Australia's National
Science Agency

National Soil Monitoring Program for Australia

Standard Operating Procedures and Guidance Notes

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Acknowledgments

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Inputs through contributions and reviews have been received from people in the soil science and agriculture community including:

- Many technical experts from around the country
- The National Committee on Soil and Terrain
- State and Territory land resource agencies
- Participants in pre-project workshops organised by Department of Agriculture, Fisheries and Forestry
- Knowledge gained and documentation prepared from other related soil monitoring programs

1 Introduction

This document presents the Standard Operating Procedures and Guidance Notes for the Australian National Soil Monitoring Program that commenced in 2024.

The objectives of National Soil Monitoring Program are:

1. Collect and collate strategic, nationally consistent, soil monitoring data.
2. Monitor soil state and trend to soil processes and properties that can be correlated with land use, land management practices and productivity.
3. Provide information to help with strategic decisions to guide soil-related sustainable productive agriculture outcomes.

Standard Operating Procedures (SOPs) are a set of written step-by-step instructions on how to conduct repeatable tasks so that a person can carry out the task correctly and that others will perform the same task in the same way, including at different locations. This ensures reliable, efficient, and consistent work activities are conducted; provides material for training; reduces the risk of error from people doing it their way; documents updates identified for tasks as the work matures; and enables quality control assessments of the work tasks to be accessed against a set of expectations.

Guidance notes provide advice on how to proceed and possible options when a task cannot be performed as planned.

Supporting the Guidance material will be a separate document of Frequently Asked Questions.

It is expected that this document of Standard Operating Procedures and Guidance Notes will be regularly reviewed and updated, particularly in the start-up phase as early adopters apply the procedures to do the work and identify where more information is needed.

2 Brief Overview of Work Required

The following two figures provide and overview of the NSMP project (Figure 2-1) and details about collection of soil samples at a site (Figure 2-2).

