NSW GOVERNMENT | Office of Environment & Heritage

User Manual

for the Digital Infield Regolith Tool (eDIRT)
version 1.0

Published by:
Office of Environment and Heritage NSW
59 Goulburn Street, Sydney NSW 2000
PO Box A290, Sydney South NSW 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (environment information and publications requests)
Phone: 1300 361 967 (national parks, climate change and energy efficiency information, and publications requests)
Fax: (02) 9995 5999
TTY users: phone 133 677, then ask for 131 555
Speak and listen users: phone 1300 555 727, then ask for 131 555
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

Report pollution and environmental incidents
Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au
See also www.environment.nsw.gov.au

ISBN 978 1 74359 927 3
OEH 2015/0159
March 2015

Preface

The intent of this document is to combine the various sources of information about eDIRT into a single document that describes all major aspects of the system for the end user – both in terms of its operation and the data it allows the end user to collect. In describing the range of fields available through eDIRT, this document therefore draws together reference material from a number of sources, including the *Australian Soil and Land Survey Field Handbook, 3rd Edition* (NCST 2009) and the *SALIS Soil Data Entry Handbook, 3rd Edition* (Milford *et al.* 2001) and its supplements.

Acknowledgements

This document was prepared by Humphrey Milford and Nicole Simons.

Our great thanks go to Chuong Tran (project manager/business analyst) and Frank Hong (application developer) for the creation of eDIRT.

From the NSW Office of Environment and Heritage (OEH) our thanks go to Casey Murphy, Mark Young and Robin McAlpine for their technical input, and Brian Jenkins and Dr Greg Summerell for their support. Dr David McKenzie and Lindsay Hyde (McKenzie Soil Management Pty. Ltd.) and Peter Bacon (Woodlots and Wetlands Pty. Ltd) provided important external user testing and their cooperation and feedback is greatly appreciated.

We also appreciate the advice received during the formative stages of eDIRT from the members of the eDIRT Technical Working Group, comprising Robert Banks (principal soil scientist, SoilFutures Consulting Pty. Ltd.), John Friend (NSW Department of Primary Industries), and Dr Mitch Tulau, Michael Eddie, David Morand, Casey Murphy and Mark Young (NSW OEH).

Funding for the development of eDIRT was provided by the *National Partnership Agreement on Large Coal Mines and Coal Seam Gas* through the NSW Department of Primary Industries (DPI). In particular we thank Rebekah Gomez-Fort and John Friend from DPI for their involvement.

Contents

1. What is eDIRT?

eDIRT is an Internet application for the in-field recording of soil information. Its primary role is to replace the previous generation of scannable Soil Data Cards used to enter soil information into the NSW Soil and Land Information System (SALIS).

eDIRT is suitable for use on both fixed (desktop PC) and mobile platforms (laptops, tablets and smartphones) using all major operating systems available at the time of its development. eDIRT has been optimised for use on a tablet or large smartphone with a touch screen, mobile network connectivity and a Global Positioning System (GPS) receiver.

eDIRT can be used both online (connected to the Internet via a fixed or mobile network) and offline (in remote areas without mobile network connectivity). The eDIRT application is supported by an Internet server that supplies eDIRT with data and program updates. The eDIRT server also synchronises ('syncs') the soil profile data you collect when you're online, so that if your device stops working or your data is deleted you can easily retrieve it.

2. eDIRT Basics

2.1 Getting Started

- See our recommendations about platforms and Web browsers below for the ultimate eDIRT user experience.
- Register and download the eDIRT program to your device(s), and download updates, by logging on at http://edirt.environment.nsw.gov.au.
- Calibrate your device's GPS receiver before you start collecting data.
- Log on to eDIRT as soon after collecting data as possible, so that your device can sync your data with the eDIRT server.
- Unless required to update the eDIRT system, **do not clear your browser cache! Doing so will delete all unsynced profiles on your device.** See **Section 2.3** for more information.

2.2 Preferred Devices and Platforms

For best use of eDIRT we recommend the use of a touch-enabled mobile device (tablet or large smartphone), although eDIRT will also operate on laptop and desktop computers. Our recommendations on platforms and web browsers are listed in the table below.

Platform	Web browser
Google® Android™, version 4.4 and above	Google® Chrome™ for Android™, version 39 and above
Microsoft® Windows®, version 7 and above	Google® Chrome™, version 39 and above
Apple® iOS, version 7 and above	Google® Chrome™, version 39 and above

Other platforms and browsers may allow eDIRT to run but may not necessarily support all functions and features. We do not recommend use of the Apple® Safari® web browser as it does not properly support several necessary components of eDIRT.

2.3 Managing the browser cache

The browser cache is an area of storage in memory or on hard disk (depending on your device) that stores web pages that you have recently visited. This allows your web browser to quickly reload a page from the cache if you visit it again, rather than have to download the web page again from the Internet.

eDIRT uses the browser cache to store a local version of the eDIRT application. This allows you to use eDIRT remotely, i.e., without an Internet connection. Before you update the eDIRT application (typically in response to email advice from us) you will need to clear your browser cache.

However, be careful! eDIRT uses an Internet database specification called WebDB to store the profile data you collect on your device. In browsers such as Google® Chrome™ the database resides, like the eDIRT application, in the browser cache. When the browser cache is cleared, the contents of the WebDB database are deleted.

It is **very important** therefore that you do not clear the browser cache unless you have first synced the profiles on your device. Any profiles not synced with the eDIRT server will be permanently lost. It is best, therefore, to clear the browser cache and update eDIRT before you go on a field trip, and not clear the browser cache until you have submitted all the profiles you have collected. In normal circumstances, unless an update to eDIRT has been released, there should be no need for you to clear your browser cache.

If you have inadvertently deleted some profiles prior to submitting them, you can retrieve those profiles synced to the eDIRT server by contacting the eDIRT administrator at edirt.admin@environment.nsw.gov.au. Please supply as much identifying information as possible, e.g., your eDIRT user name, survey and profile numbers, etc..

2.4 Satellite Navigation System Support in eDIRT

For best use of eDIRT we recommend a device incorporating properly calibrated 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 a line-of-sight view of at least 4 satellites to achieve a positioning fix, and access to more satellites will provide a more accurate estimate of position.

There are now several satellite navigation systems in service, including **GPS** (United States of America), **GLONASS** (Russia) and **BeiDou** (People's Republic of China). The more of these systems your device can access, the more accurate its reported position will be. Other factors influencing this accuracy include atmospheric effects, sky blockage (e.g., trees, buildings, hills) and the quality of the hardware.

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 to reduce time taken to achieve an accurate locational fix.

It is also very important that you ensure that the onboard GPS in your device is calibrated before use. You can do this on an Android™ or Windows® device by using a specialised GPS app that includes a calibration function. On an Apple® iPad® 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 iPad® is switched on; otherwise the GPS readings it supplies to eDIRT may be inaccurate.

2.5 Remote Use of eDIRT

eDIRT will operate in both online (connected to a data connection) and offline (not connected to a data connection) mode. However, before you go offline you should ensure that you have connected your device to eDIRT so that you have downloaded the latest program and data updates. When your device is ready to go offline you will see a message “Offline mode ready” in the Quickstart guide screen.

Before using eDIRT in the field it is also recommended that the device be tested in the office in offline mode by disconnecting or disabling all data connections to the device and creating a trial profile using eDIRT.

Ideally, you should connect to eDIRT online frequently so that your device can synchronise its onboard eDIRT data with the eDIRT server. This will not only ensure that you have the latest program and data updates but will ensure that your profile data can be retrieved if your device fails or gets lost.

You can easily tell whether you are online in eDIRT because the small figure next to your name in the top right-hand corner of the eDIRT screen will display in green when eDIRT is online, and grey when eDIRT is offline.

2.6 eDIRT Help

Most sections and attributes in eDIRT incorporate links to help information, which describes each attribute and the available values that may be recorded. This help information is also available in the document you’re reading now, which you can print as a more permanent reference.

3. Using eDIRT

3.1 Basic Process

Collecting a soil profile using eDIRT involves the following basic steps:

1. Select or create a template (see **Section 4.1**)
2. Collect the soil profile data (see **Section 4.5** and subsequent sections)
3. Validate the soil profile data (see **Section 3.2**)
4. Submit the soil profile to SALIS (see **Section 3.3**)

3.2 Validate

At any point during the collection of a soil profile – although typically at the end – you can validate the data you have collected. Once you click the **Validate** button (from either the **My soil profiles** screen or **Soil profile** screen), eDIRT will check the soil profile(s) you have selected against its data integrity rules and will return the results to your screen. You can use the **Go to** buttons to navigate instantly to each error.

Validation errors (displayed in red) are incorrect, invalid or missing values that must be corrected before the profile can be submitted to SALIS.

Fields without values (displayed in yellow) are fields included in the selected template for which no value(s) have been recorded. This is intended for your information, in order for you to quickly identify any fields important for your data collection in which values have not been recorded.

Text entries (displayed in green) provide a list of the values you have recorded (if any) in the text fields included in the selected template. This is intended for your information so you can quickly see all of the text entries you have collected, and quickly navigate to any text entries you have yet to collect or any entries requiring correction.

3.3 Submit

Once you have entered all data and corrected all errors you can submit your profile to SALIS by using the **Submit** button. eDIRT will upload the profile from your device to its server for approval and loading to SALIS. Thus, you need to be online to submit a profile.

3.4 Editing a profile submitted via soil data card

If you have submitted a soil profile to SALIS using a Soil Data Card, you can use eDIRT to correct any errors identified during the data card loading process. You will be sent an email identifying each profile in error that requires your action.

To access a profile in error and correct those errors, follow these steps:

1. Log in to eDIRT.
2. Click on the **My profiles** menu item.
3. In the **My profiles** screen, click on the **Transfer in** button. The **Transfer in profiles** form is displayed.
4. Use the **Transfer in** button to load the specified profile onto your device.
5. Click the **Close** button on the **Transfer in profiles** form.
6. In the **Soil profile listing**, click on the **Edit** button for the profile you wish to correct. Any errors will be displayed at the top of the Profile summary tab.
7. Use the **Go to** buttons to navigate to the first error, and correct it using the onscreen controls.
8. Once you have corrected an error, return to the **Profile summary** tab and click on the **Accept** button to confirm that you have corrected the error, or to confirm that you accept eDIRT's action to correct it. All errors must be marked as accepted before you can submit your profile.
9. Repeat steps 7 through 8 for all identified errors.
10. When finished, click on the **Validate** button to confirm that no errors persist.
11. Click on the **Submit** button to submit the corrected profile to SALIS.

4. Profile attributes

4.1 Profile template

4.1.1 What is a template?

A template is a series of settings that filters the large number of fields available through eDIRT to provide only the fields the user needs to record the data they want. Each soil profile that you create using eDIRT is associated with a particular template, which tells the system which fields to display on the various screens. The underlying structure of the eDIRT database and the fields recorded in it are not changed by the template.

eDIRT includes a number of standard templates configured with different mixes of attributes for different purposes, such as basic soil observations, complete soil descriptions and observation points for assessment of *Biophysical Strategic Agricultural Land* (*BSAL*). You can view the available templates, copy these templates and modify them to suit your own needs using the **My templates** screen, then share them with other users if required.

Later, you may change this mix of fields, either by modifying the template or assigning a new template. However, note that no changes to the data itself will occur, as the underlying structure of the eDIRT database does not change. Although some fields you may have used to record data may not be visible in the new or modified template, and data you entered in those fields is still recorded in the system and will need to be deleted before your profile can be loaded to SALIS.

