usually becoming progressively more cemented with depth; usually relatively uniform laterally; commonly forms the B horizon of Humus Podzols and referred to as coffee rock or sandrock.
- **cultivated**: subsurface soil layer having higher bulk density, lower total porosity and lower permeability to both air and water than the soil directly above or below as a result of cultivation practices.
- **other**: used when none of the above descriptions suits the observation; further comments should be entered into the adjacent notes field.

11.16.2 Cementation

The degree of cementation of a pan is assessed by the reaction of a piece of the pan, 30 mm diameter, placed in water for 1 hour.

Available values are:

- **uncemented**: the pan sample slakes.
- **weakly cemented**: a soaked piece of the pan can be crushed between the thumb and forefinger.
- **moderately cemented**: crushing is beyond the power of thumb and forefinger, but the sample crushes underfoot on a hard flat surface when the weight of an average man
  (80 kg) is applied slowly.
- **strongly cemented**: a soaked piece of the pan cannot be crushed underfoot, but it can be broken with a hammer.
- **very strongly cemented**: a soaked piece of the pan cannot be broken with a hammer or can be broken only with extreme difficulty.

11.16.3 Continuity

Describe the lateral pan continuity across an exposure of ≥1 m.

Available values are:

- **continuous**: extends as a layer with little or no break across the exposure.
- **discontinuous**: broken by cracks, but the original orientation of fragments is preserved.
- **broken**: broken by cracks, and the fragments are disoriented.

11.16.4 Structure

Describe the pan structure or appearance within an exposure.

Available values are:

- **massive**: no recognisable structure occurs.
- **vesicular**: sponge-like structure with large pores which may or may not be filled with softer material.
- **pisolitic**: spheroidal concretions cemented together.
- **nodular**: nodules of irregular shape cemented together.
- **platy**: plate-like units cemented together.
- **vermicular**: worm-like structure and/or cavities.

11.17 Cracks and macropores

The space occupied by air or water within the soil matrix, and visible with the naked eye, may be described. This is an important factor for consideration of a soil's hydraulic properties – for example, rates of infiltration and permeability.

Two aspects of this space are considered: **cracks** are generally planar voids and **macropores**, including those formed by biological activity, are approximately circular in cross-section. The occurrence of **cracks** may be recorded within specific width classes or as unspecified width. The number of **macropores** observable within a specified sample area may be recorded for specific diameter classes or as unspecified diameter.

If required, other information or more detailed descriptions can be recorded in **layer notes**.

11.17.1 Crack width and presence/absence

Cracks, or interped spaces, form an integrated pattern so that the **peds** can be defined and detached. The size of these **cracks** may vary with changes in soil **water status**. Record for this and each subsequent width range whether or not **cracks** of that width are observed in the **layer**.

Fine (<5 mm)

Indicate whether or not cracks of this width range are observed in the layer.

Medium (5–10 mm)

Indicate whether or not cracks of this width range are observed in the layer.

Coarse (10–20 mm)

Indicate whether or not cracks of this width range are observed in the layer.

Very coarse (20–50 mm)

Indicate whether or not cracks of this width range are observed in the layer.

Extremely coarse (>50 mm)

Indicate whether or not cracks of this width range are observed in the layer.

11.17.2 Macropore diameter and amounts

Record for this and each subsequent diameter range, the estimated number of **macropores** of that diameter observed within the specified sample area. For diameters ≤2 mm, the sample area is equal to 10 mm ´ 10 mm. When the diameter is >2 mm, the sample area used equals 100 mm ´ 100 mm.

Very fine (<1 mm)

Record whether or not **macropores** of this diameter range are observed in the layer by selecting an amount.

Fine (1–2 mm)

Record whether or not **macropores** of this diameter range are observed in the layer by selecting an amount.

Medium (>2–5 mm)

Record whether or not **macropores** of this diameter range are observed in the layer by selecting an amount.

Coarse (>5 mm)

Record whether or not **macropores** of this diameter range are observed in the layer by selecting an amount.