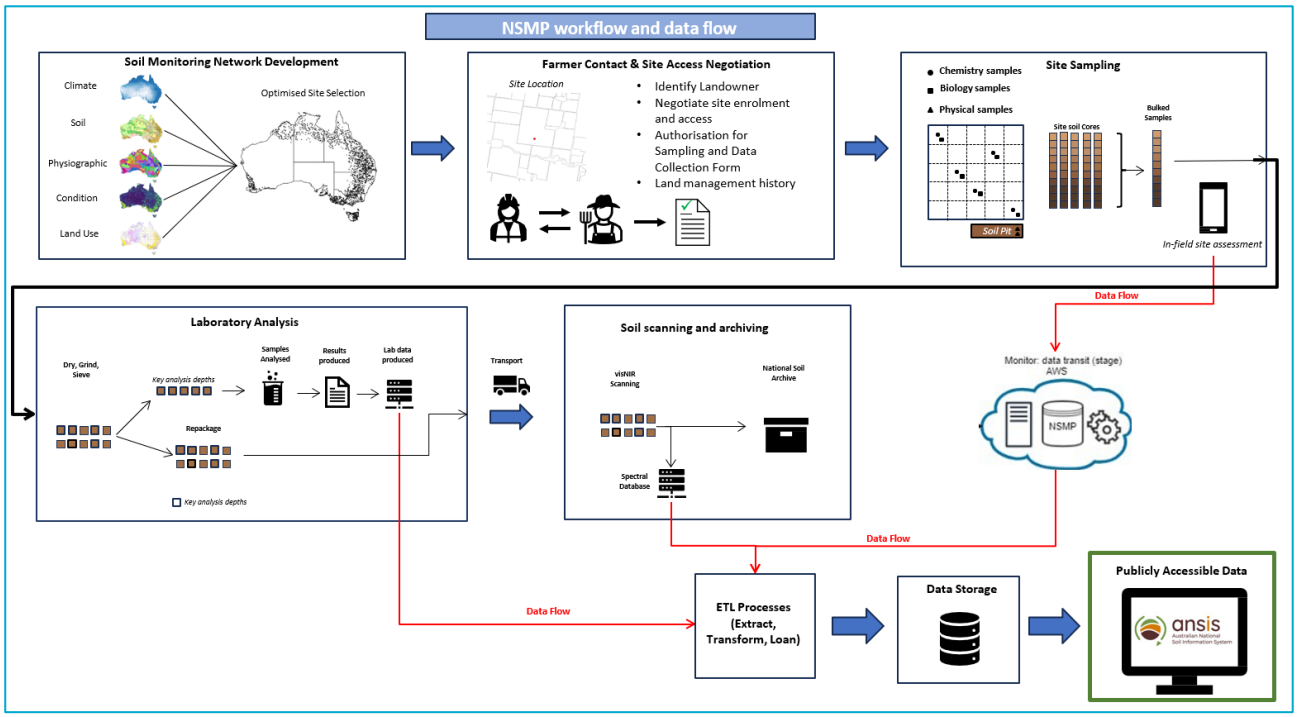

Figure 2-1. NSMP workflow and data flow

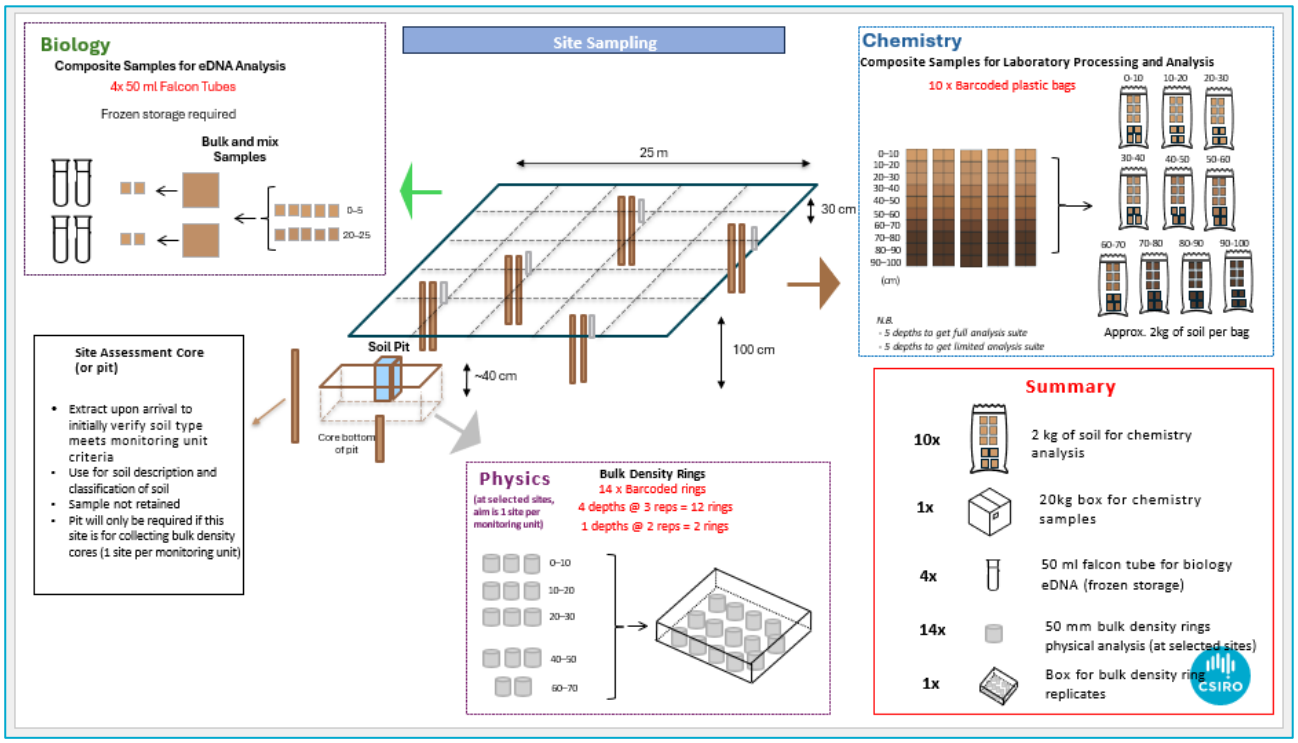

Figure 2-2. Sample collection to be conducted at a site.

3 Verify Suitability of Monitoring Site

Standard Operating Procedure

Project:	**National Soil Monitoring Program for Australia**
Title:	**Verify suitability of Monitoring Site**
Version Date:	30 October 2024
Version:	0.8 Initial draft

Purpose

Prior to field work being conducted to establish and sample a National Soil Monitoring Site, several factors should be considered to verify that the site location is suitable.

Scope

The Monitoring Site location is predetermined based on modelling of digital data as described in the National Soil Monitoring Network report.