Therefore, before you change or modify templates, please review your data to ensure that any information you do not wish to record has been removed. Any data recorded that is excluded from the selected template will be identified in the **Validate** screen.

4.1.2 Creating a new template

To create a new template, navigate to the **My templates** screen and use the **Copy and create new template** button on an existing template.

eDIRT will then display the **Edit soil profile template** screen, where you can provide a new **Template name**, and provide a description of the template in the **Template comment** field.

To select which fields you wish the template to display, use the hierarchical tree in the Template window to navigate to and select/deselect fields by clicking on their tick boxes. You can select/deselect individual fields or whole groups of fields.

You can use the **Attributes Included in This Template** section to view all attributes and groups selected for display in your template; the **Attributes Excluded from This Template** section lists all fields that are not included for display in your template.

Once you have finished identifying the new template and selecting the required fields, click on the Save button. The new template will now be listed in the **My templates** screen.

4.1.3 Making a template public

eDIRT administrators have the capability to make templates public, which then allows the template to be copied and used as the basis of a new template for any eDIRT user. Your template will be available to other eDIRT users on their next sync.

If you wish to share a template between team members, ask the eDIRT administrators to temporarily make that template public. Your fellow team members can then make copies of the template on their devices. Once done, the eDIRT administrators can revert the original template to private status so its distribution is restricted.

4.2 My soil profiles

This page lists all of the soil profiles currently stored on your device (if any) and their status. You can carry out various operations here, including:

- Add a new soil profile
- Edit or delete an existing soil profile
- Validate one or more soil profiles to ensure the data is free of errors; and
- Submit one or more profiles for upload to SALIS (online mode only).

4.3 Profile status

Each profile stored on your device has its own status.

- **Pending:** the soil profile is stored only on your device, and has not yet been backed up on the eDIRT server.
- **Synced (Synchronised):** the soil profile is stored on your device and has been backed up on the eDIRT server. If your device fails or you lose your data (e.g., through clearing the browser cache in Google© Chrome™), the profile will be copied back to your device when you next connect to eDIRT online.
- **Submitted:** a profile that has been submitted to SALIS will disappear from the table, or be displayed only before the screen has refreshed, as the profile is uploaded off your device to the eDIRT server for processing and loading to SALIS.

4.4 Soil profile listing

This table lists the soil profiles currently stored on your device (if any) and their status. You can filter the table contents by using the Show buttons, and you can sort the contents by tapping on

one of the column headers. Tap once to sort in ascending order, and again to sort in descending order. To select one or more profiles, tab on their tick boxes in the left-hand column of the table. This allows you to delete, validate or submit one or more profiles in a single operation.

4.4.1 Show: Synchronised

Tapping on this button restricts the **Soil profile listing** table to display only profiles with a **Status** of *Synced*.

4.4.2 Show: Pending

Tapping on this button restricts the **Soil profile listing** table to display only profiles with a **Status** of *Pending*.

4.4.3 Show: Custom filter

Tapping on this button displays the **Custom filter** form, where you can enter data into one or more fields to filter the **Soil profile listing** table. To clear the filter criteria, tap on the **Reset** button.

4.4.4 Add new soil profile

Tap on this button to add a new soil profile record.

4.4.5 Edit

Tap on this button, which is displayed in the right-hand column in the **Soil profile listing** table for each profile, to edit that profile.

4.4.6 Delete

Tap on this button to delete one or more selected profiles from the **Soil profile listing** table. This button is not available until you select one or more profiles in the **Soil profile listing** table.

4.4.7 Validate

Tap on this button to validate one or more selected profiles from the **Soil profile listing** table. This button is not available until you select one or more profiles in the **Soil profile listing** table.

4.4.8 Submit to SALIS

Tap on this button to submit one or more selected profiles from the **Soil profile listing** table to SALIS, when online. This button is not available until you select one or more profiles in the **Soil profile listing** table.

A submitted profile is no longer stored on your device and can no longer be edited using eDIRT, unless the profile is sent back to you by the eDIRT administrator for errors to be corrected, or unless you undo the **Submit** operation.

You can undo a **Submit** on a profile by using the **Transfer in** button, and selecting the **Undo submit** button for the profile in question. This is only available for profiles which have not yet been processed by the eDIRT administrators.

4.4.9 Transfer in

Use this button to download a profile you have released from another device using the **Transfer out** function (when online). The **Transfer in profiles** window that is displayed will allow you to select the profile(s) to move onto your current device. For an example of its use, see **Transfer out** below.

4.4.10 Transfer out

Use this button to move one or more profiles from the current device to another device, when online. The selected profile(s) will disappear from the **Soil profile listing** on the current device and

will immediately be available for **Transfer in** on another device on which you have logged into eDIRT.

For example, if you wished to move a profile from your mobile device, which you have used in-the-field, to your desktop PC for further data entry, you would log into your mobile device in online mode, select the profile, and tap the **Transfer out** button. You would then login to eDIRT on your desktop PC, select the **Transfer in** button, and select the profile in the **Transfer in profiles** window that appears.

4.5 Profile summary

This section contains essential identifying and locating information about a profile.

The fundamental soil record in eDIRT 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). Each **profile** is uniquely identified by its number and geographic location.

Soil profiles are grouped into larger parent entities called **surveys**, each with its own unique name and number. **Profiles** may also be grouped into intermediate entities called **Stations**. **Stations** enable the recording of multiple **profiles** at a single **site** over a period of time, so as to allow monitoring, evaluation and reporting of changes in landscape and soil characteristics.

eDIRT allows collection and storage of soil morphological and chemical information along with a wide range of physiographic information relating to the site and general area of the **profile**. The exact data recorded for each **profile** may vary significantly depending on the purpose for which the data was collected. However, all **profiles** must be accurately geolocated and must include a set of fundamental data attributes, including the identity of the person who collected them.

4.5.1 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 and sync the new survey to your device.

4.5.2 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 so as to avoid confusion.

4.5.3 Station

Stations are used to designate time series data collection - i.e., 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 so as to avoid confusion. Each station will have 1 or more profiles, each of which records the data collected at a single visit.

4.5.4 Site location

A short description of the location of the profile - e.g., "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:

HWY (highway), XRD (crossroad/intersection), RD (road), RES (Reserve), R (river), MT (Mountain), N (north), NP (National Park), S (south), SF (State Forest), E (east), CK (creek), W (west), ST (street), ADJ (adjacent), STR (stream), FR (from), NR (near), CNR (corner), T/O (turnoff), BR (bridge), TR (track).

4.5.5 Profile date

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

4.5.6 Described by

A unique 4-digit number must be recorded to identify the person describing the **profile**. This is automatically populated by eDIRT for you. It is important that the person actually describing the **profile** be identified so that the data can be reliably attributed to that person, rather than (for example), the person supervising the project for which the data was collected.

4.5.7 Release status

Soil profile data can be submitted through eDIRT with one of three 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 (see below).
- **Confidential**: the data is only accessible to the data owner, i.e., the person who submitted it, and to system administrators. This status is only to be used in special circumstances, e.g., for privacy or legal reasons. Justification for the allocation of this status must be provided in the **Request confidentiality** field.

4.5.8 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).

4.5.9 Request confidentiality

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

4.6 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 **My location** button. However, we **strongly recommend** that you calibrate the GPS inside your device before going offline to ensure maximum accuracy. You can do this by downloading a specialised GPS app that includes calibration software (for Apple® iPad® devices, a hard reset – holding down the Power and Home buttons until the Apple logo is displayed, should produce a similar outcome). Alternatively, you may wish to use a dedicated handheld GPS receiver to report your location and enter this information into eDIRT manually.

4.6.1 Coordinate system

This field identifies the coordinate system used to locate the **profile** on the earth's surface.

Available values are:

- **GDA**: a geocentric coordinate system using latitude and longitude to identify locations on the earth's surface. Also known as GDA94, 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.
- **MGA/UTM**: a metric rectangular grid system comparable to the AMG grid in use since the 1980's. Grid references are recorded as an Easting, a Northing and a Zone. 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 AMG system, but because it is projected from a different datum the coordinates of the same place in MGA will be different by several hundred metres from the coordinates of the same place in AMG. To deliver MGA coordinates from your GPS the coordinate position format should be set to UTM.

4.6.2 Zone

Zones divide Australia into a number of 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 conjuction 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 NSW are shown in ***Figure 1*** (next page) and are defined as:

- **54** - From 138° E to 144° E
- **55** - From 144° E to 150° E
- **56** - From 150° E to 156° E

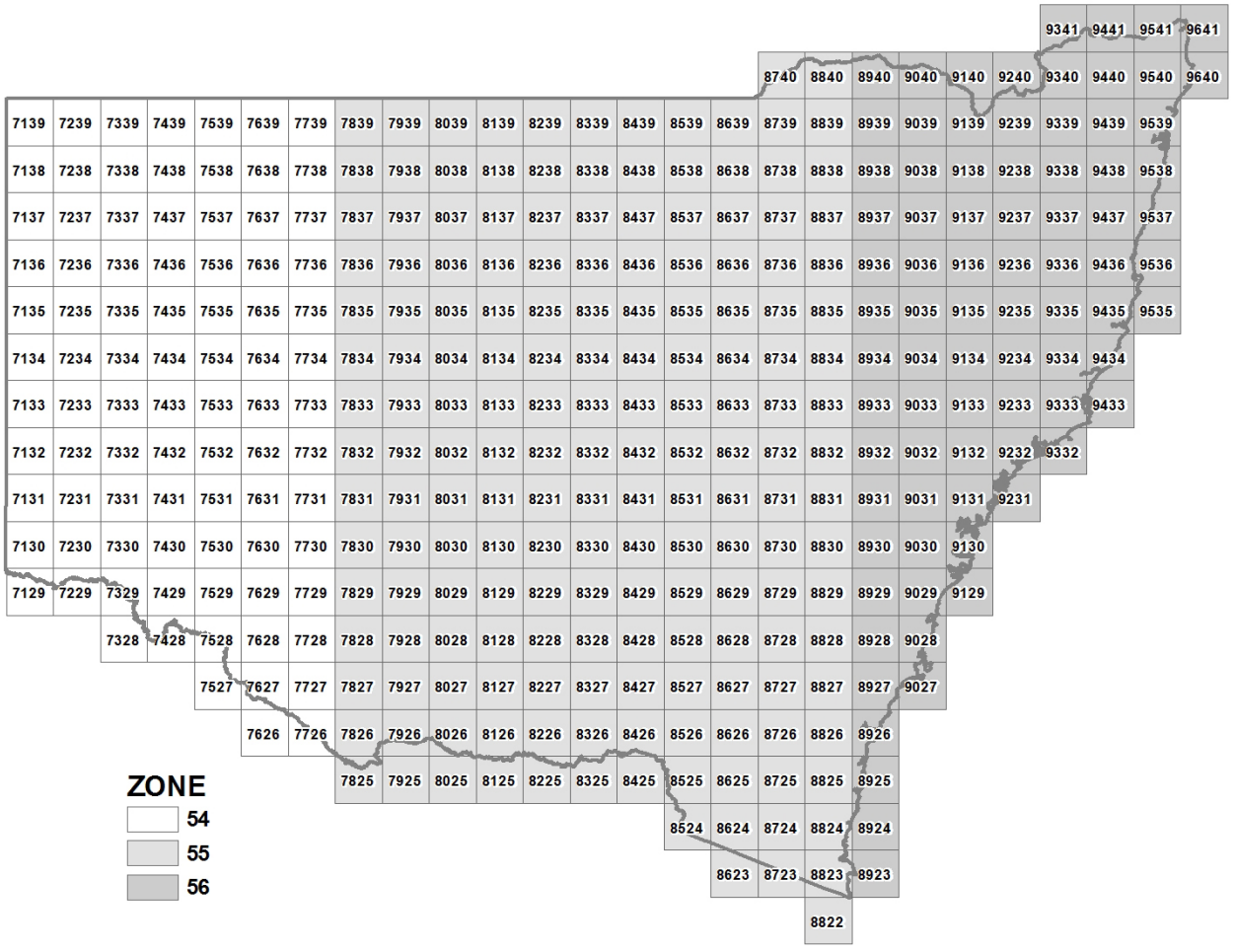

Figure 1: Map showing UTM zones in NSW and corresponding 1:100,000 map sheet numbers

4.6.3 MGA Easting

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

4.6.4 MGA Northing

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

4.6.5 MGA/UTM to GDA

This control allows you to translate coordinates entered in MGA/UTM into Latitude/Longitude coordinates in GDA. This will also enable eDIRT to display your location on its inbuilt map (online access required).