Unspecified diameter

Record whether or not **macropores** of this diameter range are observed in the layer by selecting an amount. Wherever possible, however, you should specify the diameter by using the above fields.

11.18 Roots

Roots may be described within specific root diameter classes. For each class, the **Amount** or number of **roots** in an area of 10 cm ´ 10 cm may be recorded. Carefully pick back about 5 mm over an area of 10 cm ´ 10 cm of the profile face with a trowel or knife. Estimate the number of **roots** visible in each root diameter class. It is difficult to accurately estimate the number of **roots**, but the broad groups of attributes should suffice for most soil survey purposes. Where necessary, **layer field notes** can be used to record more detailed descriptions using other attributes or more values. A general indication of **roots** within the **layer** can be recorded by using the **root** size class of 'Unspecified size'.

11.18.1 Root size

Record the abundance of roots within the **layer**, either by diameter class or as roots of unspecified diameter.

Very fine (<1 mm)

Record whether or not **roots** of this size range are observed in the **layer** by selecting an amount.

Fine (1–2 mm)

Record whether or not **roots** of this size range are observed in the **layer** by selecting an amount.

Medium (>2–5 mm)

Record whether or not **roots** of this size range are observed in the **layer** by selecting an amount.

Coarse (>5 mm)

Record whether or not **roots** of this size range are observed in the **layer** by selecting an amount.

Unspecified size

Record whether or not **roots** of this size range are observed in the **layer** by selecting an amount.

11.18.2 Root distribution

Describes the distribution of **roots** within the soil mass and their relationship, if any, with soil aggregates.

Available values are:

- **in-ped**: most roots pass through the peds.
- **ex-ped**: most roots follow ped interfaces.
- **in-ped and ex-ped**: roots both pass through peds and follow ped interfaces.

11.19 Soil faunal activity

Refers to the modification of soil morphology, in particular **structure** and **macropores**, by soil fauna including ants, earthworms, termites, larvae, etc. It may result in a lowering of the bulk density and consequent increasing of permeability. The degree of modification in a **layer** is dependent upon the dominant types of organisms and the intensity or degree of activity.

If required, other information or more detailed descriptions can be recorded in **layer notes**.

11.19.1 Faunal activity degree

The degree of soil faunal activity in the layer is the volume of soil affected by faunal activity as a proportion of the total volume of the layer.

Values available are:

- **none**
- **low (<10%)**
- **moderate (10–50%)**
- **high (>50%)**

11.19.2 Faunal activity type

Describe the type of **Soil faunal activity** in each layer. If the value of 'other' is selected then a text box will be provided for a further description to be entered.

Values available are:

- **cylindrical burrows/krotovinas**
- **earthworm casts**
- **termite channelling**
- **ant channelling**
- **other**.

12. Sample attributes

You can record one or more **samples** for each **profile**.

To add a sample, click or tap on the 

Add Sample button.

Each sample is uniquely identified by its sample code, which consists of the following fields, separated by backslash (/) characters:

- A code representing the testing laboratory
- A two-digit number representing the year in which the sample was tested
- A number representing the batch of samples within which the sample was tested
- A number representing the sample
- A number (in parentheses) representing the fraction of the sample that was tested (optional).

12.1 Sample attributes

12.1.1 Soil laboratory

Record the laboratory where the sample testing was undertaken. If the laboratory is not listed, please contact the eDIRT administrator by email at edirt.admin@environment.nsw.gov.au

12.1.2 Laboratory sample date

Record the date when the sample was processed in the laboratory.

12.1.3 Laboratory batch number

Record the batch number allocated by the test laboratory which may have grouped samples. If no batch was assigned by the laboratory use '1'.

12.1.4 Laboratory sample number

Record the unique number allocated by the test laboratory to identify each sample.

12.1.5 Laboratory fraction

Record the fraction number allocated by the test laboratory which may have split an individual sample. If no fraction was assigned by the laboratory use '1'.