Before investing time and resources into field work to establish the site, initial checks should be made to verify that the site is suitable. This is to be conducted in three sequential steps to confirm the listed criteria are satisfied:

1. Office desktop evaluation
2. Discussion with landowner
3. Site visual inspection

- If all the criteria are met, then the site is suitable for establishment.
- If some of the criteria are not met, there may be an opportunity for the site to be moved based on the Guidance for Monitoring Site Relocation (see section below).
- If the predetermined site is not suitable and cannot be relocated, then it is rejected, and a brief note made in the site register as to why.

References and Related Documents

National Soil Monitoring Network for Australia

Monitoring Site locations register

Authorisation for soil sampling and data collection form

National Soil Monitoring Program information flyer

Frequent asked questions

Roles and Responsibilities

- NSMP Project Leader – to provide site location to field team leader and assist with decision making when there is uncertainty.
- NSMP Sample design team – to provide list of site locations, and to support relocation of sample sites.
- Field Team Leader – to conduct verification of site suitability and document outcome. Some of the assessment will require judgement and therefore a level of experience and understanding of monitoring is required.
- Landowner or their representative – provide permission to work on their land, sign Authorisation Form confirming access and use of data, advise on how to access site, advise on timing to conduct the work with respect to current land use operations, discuss land use and soil management at the site. Advise on any buried services e.g. power communications, gas, water lines or any other health and safety issue.

Equipment

- Computer with GIS software to view site locations
- Access to imagery and other digital datasets
- Telephone communications

Procedures

Steps to follow and criteria to check to confirm if the Monitoring Site is suitable.

Office desktop evaluation

Each pre-determined Monitoring Site will occupy a set of features which should represent the Monitoring Unit land use and soil order classification (e.g. grazing modified pasture, Vertosol). In the sampling design, these features were estimated using national datasets, which have various degrees of uncertainty associated when downscaling to the site level The desktop evaluation should use remote sensed imagery, local knowledge, soil maps, other maps, existing reports, any other information to confirm at a minimum the following criteria are satisfied for the pre-determined Monitoring Site location. The desktop evaluation should ensure the site:

- Is in an area that meets the requirements of the named Monitoring Unit regarding intent of the soil type characteristics and land use.
- Occurs within an area and land use that appears somewhat homogenous.
- Could be accessed safely at the expected time of sampling.

- Is not significantly disturbed, e.g. near current or old fence lines, near a water trough, stock camps or isolated shaded areas where stock congregate, near gates, feed trails and feed-out areas, dam sites, cut and fill areas, headlands, adjacent to buildings or infrastructure or service easements.
- Has sufficient clearances for buried services (e.g. water trough lines, underground power lines, fibre optics cables, below surface drains) and data retained for future reference (dial before you dig and from discussion with landowner / manager)

- If the site appears to be suitable, move to the next stage (2. Landholder information)
- If there are some concerns, but the site could be moved based on the Guidance for Monitoring Site Relocation (see below), then do so and re-evaluate.
- If the site is rejected, make a note in the Site Register as to why.

Discussions with landowner

The second step for site verification is to assess the suitability of the site based on detailed information provided by the landowner, manager or their appropriate representative. To assist determining suitability of the Monitoring Site this individual should have sufficient knowledge and authority to:

- provide permission for work to be conducted on the property,
- sign the Authorisation Form for Sampling and Data Use,
- provide information about the area where the site is to be located,
- provide detail regarding access and appropriate time to conduct the work that considers the current land management, and
- land use and management history.

- Identify landowner, manager or their representative and obtain contact information. The process used to identify the landholder from a geographic coordinate will be at the discretion of the sampling team and should follow the appropriate channels. Local networks such as Local Land Services, local farmer group, agronomy groups, NRM groups and state agricultural departments should be considered in this process as potential sources of information.
- Contact the appropriate person and introduce them to the National Soil Monitoring Program, it's intention and we would like to establish a Monitoring Site on their property. The below points should be used in these discussions, along with the Frequently Asked Questions (FAQs):