4.6.6 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^o at the equator to 90^o at the north or south poles. Latitudes in NSW range from approximately 24^o S (-24^o) to 38^o S (-38^o). Latitude should be entered in decimal degrees (DD).

4.6.7 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^o at the Prime Meridian to 180^o W (-180^o) and 180^o E (180^o). Longitudes in NSW range from approximately 141^o E (141^o) to 154^o E (154^o). Longitude should be entered in decimal degrees (DD).

4.6.8 My location

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

- Atmospheric effects;
- Sky blockage (e.g., trees, buildings, hills);
- Quality of the GPS receiver;
- The range of satellite navigation systems the GPS can access; and
- 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 several hundred metres. A device that can access only 1 satellite navigation system (e.g., GPS) will be less accurate than one that can access 2 (e.g., GPS, GLONASS), and a device that can access 3 (e.g., GPS, GLONASS, BeiDou) can provide levels of locational accuracy close to those of a dedicated handheld GPS receiver.

You may also wish to return to the **Location** tab once you have completed your profile description and requery the GPS using the **My Location** button, as the GPS may have acquired more satellites, readings may have stabilised and the coordinate accuracy may be improved.

4.7 Site details

4.7.1 Photo taken

This attribute allows the surveyor to record whether at least one photograph of the **profile**, **site** or both were taken. Any notes about the photographs taken may be recorded in the **Images** tab, where images you take can be associated with each **profile**.

4.7.2 Site type (BSAL)

This field allows the type of site being described to be recorded, using the three 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** - Check sites are assessed 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 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** - Detailed sites are soil profile inspection 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** - These are observation sites used only within areas that fail the obvious landscape requirements of the BSAL classification, e.g., rock outcrop, surface rockiness or gilgai microrelief. Neither detailed soil profile description nor soil survey is necessary

4.7.3 Potential BSAL

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 - i.e., 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).

4.7.4 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 - e.g., 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 - e.g., 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 **Site field 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 **Site field 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 Site Field 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 **Site field 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 **Site field 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 other 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 **Site field 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 (e.g., its size) should be recorded in the **Site field 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**Site field 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.

4.7.5 Type Profile

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

4.7.6 Nature of exposure

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

4.7.7 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.

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; 2-page Soil Data Card

Level	No. of Variables	Time taken	Type of data	Nature of description	Interpretation
B	50 – 200	20 - 60 mins	Profile description	Can be detailed but qualitative, static and semi-empirical	Specific statements on some limitations; 4-page Soil Data Card
C	80 – 400	2 - 20 days	Profile description and laboratory data	Detailed, quantitative and static but mechanistic	Specific statements of most forms of limitations; 8-page Soil Data Card
D	100 - 500	10 - 30 days	Direct measures of parameters controlling soil processes	Detailed, quantitative, dynamic and mechanistic	Dynamic and probabilistic prediction of processes controlling land use. Input for computer models; 8-page Soil Data Card plus Addenda

4.8 Soil and Map Codes

4.8.1 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 Site Field Notes.

4.8.2 Soil map code

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

4.8.3 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 http://www.environment.nsw.gov.au/soils/20120394lsc2spubslandingpage.htm.

Available values are:

- **1** - Very slight to negligible limitations. Land capable of sustaining high impact land uses (e.g. 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 (e.g. 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 (e.g. 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.

4.8.4 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.

4.8.5 Australian Soil Classification (2002 revision)

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 *Australian Soil Classification* (Isbell 2002). Under the ARMCANZ agreement the Australian Soil Classification (ASC) must be used as the primary soil classification for all work relating to the NSW or Federal Governments.

Sub order

As described in the Australian Soil Classification (Isbell, 2002).

Great group

As described in the *Australian Soil Classification* (Isbell, 2002).

Sub group

As described in the *Australian Soil Classification* (Isbell, 2002).

ASC family

As described in the *Australian Soil Classification* (Isbell, 2002).

Horizon thickness

As described in the *Australian Soil Classification* (Isbell, 2002).

Gravel content

As described in the *Australian Soil Classification* (Isbell, 2002).

Max texture A

As described in the *Australian Soil Classification* (Isbell, 2002).

Max texture B

As described in the *Australian Soil Classification* (Isbell, 2002).

Clay content A

As described in the *Australian Soil Classification* (Isbell, 2002).

Clay content B

As described in the *Australian Soil Classification* (Isbell, 2002).

Soil depth

As described in the *Australian Soil Classification* (Isbell, 2002).

Thickness of organic materials

As described in the *Australian Soil Classification* (Isbell, 2002).

Uppermost organic material

As described in the *Australian Soil Classification* (Isbell, 2002).

Confidence level

As described in the *Australian Soil Classification* (Isbell, 2002).

Final ASC

As described in the *Australian Soil Classification* (Isbell, 2002).

4.8.6 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)

4.8.7 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).

Sub division

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).

4.8.8 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).

4.9 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.

4.9.1 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.

4.9.2 Slope measurement method

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

4.9.3 Slope measurement method (BSAL)

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

Available values are:

- **inclinometer** - A basic hand-held 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 hand-held 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.

4.9.4 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.

4.9.5 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 ' - ' before the numeric value.

4.9.6 Aspect

Refers to the direction that the slope faces and should be recorded in the field using one of the eight 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.

4.9.7 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 - e.g., footslopes.

- **Alluvial** - Unconsolidated surface material deposited mainly by running water - e.g., streams or rivers.
- **Littoral** - Surface material is comprised of unconsolidated sediments deposited by tidal water.
- **Lacustrine** - Unconsolidated surface material deposited mainly in standing water - e.g., 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.

4.9.8 Site morphology

Site morphology is the morphological type that best describes the landform element. The morphological types are illustrated in ***Figure 2*** and defined below.

Available values are:

- **Flat** - Is neither a crest nor a depression and is level or very gently inclined (less than 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, two 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.

4.9.9 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 - i.e., 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 - i.e., the slope is planar, so that any runoff flows downslope in the same direction.

- **Convergent** - The cross-section of the slope is concave - i.e., the cross-section curves downwards towards its centre, so that any runoff converges from the extremities towards the centre.

4.9.10 Slope morphology

Refers to the slope inclination relative to adjacent landform elements (see ***Figure 2***). 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, element downslope is steeper.
- **Waning** - Element upslope is steeper, element downslope is gentler.
- **Maximal** - Element upslope is gentler, element downslope is gentler.
- **Minimal** - Element upslope is steeper, element downslope is steeper.

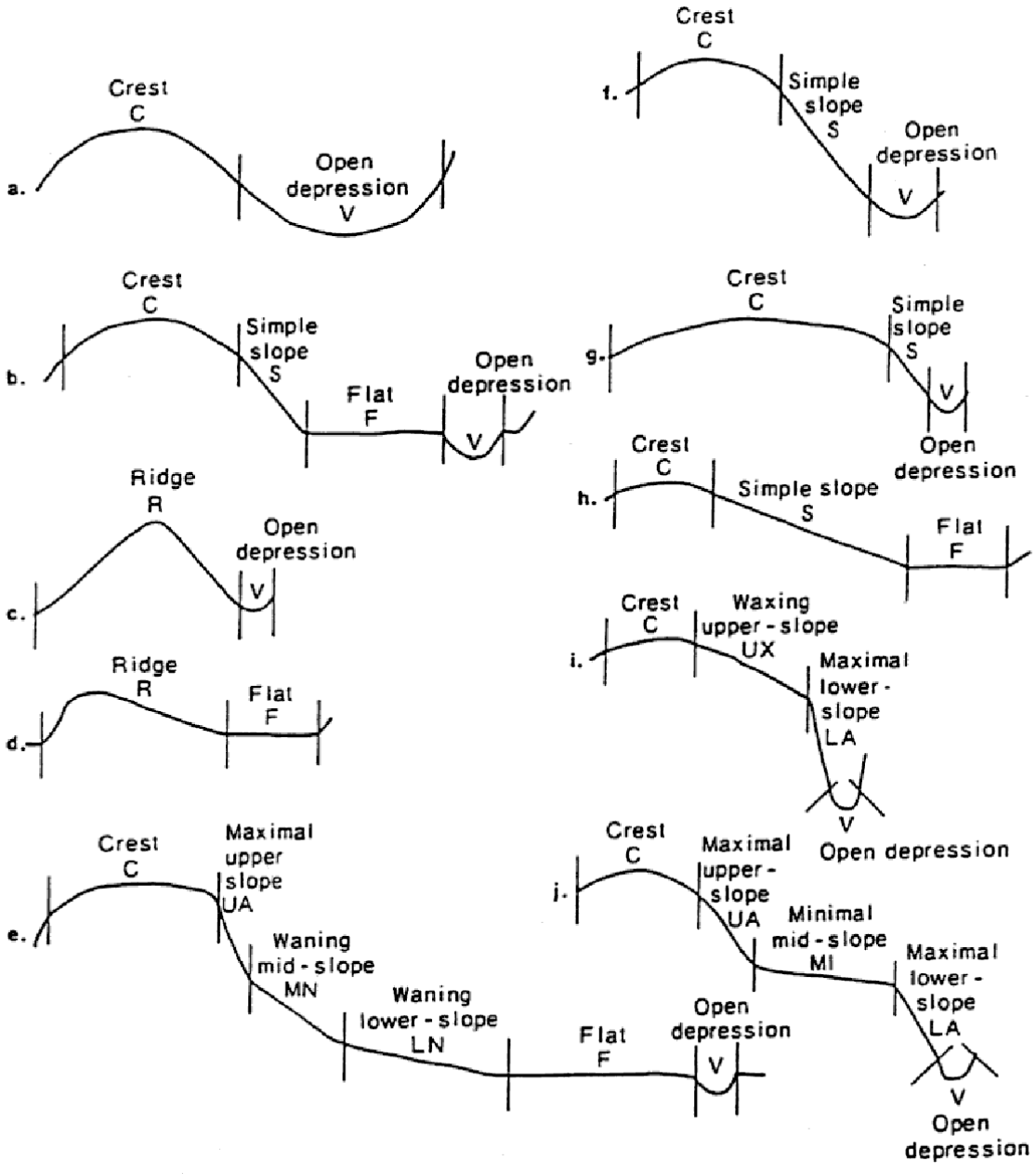

Figure 2: Morphological types of landform element (after NCST 2009)

4.9.11 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 assist when assigning a value.