12.1.6 Upper depth

Record the upper boundary of the sample in meters.

12.1.7 Lower depth

Record the lower boundary of the sample in meters.

12.1.8 Sampling technique

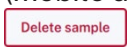
Record any useful information such as core, batter, bulked, control, and treatment.

12.1.9 Reason

Insert any information about the reason for the sample being collected, if required.

12.1.10 Sample notes

Record any useful additional information about the sample, specific test results or variations to the test methods.

All **samples** added and saved are displayed in a tabular list. To edit an existing **sample**, click or tap on its row in the table (web app) or click or tap on the row's  **Edit** button (mobile app). To delete a **sample**, click or tap to edit the sample then click or tap on the  **Delete sample** button.

12.1.11 Grid location X

For monitoring sites, such as those described using the *Protocols for soil condition and land capability monitoring* (DECC unpublished), you may specify the grid cell within which a particular sample has been collected by supplying its X and Y coordinates. Record the X coordinate in this field. The *Protocol* typically uses a 100-cell grid in a 10 ´ 10 square configuration, thus the X coordinate is a number between 0 and 9.

12.1.12 Grid location Y

For monitoring sites, such as those described using the *Protocols for soil condition and land capability monitoring* (DECC unpublished), you may specify the grid cell within which a particular sample has been collected by supplying its X and Y coordinates. Record the Y coordinate in this field. The *Protocol* typically uses a 100-cell grid in a 10 ´ 10 square configuration, thus the Y coordinate is a number between 0 and 9.

12.2 Laboratory result

To add a **laboratory result** to a **sample**, follow these steps:

1. Click or tap on the  **Add result** button.
2. Enter part/all of a lab test method code or method name into the **Search laboratory test** field.
3. In the drop-down list that appears, select the required method
4. Enter the test result into the **Test result** field.
5. Click or tap on the  **Add** button.

As you add laboratory results to a sample, they are listed in the **Laboratory results** table.

12.2.1 Test code

Lists the code for the selected National test method.

12.2.2 Test name

Lists the name for the selected National test method, from the National reference texts:

- Rayment GE and Lyons DJ (2011) *Soil Chemical Methods – Australasia*, CSIRO Publishing.
- McKenzie NJ, Cresswell H and Coughlan K (2002) *Soil Physical Measurement and Interpretation for Land Evaluation*, CSIRO Publishing.

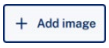
12.2.3 Result

Records the result for the specified test method, taking account of the 'units of measurement' assigned.

12.2.4 Unit of measurement

The unit of measurement appropriate for the specified test method (read only).

13. Image attributes

You can attach one or more **images** to a **profile**. To do so, click or tap on the 

Add image button.

To edit the details of an image, click or tap on it, then click or tap on the 

Edit button.

To delete an image, click or tap on it, then click or tap on the 

Delete button.

13.1 Title

Record a title for the image.

13.2 Caption

Record a caption for the image.

13.3 Date

Record the date on which the image was taken.

13.4 Keywords

Record some keywords associated with the image – for example, a soil type, type of land use or soil erosion, etc.

13.5 Description

Enter a text description of the image, if required.

14. References

Abraham SM and Abraham NA (eds) (1996) *Soil Data System Site and Profile Information Handbook*, 2nd edn, NSW Department of Land and Water Conservation, Sydney, NSW.

Atkinson G and Melville MD (1987) 'Soils', in *Atlas of NSW,* CMA, Bathurst, NSW.

Bates RL and Jackson JA (eds) (1984) *Dictionary of Geological Terms* (3rd Edition), Doubleday, New York, NY, USA.

Beadle NCW, Evans OD and Carolin RC (1982) *Flora of the Sydney Region* (3rd Edition), AH and RW Reed, Sydney, NSW.

Bouma J (1989) 'Using soil survey data for quantitative land evaluation', *Advances in Soil Science,* **9**:177-213.