- Currently there is no *national* soil monitoring program to provide information and guidance on soil health. This is foreseeably a long-term program (20 years or more) to provide base-line information and to monitor change in soil condition.
- The data will assist national and state allocation of resources to support maintenance and improve soil health. Provide information to help with strategic decisions to guide soil-related sustainable productive agriculture outcomes.
- The site will provide baseline information about the soil.
- The site would be revisited through time, possibly every 5 years (to be determined) for further soil sample collection to monitor the soil state and condition of the site within a broader regional context.
- Briefly explain the work that would be conducted. The site plot is a 25 by 25 meters area, within the plot area core samples (50mm diameter) will be obtained at 10 locations to 1 metre depth, and 1 pit or core location adjacent to the plot to describe and classify the soil. Disturbance at the site would be minimised by conducting as much work as practical with handheld tools, in some cases a vehicle mounted core rig may be used.
- Samples would undergo a series of chemical, physical, and biological tests to provide data to understand the soil health, these are different tests to soil fertility testing.
- Data results would be provided to the contact person within 6-12 months of sampling. This delay is due to the large volume of project samples to be tested along with data checking and evaluation. This is a different to soil fertility assessment that farmers may be more familiar with and have quicker turnaround times.
- Data results would be publicly available via the Australian National Soil Information System. Landholder details would not be made available. Analysis and public reporting from this work would present findings on a consolidated data basis (many farms and site locations) for monitoring units or regions.
- A handout/flyer can be provided that has information about the project.
- If they are supportive then discuss the site location and confirm suitability criteria in the next step.

- Confirm that the landowner or their representative is supportive of the program of work and move to the next stage. Confirmation criteria requires that they would:
  - Provide permission for access to the property for field work and soil sampling.
  - Allow future sampling could be conducted in approximately 5 years, when that time comes contact will be made to confirm approval.
  - Sign the Authorisation Form for Access and Data Use.
  - Discuss the site location in more detail to determine its suitability, access requirements and limitations, safe field work environment, if vehicles can be taken

through the property to the site or where the nearest suitable vehicle stopping location would be.

- Discuss information regarding land use history and land management within the paddock.
- Confirm that there are no immediate plans to change the land use of the paddock. If there is a planned change, then determine if the change is significant enough that the site would no longer meet the Monitoring Unit concept, if so then the site may be rejected.
- Conduct business-as-usual land management practices across the site as would be conducted in the paddock, and that the site is not given any special attention or treatment.
- Provide contact details – mail address, phone number, and email information for follow-up contacts nearer the time for field work and latter reporting of results. This information would be held securely by CSIRO and used for future soil monitoring visit contact purposes.

- If the landowner or their representative is not supportive, then the site is rejected and a note made in the Monitoring Site Locations Register as to why.

Site visual inspection

On first arrival at the site, confirm the site is representative of the Monitoring Unit concept for land use and soil type, and that it is suitable and safe for establishment.

- If the site satisfies the criteria, then establish the plot, and sample the soil.
- If there are concerns, consider relocating the plot based on the Rules for Site Relocation, then do so and re-evaluate.
- If the site does not satisfy the criteria and cannot be relocated, then reject the site, and make a note in the site register as to why.

Conduct the following to assist in determining if the site plot location satisfies the criteria and is suitable:

- Mark out the general dimensions of the site plot and walk over the area, checking that it appears relatively uniform in terms of slope, slope position, drainage features, surface condition and vegetation community.
- Observe the land use at the site to confirm that it corresponds with the Monitoring Unit concept. If the land use is mixed farming, the current stage of rotation, rotation sequence, and the history of the paddock should be verified by discussions with the land manager. This is to understand the relationship of the rotation to timing of sampling. The site should occur within an area representative of the paddock so that the management across this area is consistent with that recorded for the paddock history.

- Observe basic soil characteristics using an auger at the 4 corners of the site, to confirm that the soil texture, colour, consistence and structure for the topsoil and subsoil is within the expected Monitoring Unit concept.
- Observe for impact at the site that would not normally be expected in the paddock, examples to consider include extra traffic movement, near gates, fences, headlands, firebreaks, near obstacles (rocks, trees, streamline, flood zone), near infrastructure (dams, water trough, silo, buildings, pipelines, power lines), locations where livestock may congregate.
- Observe for environmental actions that may not be typical or would introduce more variability or uncertainty into the monitoring results, examples to consider include severe erosion, inundation, degradation, aggradation, or flooding.

Guidance on Land Use and Soil Type that differ from the Monitoring Unit concept

The Monitoring Unit concept is determined based on modelling of digital data from national scale map datasets. The Monitoring Unit is characterised by dominant Land Use and Soil Type. The national datasets will not be accurate at the field scale and therefore on evaluation of the site there may be differences.

The question asked is: how different does the land use and/or soil type at the site must be from the expected concept before that location is relocated or the site rejected?

For Land Use, the difference is set at a level of managed vs un-managed e.g. expected improved pasture, but it is an irrigated crop – both are managed and that is OK; expected a remnant bush site but it is improved pasture – one is unmanaged and the other managed that is NOT OK.

For Soil Type, the difference is set at a level of Strong texture-contrast soil, Lacking strong texture-content soils plus Vertosols and Podosols, Other soils.