Local Relief	Slope percentage						
	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

4.9.12 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 up slope area may give rise

to an erosional stream bed between scarps. Typical elements are stream bed, bar and plain. Also includes scarp (cf. sheet-flood fan and 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) (cf. alluvial plain and 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 (cf. mountains, hills, low hills, rises and plain).
- **Bar plain** - A 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) (cf. 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 (cf. 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 cone. 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 (cf. 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 (cf. alluvial plain and 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. (cf. alluvial plain, floodplain and 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 and 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 (cf. 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 (cf. mountains, low hills, rises and 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 being 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 and 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 (cf. 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 (cf. 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 are 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 (cf. alluvial plain and floodplain).
- **Meteor crater** - Extremely rare; comprising a circular closed depression (cf. 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 (cf. hills, low hills, rises and 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 (cf. sheet-flood fan and 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 (cf. mountains, hills, low hills and 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 (cf. alluvial fan and 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 (cf. floodplain and 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.

4.9.13 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 72o slope gradient), usually eroded by gravitational fall as a result of erosion of the base by various agencies; sometimes built up by marine organisms (cf. 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 (cf. cliff).
- **Cone** - A 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 extra-terrestrial 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 (cf. 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 two sides of a stream channel at the level reached by frequent floods; part of a covered plain (cf. 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 (cf. 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** - Sheet of any loose, fragmental material, lying on or mantling a slope. (Note: 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.

4.9.14 Position in landform element

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

4.9.15 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 less than 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 less than 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 less than 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 greater than 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 greater than 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.
- **Debil debil** - Small hummocks rising above a flat surface. Vary from rounded, both horizontally and vertically, to flat-topped, elongate and relatively steep-sided. Usually closely and regularly spaced, ranging between 0.06 - 0.6 m in both vertical and horizontal dimensions. Common in northern Australia on soils with impeded internal drainage and in areas of short seasonal ponding. May be formed by biological activity.
- **Swamp hummock** - Steep-sided hummocks rising above a flat surface. Hummocks are frequently occupied by trees or shrubs while the lower surface may be free of vegetation or occupied by sedges or reeds. They are subject to prolonged seasonal flooding.
- **Contour gilgai** - Long elongated depressions and adjacent parallel downslope mounds that follow slope contours. These depression-mound associations are separated from each

other by shelves 10 - 100 m wide. Depressions are <0.5 m deep and 30 - 50 m wide. Mounds are low, usually <0.5 m high, and often poorly defined.

- **Mound/depression** - Undifferentiated, irregularly distributed or isolated mounds and/or depressions set in a flat surface.
- **Karst** - Depressions in limestone country.
- **Sinkhole** - Closed depression with vertical or funnel-shaped sides.
- **Mass movement** - Hummocky microrelief on the surface of landslides, slumps, earth flows and debris avalanches.
- **Contour trench** - Trenches typically 0.2 m deep and 0.6 m wide, with near-vertical walls, alternating with flat-crested ridges about 1.3 m wide, which extend along the contour for several metres or tens of metres. Known in areas of south-eastern Australia over 350 m altitude with a high effective rainfall, where they are associated with a grassland or heathland vegetation on undulating rises.
- **Spring mound** - Mound associated with water flowing from rock or soil without human intervention.
- **Spring hollow** - Depression associated with water flowing from rock or soil without human intervention.

4.9.16 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 less than or equal to 500 mm deep beneath the prevailing land surface at their deepest point.
- **>500 mm depth** - The gilgai microrelief features observed at the site are greater than 500 mm deep beneath the prevailing land surface at their deepest point.

4.9.17 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 less than or equal to 50% of the land surface.
- **>50% area** - The gilgai microrelief features observed at the site cover more than 50% of the land surface.

4.9.18 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 insitu 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 coast lines 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.

4.10 Land use

4.10.1 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 - e.g., *Eucalyptus* spp.
- **Softwood plantation** - Land where the vegetation has been cleared and replaced with a plantation of softwood species - e.g., *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 - e.g., 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.

4.10.2 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**.

4.10.3 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.

4.10.4 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**

4.11 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 – eg; sedimentary division – and record other, then record in the text field provided.

4.11.1 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; or,
- the solum layers may have formed from depositional material such as alluvium or windblown sand.

Available values are:

- **Not identified**.
- **Unconsolidated** - A range of materials, usually forming surface layers or deposits and not compacted or cemented into rock.
- **Gravel** - Loose detrital material composed mainly of small pebbles or rock fragments, >2 mm and <60 mm; may be mixed with other unconsolidated material.
- **Sand** - Material with the particle size range of 2 mm to 0.02 mm; commonly quartz grains.
- **Silt** - Material within the particle size range of 0.02 mm to 0.002 mm. Non-plastic when moist and not deposited by floods (see Alluvium).
- **Clay** - Fine-grained material, <0.002 mm; composed normally of hydrated aluminium silicate minerals and plastic when moist.
- **Organic material** - A deposit composed of plant remains at various stages of decomposition.
- **Alluvium** - Unconsolidated detrital material transported by water.
- **Colluvium** - Heterogeneous rock and soil detritus transported by downslope processes.
- **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.
- **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.
- **Marine** - Sediment that has been transported and deposited by marine processes; includes beach sands and the fine sand, silt and mud of tidal flats.
- **Calcareous sand** - Material with the particle size range of 2 mm to 0.02 mm containing up to 50% calcium carbonate.
- **Fill** - Man-made deposits of rock, soil, tailings, etc.
- **Mud** - Mixture of water with silt or clay-sized particles.
- **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.
- **Sedimentary** - Rocks resulting from the consolidation of sediment, including organic accumulations and chemical precipitates; distinguished from loose sediments by the degree of lithification.
- **Shale** - Fine-grained detrital sedimentary rock which is laminated and easily split into layers.
- **Siltstone/mudstone** - Fine-grained detrital sedimentary rock composed mainly of silt or clay respectively and is not easily split into layers.
- **Sandstone-quartz** - Detrital sedimentary rock with predominantly sand-sized quartz particles cemented by silica or carbonates with little fine-grained matrix material.
- **Sandstone-lithic** - Detrital sedimentary rock with predominantly sand-sized particles including rock fragments, quartz and feldspar set in a fine-grained matrix.
- **Conglomerate** - Detrital sedimentary rock substantially composed of rounded particles which are larger than 2 mm in diameter.

- **Limestone** - Non-clastic sedimentary rock consisting essentially of the carbonate minerals calcite and dolomite; may be organic, detrital or chemically precipitated.
- **Tuff** - Consolidated volcanic ash; water-laid tuffs generally show excellent bedding and may appear similar to shales or sandstones; pyroclastic fragments are less than 20 mm in diameter.
- **Breccia** - Coarse-grained clastic rock of angular, broken rock fragments in a fine-grained matrix or held together with mineral cement.
- **Greywacke** - Dark grey firmly indurated sandstone with poorly sorted quartz and feldspar with dark rock and mineral fragments in a clayey matrix.
- **Arkose** - Coarse-grained sandstone, typically pink or red, of quartz and at least 25% feldspar in clay and iron oxide matrix.
- **Dolomite** - Sedimentary rock containing >90% dolomite and <10% calcite; often associated and interbedded with limestone.
- **Calcrete** - Calcareous duricrust; a conglomerate of sand and gravel cemented by calcium carbonate into a hard mass.
- **Aeolianite** - (Eolianite); a consolidated sedimentary rock consisting of clastic material deposited by the wind.
- **Chert** - A hard dense sedimentary rock of interlocking quartz crystals, often white or coloured; also called flint.
- **Jasper** - Red chert, usually associated with iron ores.
- **Metamorphic** - Rocks that have been changed in their mineralogical, textural or small scale structural compositions by the action of heat and/or pressure.
- **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.
- **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.
- **Slate** - Fine-grained regionally metamorphosed argillaceous rock which has a well-developed cleavage and splits readily into thin plates.
- **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.
- **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.
- **Greenstone** - Any compact dark green metamorphosed basic igneous rock.
- **Amphibolite** - Crystalloblastic rock consisting mainly of amphibole and plagioclase with little or no quartz.
- **Marble** - Limestone which has been recrystallised by heat and pressure during metamorphic processes.
- **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.

- **Coarse-acidic** - Igneous rock type with more than 20% free quartz and containing the feldspars orthoclase and/or plagioclase; grain size is normally greater than 5 mm, but may include medium-grained rocks with grain sizes greater than 3 mm; includes granite and adamellite.
- **Coarse-intermediate** - Feldspathic igneous rock type with less than 10% free quartz and up to 50% ferromagnesian minerals; grain size is greater than 3 mm; includes granodiorite, diorite, monzonite and syenite.
- **Coarse-basic** - Quartz-free igneous rock type containing more than 50% ferromagnesian minerals; calcic-plagioclase is the dominant feldspar; common ferromagnesian minerals are olivine and pyroxene; grain size is greater than 3 mm; includes gabbro.
- **Fine-acidic** - Igneous rock type with an excess of 20% free quartz, less than 20% ferromagnesian minerals and containing the feldspars orthoclase and plagioclase; grain size is normally less than 1 mm but may include medium-grained rocks with grain sizes up to 3 mm and the acid porphyries; includes rhyolite, quartz porphyry and quartz-orthoclase porphyry.
- **Fine-intermediate** - Feldspathic igneous rock with less than 10% free quartz and up to 50% ferromagnesian minerals; grain size is less than 3 mm; includes trachyte, trachyandesite and andesite.
- **Fine-basic** - Quartz-free igneous rock type containing more than 50% ferromagnesian minerals; calcic-plagioclase is the dominant feldspar; grain size is less than 3 mm; includes basalt, latite and dolerite.
- **Serpentinite** - Rock consisting almost wholly of serpentine-group minerals; includes antigorite, chrysotile.
- **Gabbro** - A group of dark coloured basic intrusive igneous rocks; it is the approximate intrusive equivalent of basalt.
- **Dolerite** - Intrusive igneous rock with lath-shaped plagioclase crystals included in pyroxene crystals; also called diabase.
- **Diorite** - Group of intrusive intermediate igneous rocks; intrusive equivalent of andesite.
- **Syenite** - Coarse-intermediate plutonic igneous rock; the intrusive equivalent of trachyte; usually contains orthoclase, microdine or perthite, a small amount of plagioclase, hornblende and other mafic minerals but little or no quartz.
- **Granodiorite** - Coarse-intermediate intrusive igneous rock; the intrusive equivalent of rhyodacite; contains quartz, oligoclase or andesine, potassium feldspar and mafic minerals.
- **Adamellite** - Coarse-acidic igneous rock.
- **Granite** - Coarse-acidic plutonic igneous rock.
- **Aplite** - Light coloured, intrusive, acidic igneous rock characterised by fine-grained texture.
- **Quartz porphyry** - Extrusive or intrusive rock containing larger crystals of quartz and alkali feldspar set in a finer groundmass.
- **Basalt** - Dark to medium dark coloured fine-grained extrusive mafic basic igneous rock.
- **Andesite** - Dark coloured fine-grained intermediate extrusive rock.
- **Trachyte** - Fine-grained porphrytic intermediate extrusive rock; main components are alkali feldspar and minor mafic minerals.
- **Rhyolite** - Fine-grained porphrytic acidic extrusive igneous rock; exhibits flow texture; consists of quartz and feldspar in a glassy to cryptocrystalline groundmass.
- **Obsidian** - Black or dark coloured volcanic glass.
- **Scoria** - Vesicular cindery crust on the surface of andesitic or basaltic lava; usually heavier, darker and more crystalline than pumice.