Butler BE (1955) A system for the description of soil structure and consistence in the field. J.A.I.Ag.Sci. **21**:239-49.

Butler BE and Hubble GD (1977) 'Morphological properties', in Russell JS and Greacen EL (eds) *Soil Factors in Crop Production in a Semi-Arid Environment,* University of Queensland Press, Brisbane, Queensland.

Charman PEV and Murphy BW (eds) (1991) *Soils — their properties and management, a soil conservation handbook for NSW*, Sydney University Press, Melbourne, Victoria.

Crouch R (1976) Field tunnel erosion — a review, J.S.C.S. NSW **32**:98-111.

Dent D (1986) *Acid sulphate soils — a baseline for research and development*, ILRI Publ. No. 39, International Institute for Land Reclamation and Improvement, Wageningen, The Netherlands.

Emerson WW (1967) 'A classification of soil aggregates based on their coherence in water', *A.J.S.R.* **5**:47-57.

FAO (1998) World Reference Base for soil resources, FAO, Rome.

Gary M, MacAfee R and Wolf CL (eds) (1972) *Glossary of Geology*, American Geological Institute, Washington DC, USA.

Hackett C (1983) 'Role and content of species-level crop descriptions', *Econ.Bot.* **37**:322-330.

Hodgson JM (1976) *Soil Survey Field Handbook,* Soil Survey Tech. Monograph No. 5, Bartholomew Press, Dorking, UK.

Isbell RF (1996) *The Australian Soil Classification*, CSIRO, Australia.

Leigh and Mulham 1965, *Pastoral Plants of the Riverine Plain*. Jacaranda Press in Association with CSIRO Division of Plant Industry, Brisbane.

McDonald RC, Isbell RF, Speight JG, Walker J and Hopkins MS (1990) *Australian Soil and Land Survey Field Handbook*, 2nd edn, Inkata Press, Melbourne and Sydney.

McKenzie NJ (1992) *A strategy for co-ordinating soil survey and land evaluation in Australia*, CSIRO Division of Soils, Divisional Report No. 114, CSIRO, Australia.

Melville MD and Atkinson G (1985) 'Soil colour — its measurement and its designation in models of uniform colour space', *J.Soil Sci.* **36**:495-512.

Moore WG (1988) *The Penguin Dictionary of Geography* (7th Edition), Penguin, London, UK.

Morse RJ, Atkinson G and Craze B (1982) *Soil Data Card Handbook*, Soil Conservation Service of NSW Technical Handbook No. 4, Soil Conservation Service of NSW, Sydney, NSW.

Munsell Color (2009) *Munsell soil color charts*, revised edn, Munsell Color (X-Rite), Grand Rapids, MI.

Northcote KH (1966) Atlas of Australian Soils, Sheet 3, Sydney Canberra-Bourke-Armidale Area, with Explanatory Data, CSIRO and Melbourne University Press, Melbourne, Victoria.

Northcote KH (1979) *A Factual Key for the Recognition of Australian Soils,* 4th edn, Rellim Technical Publications, Coffs Harbour, NSW.

Northcote KH (1960–1968), *Atlas of Australian Soils*, CSIRO and Melbourne University Press, Melbourne, Victoria.

Oyama M and Takehara H (1970) *Revised Standard Soil Color Charts* (2nd Edition), Frank McCarthy Color Pty Ltd, Kew, Victoria.

Paton TR (1978) *The Formation of Soil Material*, Allen and Unwin, London, UK.

Raupach M and Tucker BM (1959) The field determination of soil reaction. J. A.I.A.S. **25(2)**:129-133.

Smith GD, Ayra LM and Stark J (1975) *The densipan, a diagnostic horizon of densiaquults for soil taxonomy*. Soil. Sci. Soc. Amer. Proc. **39**:369-70.

Soil Survey Staff (1975) *Soil Taxonomy: a Basic System of Soil Classification for Making and Interpreting Soil Surveys*. USDA Agriculture Handbook No 436. Government Printer, Washington, DC, USA.