For practical reasons, when the field visit to establish the site occurs it is expected that the site location is retained unless there is a difference at the higher levels of Land Use and Soil Type for the Monitoring Unit concept. Even if there is a difference, the surrounding landscape should be considered and if that location appears representative of the main land use and soil type then continue with establishing the monitoring site.

The Field Team Leader needs to understand the intent of the Soil Monitoring Program and then use their experience and judgement to determine if the location would make a good representative National Soil Monitoring Site location.

Guidance for Monitoring Site Relocation, Replacement, and Rejection

If the predetermined target site location is not suitable then it could be relocated, but it must be relocated without bias and to a location that satisfies the intent of the Monitoring Unit it was to represent. The relocated site must share the same land use and soil type.

Site relocation can occur at any of the three verification steps described above:

Step 1 - Following office desktop evaluation

Step 2 - Following discussions with landowner (or lack thereof)

Step 3 - Following site-visual inspection.

Additionally, 2 levels of relocation may exist:

1. Substantial – change of farm or landholder (based on information from Steps 1 and 2 above)
2. Minor – shift location within paddock or change to neighbouring paddock (based on Steps 2 and 3 above)

To ensure a standard approach in the National Design, the following guidance for site relocation should be considered at each step of the site verification process.

For Substantial relocation:

1. This will need to be conducted by the Field Team Leader in collaboration with the Sample Site Design Team (CSIRO NSMP).
2. The need to do this should generally occur at Step 1 or 2, which is at the desktop review or landowner discussion stages, assumption is office based and prior to travelling to the site.
3. The Sample Design Team have tools to identify potential replacement site locations that satisfy the Monitoring Unit criteria.
4. Field Team Leader receives the replacement site location details and starts at Step 1 to check its suitability.
5. If a suitable site cannot be found, then the site should be rejected.
6. Once the site has been relocated or rejected, the Monitoring Site Location Register should be updated with actions taken and reason. One or more of the following reasons should be selected:
    a. Landowner did not provide permission to work on the land.
    b. Data use collection agreement was not signed.
    c. Work area or access to site was not safe.
    d. Site was too disturbed to be representative.
    e. Did not satisfy monitoring unit intent for soil type or land use.
    f. Other, and specify what reason was.

For Minor relocation:

1. This will need to be conducted by the Field Team Leader who will make an expert judgement decision on how best to proceed.
2. The need to do this should generally occur at Step 2 or 3, assumption is the field teams are at the landholders farm ready to sample.
3. Assuming positive landowner cooperation, for pragmatic purposes then the site should be placed within the same farm ownership boundary as the target site location where appropriate, allowing the landowner contact to be maintained
4. Understand the intent of the Monitoring Unit and its spatial extent, and ensure the selected site exhibits these requirements The relocated site must be representative of the original site's criteria (i.e. Land Use and Soil Type).
5. If the site requires minor relocation, this should ideally be undertaken within the same paddock.
6. For minor adjustments. the site should be relocated randomly following a prescribed approach. A suggested method is to take and record a bearing towards the centre of the paddock and move a set distance of 50 m from the original target site. A location along the same elevation (contour) with similar upslope contributing area is ideal within the constraint of the same paddock, this method should continue at 50m intervals until a suitable site is identified.
7. If a suitable site cannot be found within the original paddock, and the surrounding paddocks satisfy the Monitoring Unit intent and landscape position, then take a bearing to centre of the nearest paddock. Move at 50m intervals into the new paddock towards the centre until a suitable site is identified. If the first alternative paddock is not suitable then consider the next closest adjacent paddock until all options are considered. The selected site must still adhere to the required criteria.
8. If a suitable site cannot be found, then the site should be rejected.
9. Once the site has been relocated or rejected, the Monitoring Site Location Register should be updated with actions taken and reasons, including if identified the coordinates of the replacement site. One or more of the following reasons should be selected:
    - Landowner did not provide permission to work on the land.
    - Data use collection agreement was not signed.
    - Work area or access to site was not safe.
    - Site was too disturbed to be representative.
    - Did not satisfy monitoring unit intent for soil type or land use.
    - Other, and specify what reason was.

4 Establishing a Monitoring Site

Standard Operating Procedure

Project: **National Soil Monitoring Program for Australia**

Title: **Establishing a Monitoring Site**

Version Date: 30 October 2024

Version: 0.8 Initial draft

Purpose

This procedure describes how to establish the sampling plot area so that soil collection locations can be identified. Soil sampling is destructive, therefore there is a need to ensure that future sampling events avoid previously sampled locations. A structured approach with perimeter and internal layout assists with facilitating this.