- **Ash -** Fine (usually <4.0 mm) pyroclastic material; usually unconsolidated.
- **Agglomerate** - Chaotic assemblage of coarse angular pyroclastic material.
- **Other** - When values listed are inadequate to describe Lithology, this may be used in conjunction with either unconsolidated, sedimentary, metamorphic or igneous and Site field notes.

4.11.2 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**.

4.11.3 Identification method

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

4.11.4 Rock outcrop

Rock in this context refers specifically to outcrop of the in situ rock material - i.e., 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**.

4.11.5 Rock outcrop (BSAL)

Rock in this context refers specifically to outcrop of the in situ rock material - i.e., 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).

4.11.6 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.

4.11.7 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.

4.11.8 Substrate material

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

4.11.9 Substrate strength

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

Available values are:

- **weak** - (<50 MPa). Knife easily cuts or scratches; pick blow crumbles or indents deeply; hammer blow shatters rock to many small fragments or powder.
- **moderate** - (50 - 100 MPa). Knife makes slight or no mark; pick blow indents shallowly; hammer blow breaks rock readily into a few large and some small fragments.
- **strong** - (>100 MPa). 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.

4.11.10 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**.

4.11.11 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.

4.12 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.

4.12.1 Site disturbance

Describe any land use activities that may have affected soil properties. More detail is provided under the entity **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.
- **Rainfed 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.

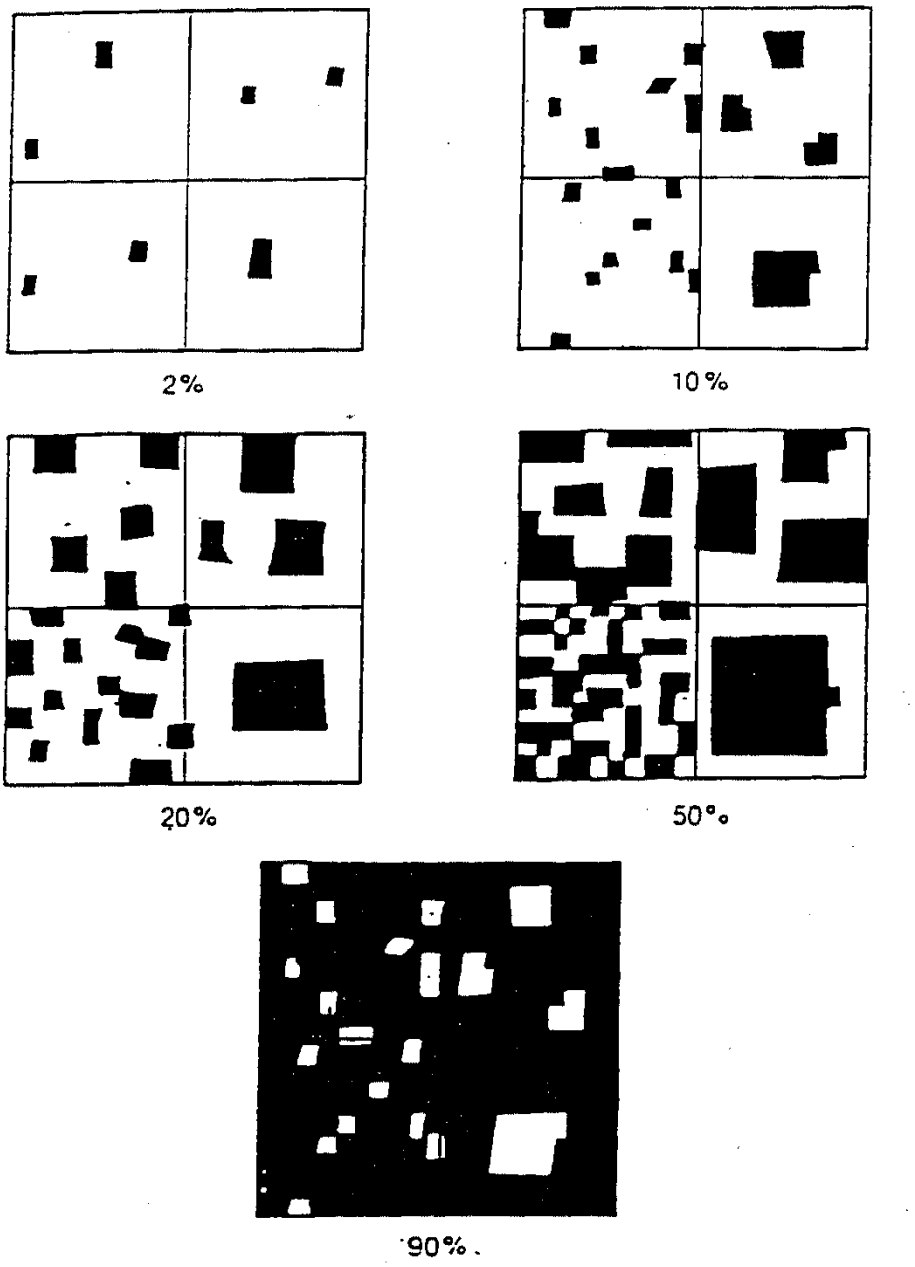

Figure 3: Chart for visually estimating percentage of abundance of an attribute

4.12.2 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 3*** (previous page) may be used in the visual estimation of ground cover percentage.

4.12.3 Current condition

Describe the current condition of the surface soil.

Available values are:

- **Gravelly** - The amount of surface gravel (particles from 2 mm to 60 mm in diameter) is in excess of 60% of ground cover percentage.
- **Cracked** - Cracks equal to or wider than 6 mm penetrate to 0.3 m or more 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 less than 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 Site field notes.
- **Other** - Record the type of condition, e.g., cryptogam, in the adjacent note field.

4.12.4 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 equal to or wider than 6 mm penetrate to 0.3 m or more 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 less than 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, e.g., cryptogam, in the text box provided when 'other' is selected.

4.12.5 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 equal to or wider than 6 mm penetrate to 0.3 m or more 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 less than 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 **Site field notes.**
- **Other** - Record the type of condition, e.g., cryptogam, in the adjacent note field.

4.12.6 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.

4.12.7 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**

4.12.8 Cryptogam mat occurence

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**

4.12.9 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**

4.12.10 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 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.

4.12.11 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 to 2, with 0 being the worst score and 2 being the best score. A soil with an overall score greater than 1.5 has relatively good structure while a soil with a score of less than 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 http://www.dpi.nsw.gov.au/agriculture/resources/soils/guides.

4.12.12 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 - e.g., at varying stocking rates, or disturbance during highway construction. These terms of reference should be defined in the **site field 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.

4.12.13 Wind exposure

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

Available values are:

- **Low exposure**
- **Moderate exposure**
- **High exposure**

4.12.14 Revised Universal Soil Loss Equation (RUSLE)

Details given here about the Universal Soil Loss Equation (USLE) are taken from SOILOSS - A program to assist in the selection of management practises to reduce erosion (Rosewell 1993). Originally developed in the USA, the USLE is designed to predict the long term average annual soil loss in runoff from specified land units in specified cropping and management systems. Basic information about the various USLE factors is given below; for more detailed information about components of the USLE see Rosewell (1993).

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 by multiplying all the above factors. eDIRT calculates this automatically.

4.12.15 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—e.g., 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 up to 0.3 m deep. It typically occurs on recently cultivated or disturbed soil. Sheet erosion grades into rill erosion or, where 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 (deeper than 0.3 m) 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** - Less than 5% of the site is scalded.
- **moderate** - 5 - 50% of the site is scalded.
- **severe** - More than 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 – e.g., mud slides, landslides – or as a slow incipient process – e.g., creep. **Severity** values for this **type** are as follows:

- **none** - No appreciable form of mass movement erosion.
- **evident** - Mass movement erosion is observed.

4.13 Hydrology

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

4.13.1 Presence of free water

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

4.13.2 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.

4.13.3 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.

4.13.4 Free water electrical conductivity

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

4.13.5 Site exposure

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

4.13.6 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 - e.g., crests.
- **Low** - Small volumes of overland flow occur - e.g., upper slopes and spurs.
- **Moderate** - Significant overland flow occurs - e.g., some midslopes and some lower slopes.
- **High** - Areas where concentrated overland flow occurs - e.g., some lower slopes and drainage depressions.
- **Very high** - Large volumes of water enter the site by channelised flow - e.g., gullies and major drainage lines.

4.13.7 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.

4.13.8 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 atrributes 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.

4.13.9 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, Ksat) 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 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 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.

4.13.10 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**

4.14 Salinity

4.14.1 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 **AgNO3** 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.
- **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.

4.14.2 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 watertable. 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 store of salt** - 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.
- **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 up to 1 m^2 in size occupying up to 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.
- **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 up to 1 m^2 in size and occupying up to 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.
- **Dryland salinity outbreak affected by severe to extreme rates of rill and sheet erosion** - Site affected by high, saline groundwater. 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.

- **Minor gully erosion: salt discharges within gully floor or from banks of gully** - Minor gully erosion is classified as isolated, discontinuous linear gullies, confined to primary or minor drainage lines.
- **Moderate gully erosion: salt discharges within gully floor or from banks of gully** - Moderate gully erosion is classified as continuous linear gullies, confined to primary or minor drainage lines.
- **Severe gully erosion: salt discharges within gully floor or from banks of gully** - Severe gully erosion is classified as discontinuous or continuous gullies, branching into minor drainage lines or multiple branching within primary drainage lines.
- **Extreme gully erosion: salt discharges within gully floor or from banks of gully** - Extreme gully erosion is classified as discontinuous or continuous multiple branching gullies or sub-parallel gullies in dispersible soils.
- **Early phase of salinity development caused by irrigation practices with salt-tolerant plant species present** - 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) or Trifolium fragiferum (strawberry clover). Salt sensitive vegetation species are entirely absent or restricted to slightly raised areas within the overall site. No more than 5% of the total area of the site is bare of vegetation.
- **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 up to 1 m^2 in size and occupying up to 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.
- **Salinity site caused by irrigation practices and associated with severe to extreme rates of rill and sheet erosion** - Site 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.
- **Soil salinity due to marine influences** - Includes areas of mangroves, brackish coastal swamps.

4.14.3 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.

4.14.4 Electromagnetic measurement

Measurement type

Allows the user to record a electromagnetic induction measurement at the site. This field allows the surveyor to record the identifying number of the 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 (i.e., 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 (i.e., with the flat sides of the instrument facing horizontally).

4.15 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.

4.15.1 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** - Canopy 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.

4.15.2 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 more than 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 five trunks of which at least three exceed 100 mm in diameter at breast height; usually 8 m or more tall.
- **Shrub** - Woody plant, multi-stemmed at the base (or within 200 mm from ground level) or, if single stemmed, less than 2 m tall.
- **Mallee shrub** - Commonly less than 8 m tall, usually with five or more trunks, of which at least three of the largest trunks do not exceed 100 mm in diameter at breast height.
- **Heath shrub** - Shrub, usually less than 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.

4.15.3 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.

4.15.4 Upper stratum height

Describe the mean upper stratum height in metres.

4.15.5 Vegetation species

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. Whilst 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 – e.g., 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** - Two 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.

5. Layer Attributes

5.1 Layer summary

A summary table containing the fields **Upper depth, Lower depth, Texture, Horizon, Pedality and Field pH** for each layer using the information that has been entered.

5.2 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 the surveyor may make a subjective decision to 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, e.g., 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 completion of the "top of substrate" value.

5.3 Status

Soils can be viewed as being comprised of **layers**, each of which may have morphological characteristics different from those which occur below and/or above it. Each **layer** is generally parallel to the land surface, although this may not be true for the **layer boundary**. **Layers** may be identified as **horizons**, but they are not necessarily equivalent. **Layers** may also be described based on arbitrarily defined levels.

5.3.1 Horizon code

Each layer can be allocated a particular 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 - e.g., A - or a more detailed classification - e.g., A1 or A2 - depending upon the characteristics evident. Where a broad horizon - e.g., B2 - has been subdivided into narrower layers - e.g., B21, B22, and B23 - these are numbered downwards from the surface.

A prefix numeral (e.g., 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 to 5 may be used with any horizon code.

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, e.g., 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 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.
- **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 or A13.
- **A11** - Darker, uppermost section of A1.
- **A12** - Usually lighter 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, and A23.
- **A3** - Transitional horizon(s) from A to B but with properties more like A. Further division is possible into A31, A32, A33.
- **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 and B13.
- **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 and B23.
- **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 and B33.
- **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, e.g., sedimentary laminae, ‘ghost’ rock structures such as saprolite.
- **C1** - Can be further subdivided into C11, C12 and C13.
- **C2** - Can be further subdivided into C21, C22 and C23.
- **C3** - Can be further subdivided into C31, C32 and C33.
- **AB** - Transition from A to B but not dominated by properties characteristic of either horizon.
- **AB1** - Can be further subdivided into AB11, AB12 and AB13.
- **AB2** - Can be further subdivided into AB21, AB22 and AB23.
- **AB3** - Can be further subdivided into AB31, AB32 and AB33.
- **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 and AC13.
- **AC2** - Can be further subdivided into AC21, AC22 and AC23.
- **AC3** - Can be further subdivided into AC31, AC32 and AC33.
- **BC** - Transition from B to C but not dominated by properties characteristic of either horizon.
- **BC1** - Can be further subdivided into BC11, BC12 and BC13.
- **BC2** - Can be further subdivided into BC21, BC22 and BC23.
- **BC3** - Can be further subdivided into BC31, BC32 and BC33.

- **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 and D13.
- **D2** - Can be further subdivided into D21, D22 and D23.
- **D3** - Can be further subdivided into D31, D32 and D33.
- **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 and F13.
- **F2** - Can be further subdivided into F21, F22 and F23.
- **F3** - Can be further subdivided into F31, F32 and F33.
- **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.

5.3.2 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:

- **b** - Buried soil horizon; used in mineral soils only. See references to buried soil layers above.
- **c** - Accumulation of concretions or nodules of iron and/or aluminium and/or manganese.
- **d** - Densipan; very fine sandy earthy pan.
- **e** - Conspicuously bleached; 80% or more 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.
- **f** - Faunal accumulation such as worm casts dominating certain A1 horizons.
- **g** - Strong gleying; 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.
- **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.
- **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.
- **k** - Accumulation of carbonates, commonly calcium carbonate.
- **m** - Strong cementation or induration; confined to irreversibly cemented horizons which are essentially continuous (more than 90%) though they may be broken.

- **n** - Accumulation of manganiferous or ferromanganiferous concretions, strong nodules or mangans.
- **p** - Ploughing, tillage practices or other human disturbance - e.g., 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 - e.g., Ap1, Ap2. Note: an Ap2 horizon is not the same as an A2 horizon but a subdivision equivalent to A12.
- **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.
- **r** - Layers of weathered rock (including saprolite) that, although consolidated, can be dug with hand tools.
- **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.
- **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.
- **w** - Development of colour and/or structure in B horizon with little or no accumulation of clay.
- **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.
- **y** - Accumulation of calcium sulphate (gypsum).
- **z** - Accumulation of salts more soluble than calcium sulphate and calcium carbonate.
- **?** - Query; used where doubt is associated with the nomenclature of the horizon; details should be recorded in text box provided when 'other' is selected.

5.3.3 Soil material code

A code may be recorded by the soil surveyor - e.g., for use in soil survey reports and for analysis of soil attributes. Up to four printable characters may be used, in any combination of letters, both upper and lower case, and numerals.

5.3.4 Impeding

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

5.3.5 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. 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.
- **Micro-morphological** - 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 - e.g., using bulk density rings.

5.3.6 Dent's classification for Acid Sulface 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 - e.g., the second (deeper) occurrence of a GBj horizon in a **profile** would be classified as 2GBj, whilst 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** – e.g., the second (deeper) occurrence of a GBj horizon in a **profile** would be classified as 2GBj, whilst the third would be classified as 3GBj.

5.4 Boundary

5.4.1 Distinctiveness

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

5.4.2 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.

5.5 Colour

5.5.1 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 to 2 units of value and an increase in chroma of 1.5 to 2 units.

A reference list of values will be found by using Munsell Soil Colour Charts (Munsell Colour 2009). More information can be found at http://www.munsell.com.

5.5.2 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. A reference list of values will be found by using Munsell Soil Colour Charts (Munsell Colour 2009). More information can be found at http://www.munsell.com.

5.5.3 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.

5.5.4 Modifier with General colour or Isbell 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.

5.5.5 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.

5.6 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 at least 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 entered in the database. The mottle type must be filled in if related **attributes** are to be described.

5.6.1 Mottle type

Mottle Type describes the general nature or likely cause of the colour patterns for each mottle dominance in each layer.

Available values are:

- **Not evident** - No mottles observed in layer.
- **Unspecified** - Mottles observed but type not identified.
- **Biological** - Colour patterns due to biological mixing of soil material from other horizons - e.g., earthworm casts.
- **Mechanical** - Colour patterns due to mechanical mixing of soil material from other horizons - e.g., 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 - e.g., fluctuating watertable.

5.6.2 Mottle abundance

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

5.6.3 Munsell colour

Mottle colour may be measured using the Munsell Soil Colour Charts (Munsell Colour 2009). More information can be found at http://www.munsell.com. In this system, colour is defined with respect to three 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.

5.6.4 Mottle general colour

Alternate to or in conjunction with Munsell Notation, values from colour can be recorded to describe the colour of the mottle. Record only one value under each dominance heading.

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.

5.6.5 Mottle general colour modifier

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

5.6.6 Mottle contrast

Describe the contrast of the boundary between the mottle and the remainder of the soil. Record only one value under each dominance heading for each layer.

Available values are:

- **Faint** - Indistinct; evident only on close examination.
- **Distinct** - Readily evident although not striking.
- **Prominent** - Striking and conspicuous.

5.7 Field texture

Field texture is determined on soil material that is finer than 2 mm diameter, i.e., 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 note the need to continue past this point for possible texture modifiers. 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**.

5.7.1 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 commonly <5%.
- **Loamy sand** - Slight coherence; will form minimal ribbon of about 5 mm; approximately clay content about 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; approximately 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; approximately 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 of about 25 mm; approximately 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% or more.
- **Sandy clay loam** - Strongly coherent bolus, sandy to touch; sand grains visible in finer matrix; will form ribbon of 25 - 40 mm; approximately clay content 20 - 30%.
- **Clay loam** - Coherent plastic bolus; smooth to manipulate; will form ribbon of 40 - 50 mm; approximately clay content 30 - 35%.
- **Clay loam sandy** - Coherent plastic bolus; sand grains visible in finer matrix; will form ribbon of 40 - 50 mm; approximately clay content 30 - 35%.
- **Silty clay loam** - Coherent smooth bolus; plastic and often silky to the touch; will form ribbon of 40 - 50 mm; approximately clay content 30 - 35% and with silt 25% or more.
- **Sandy clay** - Plastic bolus; sand grains can be seen, felt or heard in clayey matrix; will form ribbon of 50 - 75 mm; approximately clay content 35 - 40%.
- **Silty clay** - Plastic bolus; smooth and silky to manipulate; will form ribbon of 50 - 75 mm; approximately clay content 35 - 40%, with silt 25% or more.
- **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; approximately clay content 35 - 50% or more.
- **Fibric peat (fibrous peat)** - Undecomposed or weakly decomposed organic material. Plant fibres (other than living roots) are distinct, readily identifiable and make up more than 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 less than 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 approximately 1 - 2 mm in diameter and have granular or sub-angular blocky **structure**.

5.7.2 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.

5.7.3 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 particular 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 where considered 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 or more and has a clay content of 50% or more. Generally difficult to work at sticky point.

5.7.4 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 X10 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 X10 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.

5.8 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.

5.8.1 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, up to 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, more than 70% of the soil material consists of peds (NCST 2009).

5.8.2 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 X10 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. More than 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, more than 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.

5.8.3 Ped shape

Provision is made to describe both dominant and subdominant peds in terms of ped shape.

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** - Soil 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.
- **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 six 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 six 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 are more porous and usually less than 5 mm in 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 4 (next page) can be used to assist in selecting the most appropriate value.

5.8.4 Ped size

Provision is made to describe both dominant and subdominant peds in terms of ped size.

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**.

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. With platy and lenticular ped shape the minimum dimension is a vertical measurement of the ped.

5.8.5 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.

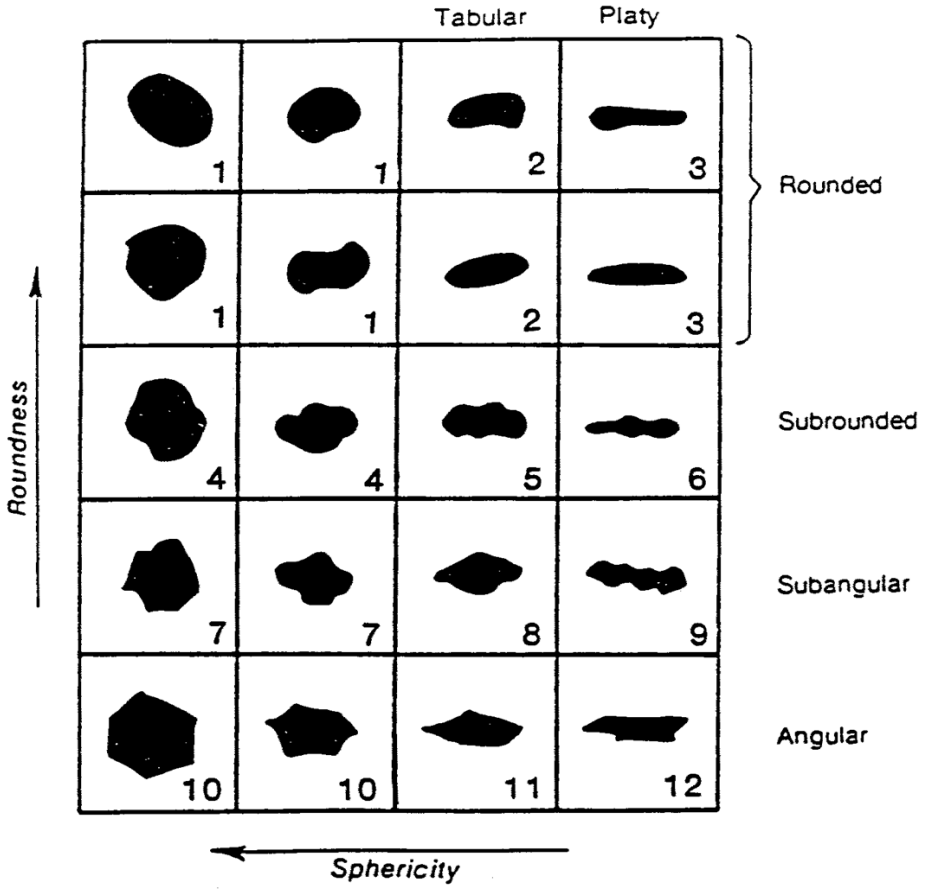

Figure 4: Ped shapes

Available values are:

- **Clods** - Artificial aggregates with a diameter of 100 mm or more comprise a greater proportion of the structure of the layer.
- **Fragments** - Artificial aggregates with a diameter of less than 100 mm comprise the greater proportion of the structure of the layer.

5.8.6 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**

5.8.7 Ped porosity

Describe the relative porosity of the soil aggregates.

Available values are:

- **Porous**
- **Dense**

5.9 Ped coating

Refers to coatings (cutans) resulting from the concentration of particular soil constituents of 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 **Layer field notes**.

5.9.1 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%)** - Up to 10% of the ped faces or pore linings are coated.
- **Common (10 - 50%)** - Between 10 and 50% of the ped faces or pore linings are coated.
- **Many (>50%)** - More than 50% of the ped faces or pore linings are coated.

5.9.2 Coating type

Observe possible coatings with a X10 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** - Coating composed of iron oxide, calcium carbonate, sodium carbonate or gypsum, that is not described by any VALUE. A description should be entered in the text box provided when 'other' is selected.

- **Unspecified** - Nature of coatings cannot be determined.

5.9.3 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. For each layer, record only one value.

Available values are:

- **Faint** - Coating is evident only on close examination with X10 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.

5.10 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.

5.10.1 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.

5.10.2 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.

5.10.3 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 **field textures**: 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 **field 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) 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) 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 two or more texture grades (becomes heavier) as it is worked. These soils have previously been termed strongly subplastic. Record the final texture grade.

5.10.4 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.

5.10.5 Stickiness

Determined on a wet (beyond ‘sticky point’, which equates to field capacity) bolus. 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.

5.10.6 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 about 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 looses 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 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.

5.11 Chemical Tests

5.11.1 pH method

A number of 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 two minutes, its colour is compared with a standard colour chart to determine the pH to the nearest half unit. NB: 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.

5.11.2 Field pH

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

5.11.3 Field EC measurement unit

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

5.11.4 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.

5.11.5 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.

5.11.6 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 (AgNO3). 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.

5.11.7 Hydrogen peroxide test

The presence of manganese dioxide can be tested by adding two or three drops of a 10% hydrogen peroxide 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**

5.12 Erodibility Tests

5.12.1 Crumb test [modification of EAT (Emerson, 1967)]

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 eight 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.

5.12.2 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 ballbearings 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.

5.12.3 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 more than 10 seconds.
- **Slow** - A noticeable reaction occurs within 5 - 10 seconds.
- **Rapid** - A very noticeable reaction occurs within a few seconds.

5.12.4 Soil erodibility class (Murphy, 1984)

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 - i.e., the aggregates break up into smaller aggregates or individual particles. Where these are less than about 2 mm, 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.

Available values are:

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 - e.g., silcrete, ortstein and laterite.	Cemented layers including iron, manganese and silicon pans - e.g., silcrete, ortstein and laterite.
	High coarse sand	High coarse sand
	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), e.g., 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, e.g., 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), e.g., black cracking clays (Ug5.1, Ug5.2 and Ug5.3 soils).	Stable non-dispersible loams and clay loams, e.g., 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), e.g., non-sodic, red, brown and yellow duplex soils (Dr, Db and Dy soils).
High	Low (1 - 2%) to very low (<1%) organic matter, e.g. soils with bleached A2 horizons. High to very high silt and fine sand (>65%).	Dispersible clays (Emerson Aggregate Classes 1 and 2), e.g., sodic, yellow and red soils, (Dy3.4, Dr3.4, Dr2.3 soils). Unstable, dispersible clayey sands and sandy clays, e.g., yellow and grey massive earths formed on sandstone and some granites (Gn2.3, Gn2.8, Gn2.9, Dy5.8 soils). Unstable materials high in silt and fine sand, e.g., unconsolidated sediments and alluvial materials.

5.12.5 Compressive strength

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

5.12.6 Shear strength

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

5.12.7 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/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/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.

5.12.8 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 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.

5.13 Coarse fragments

Coarse fragments refer to all particles larger than 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.

If no **coarse fragments** are present for a layer you can use the 'Not evident for layer' button. This will insert 'not evident' as the type and all other attributes will disappear and remain unpopulated for the specified layer. Note: If coarse fragment data has already been captured for this layer it will be over-riden and deleted with this operation.

If no coarse fragment are present for the entire profile you can use the 'Not evident for ALL layers' button. This will insert 'not evident' as the type and all other attributes will disappear and remain unpopulated for ALL layers in the profile. Note: If coarse fragment data has already been captured for layers within the profile it will be over-riden and deleted with this operation.

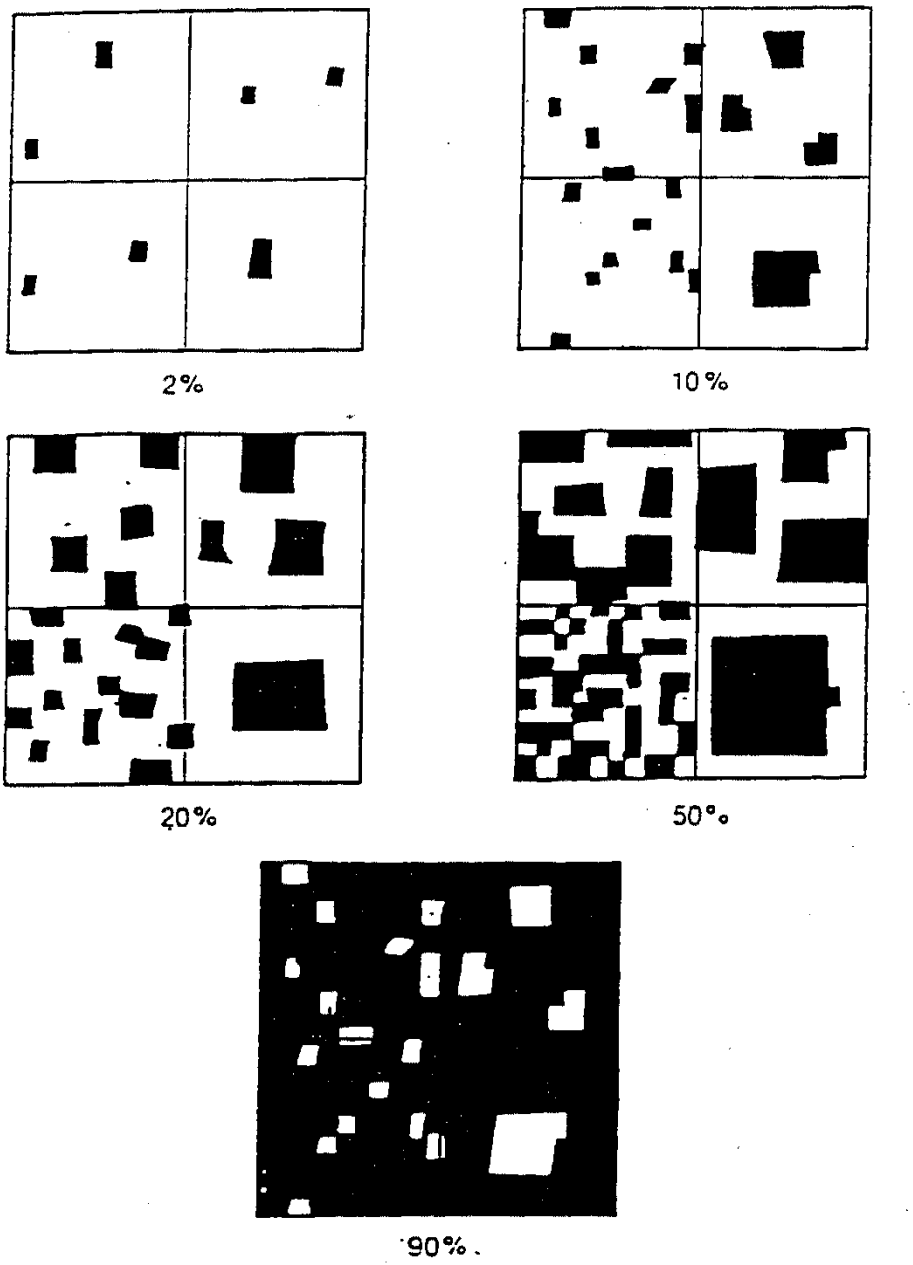

Figure 5: Chart for visually estimating percentage of abundance of an attribute

Describe the sources or types of **coarse fragments**. Provision is made to separately record the information related to each of the types by using the 'add coarse fragment type' button. Record the most important coarse fragment type first, i.e., type 1. All coarse fragment information added and saved is displayed in a summary table for comparison. If value of 'other' is selected as the 'Type' then please enter an appropriate description in the text field provided.

The amount expressed as a percentage is visually estimated using ***Figure 5*** (previous page) as a guide. A **coarse fragment type** must always have an **amount** given.

5.13.1 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.

5.13.2 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.

5.13.3 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.

5.13.4 Shape

Describe the shape of each type, using ***Figure 6*** (next page) as a visual guide.

5.13.5 Size

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

5.14 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. If no **Segregations** are present for a layer you can use the 'Not evident for layer' button. This will insert 'not evident' as the type and all other attributes will disappear and remain unpopulated for the specified layer. Note: If segregation data has already been captured for this layer it will be overridden and deleted with this operation. If no **Segregations** are present for the entire profile you can use the 'Not evident for ALL layers' button. This will insert 'not evident' as the type and all other attributes will disappear and remain unpopulated for ALL layers in the profile. Note: If segregation data has already been captured for layers within the profile it will be overridden and deleted with this operation.

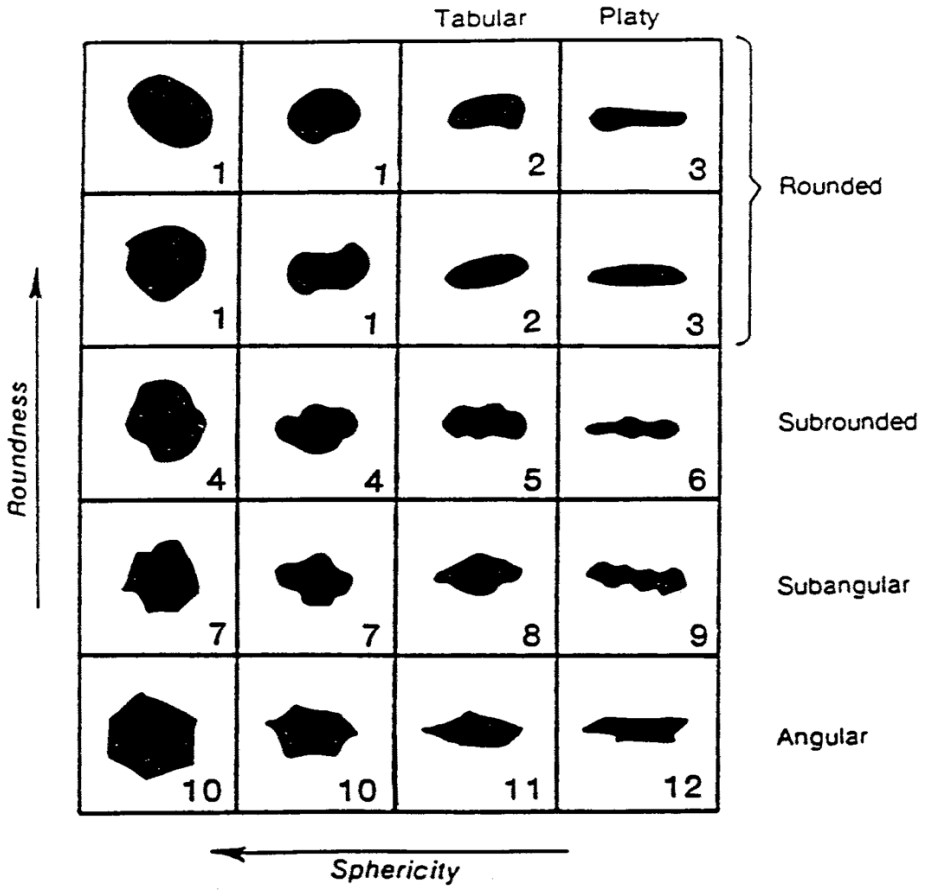

Figure 6: Fragment shapes

5.14.1 Type

Describe the types of **segregations** observed. Provision is made to separately record the information related to each of the types by using the 'add segregation type' button. Record the most important segregation type first, i.e., type 1. All segregation information added and saved is displayed in a summary table for comparison. If value of 'other' is selected as the 'Type' then please enter an appropriate description in the text field provided.

- **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 up to 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, up to 150 mm and 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.

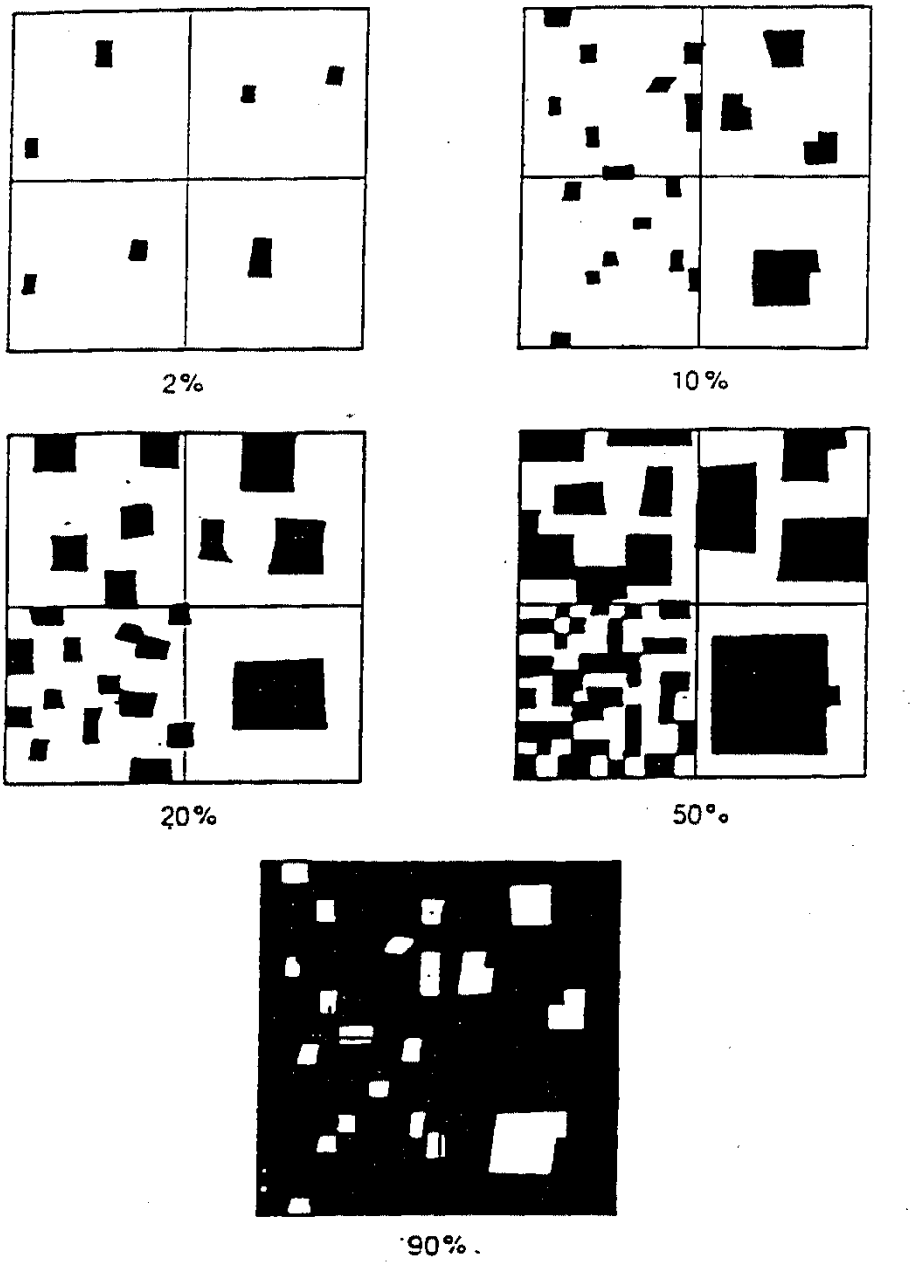

Figure 7: Chart for visually estimating percentage of abundance of an attribute

5.14.2 Amount

The volume of soil occupied by concretions may be visually estimated using ***Figure 7*** (previous page) as a guide.

5.14.3 Strength

Strength is used to qualify the **form** - e.g., 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.

5.14.4 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.

5.14.5 Size

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

5.15 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**.

If no **pans** are present for a **layer** you can use the 'Not evident for **layer**' button. This will insert 'not evident' as the type and all other attributes will disappear and remain unpopulated for the specified **layer**. Note: If **pan** data has already been captured for this **layer** it will be overridden and deleted with this operation.

If no **pans** are present for the entire profile you can use the 'Not evident for ALL **layers**' button. This will insert 'not evident' as the type and all other attributes will disappear and remain unpopulated for ALL **layers** in the profile. Note: If **pan** data has already been captured for **layers** within the profile it will be overridden and deleted with this operation.

5.15.1 Type

Describe the types of **pan** observed. Provision is made to separately record the information related to each of the types by using the 'add **pan** type' button. Record the most important **pan** type first. All **pan** information added and saved is displayed in a summary table for comparison. If 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), e.g., protrude 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.

5.15.2 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.

5.15.3 Continuity

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

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.

5.15.4 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.

5.16 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, e.g., 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 no **cracks** or **macropores** are present for a **layer** you can use the 'None for layer' button. This will insert 'none' as the crack width and macropore diameter for all size ranges for the selected **layer**. Note: If crack width and macropore diameter data has already been entered for this **layer**it will be overridden and deleted with this operation.
If no **cracks** or **macropores** are present for the entire **profile** you can use the ‘None for ALL layers' button. This will insert 'none' as the crack width and macropore diameter for all size ranges for the entire **profile**. Note: If crack width and macropore diameter data has already been entered for **any layers** within the **profile** it will be overridden and deleted with this operation.
If required, other information or more detailed descriptions can be recorded in **layer field notes**.

5.16.1 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.

Unspecified width

Indicate whether or not **cracks** of an unspecified width are observed in the **layer**. Whenever possible, however, you should specify the width by using the above fields.

5.16.2 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 less than or equal to 2 mm, the sample area is equal to 10 mm X 10 mm. When the diameter exceeds 2 mm, the sample area used equals 100 mm X 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. Whenever possible, however, you should specify the diameter by using the above fields.

5.17 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 X 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'.

If no **roots** are present for a **layer** you can use the 'None for layer' button. This will insert 'none' for all **root** size ranges for the selected **layer**. Note: If root data has already been entered for this **layer** it will be overridden and deleted with this operation.
If no **roots** are present for the entire **profile** you can use the 'None for ALL layers' button. This will insert 'none' for all **root** size ranges for the entire **profile**. Note: If **root** data has already been entered for any **layers** within the **profile** it will be overridden and deleted with this operation.

5.17.1 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 an unspecified size are observed in the **layer** by selecting an amount. Whenever possible, however, you should specify the size by using the above fields.

5.17.2 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.

5.18 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 field notes**.

5.18.1 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%)**

5.18.2 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.

6. Sample Attributes

6.1 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.

6.2 Laboratory sample number

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

6.3 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'.

6.4 Laboratory sample date

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

6.5 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'.

6.6 Sample sent by

A unique 4-digit number that has been already assigned to identify the person describing the profile. This is automatically populated by eDIRT for you.

6.7 Upper depth

Record the upper boundary of the sample in meters.

6.8 Lower depth

Record the lower boundary of the sample in meters.

6.9 Grid location X

For monitoring sites, such as those described using the Protocols for soil condition and land capability monitoring (DECC unpubl.), 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 by 10 square configuration, thus the X coordinate is a number between 0 and 9.

6.10 Grid location Y

For monitoring sites, such as those described using the Protocols for soil condition and land capability monitoring (DECC unpubl.), 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 by 10 square configuration, thus the Y coordinate is a number between 0 and 9.

6.11 Sampling technique

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

6.12 Reason

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

6.13 Sample notes

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

6.14 Laboratory results

6.14.1 Add laboratory result

Use this form to record an individual laboratory test result. Firstly, search for the laboratory test method you need by entering part or all of the method code or name into the Search laboratory test field, then selecting the required method from the drop-down list. Secondly, enter the result into the Result field.

6.14.2 Batch upload laboratory result

Use this form to record a batch of laboratory test results. You can paste a series of laboratory test results from a source such as an Excel spreadsheet, or alternatively you can enter them manually. Successful entries will be listed in the table below, whilst unsuccessful entries will return an error, e.g., if you have entered an incorrect laboratory test method code.

For manual entry, your results should be formatted as a simple tabulated list of laboratory test codes and individual results, similar to the example below. If entering lab test data manually, you can separate each test code from its result using a space or tab character. Each row should contain a single method code and result.

```
4A1 4.4
4B1 4.6
6A1 3
6B1 5
[etc.]
```

6.14.3 Test name (R&L, 2011 and McK et al, 2002)

Identifies the test name using the National reference texts:

- Rayment, G.E. and D.J. Lyons, 2011 'Soil Chemical Methods - Australasia', CSIRO Publishing.
- N.J. McKenzie, H. Cresswell, K. Coughlan, 2002 'Soil Physical Measurement and Interpretation for Land Evaluation', CSIRO Publishing.

6.14.4 Test code

Lists the National test method code for the corresponding test method.

6.14.5 Result

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

6.14.6 Unit of measurement

The unit of measurement appropriate for the specified test method.

7. Image Attributes

You can attach images to a soil profile whenever you are online. When your device is offline, eDIRT cannot attach images to profiles as it needs to upload them to the eDIRT server. You can photograph the site and/or soil profile using your device, then attach the images to the profile record later when your device is online.

7.1 Title

Record a title for the image.

7.2 Caption

Record a caption for the image.

7.3 Date

Record the date on which the image was taken.

7.4 Keywords

Record some keywords associated with the image, e.g., a soil type, type of land use or soil erosion, etc..

7.5 Description

Enter a text description of the image, if required.

7.6 Owner

A unique 4-digit number that has been already assigned to identify the person describing the profile. This is automatically populated by eDIRT for you.