Scope

The Monitoring Site location is predetermined based on assessment and modelling of digital data as described in the National Soil Monitoring Network report. The site is a point in the landscape which t a plot is established from that defines the sampling area to characterize that Monitoring Site.

Plot internal layout is established to ensure future sampling events avoid previously sampled locations.

Site sampling plot is a square shape of 25 by 25 metres (total area of 625 m^2). The selection of this shape and size is pragmatic, based on the reasoning that it describes a soil individual in the Australian landscape (see McKenzie, Coglan, Cresswell, 2002, p13) . Additionally, some of the other monitoring programs conducted in Australia use a similar layout (SCARP, SOC-M, MER - provide references) and in 2023 there was a series of soil monitoring workshops run by DAFF where advise from attendees indicated that this plot layout would be desirable.

For some circumstances it is recognised that a square will not be suitable, it may be:

- Elongated, for example on sloping landscapes where the site crosses markedly different slope elements, here the site is elongated along the contour.
- Radial, for example in a densely bushed/forested location where the site cannot be effectively laid out, here a radial on random direction and distance from the centre site location.

There are several ways doing this, and for the National Soil Monitoring Program the requirements are:

- The plot consists of 25 cells (5 by 5 for a square) and 5 cells (one from each row and column) will be sampled for each campaign.

- The sampling location positions within a plot are pre-determined using random selection. For pragmatic reasons and to ensure national consistency in sampling between site revisits, all sampling locations in the plot will be the same across sites in each sampling campaign.

Two procedures are described on how to establish the sampling plot area, either of these can be used.

- Using a tape measure
- Using a GPS, sub 1 meter accuracy

Guidance notes are provided on altering the sampling area shape, establishing the monitoring area, safe field work, accommodating obstacles, and

References and Related Documents

Report: National Soil Monitoring Network for Australia

Monitoring Site locations register

Authorisation Form for Access and Data Use

Roles and Responsibilities

- NSMP Project Leader – to provide site location to field team lead/co-ordinator and assist with decision making when there is uncertainty.
- Field Team Leader – to conduct verification of site suitability, identify any risks, establish the site origin which will form the southwest corner of the plot, ensure plot is correctly established and documentation is completed.
- Field team member – establish the plot as instructed.
- Landowner or their representative – provide permission to work on their land, sign data use agreement, advise on access, discuss land use, advise team on buried infrastructure and any health and safety concerns.

Equipment

The list (Table 4-1) is not exhaustive but provides guidance as to the equipment and minimum number of items to establish a monitoring site. Note, separate lists are provided for sample collection, soil description, additional equipment may be needed for remote area and camping.

Table 4-1. Equipment list providing guidance as to what equipment will be needed to establish a site.

Item	Number	Comments
SOP for establishing a monitoring site	1	Outlines approach procedures, and provides guidance
Authorisation Form for Access and Data Use	1	Landowner signed, confirming permission for sampling the site and data usage
GPS unit	1	Sub-meter accuracy, for locating site origin. Using project standardised datum
Site coordinates	1	Identifies target site location
50m reel tapes	3	For establishing the perimeter (2 tapes), and checking that it is square and then for locating row sample locations (1 tape)
Rope/wire with relevant marked up distances	1	Reel tapes tend to break with use and in wind. A standard rope with all relevant distances can speed up layout operations
Corner marker post/flags – star pickets, stakes or similar, about 0.5 to 1m high	4	For marking the corners while sampling and providing a visual reference for photographs
Compass – good quality	1	For aligning the perimeter north-south and east-west
Metal hooks – large tent pegs	8	For holding the tape on the ground at corners and in between
Marker flags/stakes	5	For marking the sample location positions
Field personal gear – boots, hat, clothing, coat		As required for field conditions and to satisfy health and safety requirements
Personal protection – sun protection, insect repellent, first aid equipment, water, food		As required for field conditions and to satisfy health and safety requirements

Procedures

Using a tape measure

Perimeter layout

1. With a GPS unit locate the pre-determined target coordinate for the site origin. **Guidance Note** – care should be taken to get close to the target site coordinates, however excessive time should not be spent to get the site's location exact. For the first sampling event, it is more important to ensure that from that position that the sampling plot area can be established across a relatively homogeneous area. For subsequent sampling events it is important to get as close as possible to the origin coordinate.
2. The origin coordinate is for the Southwest corner of the Monitoring Site sampling plot area.
3. From the Southwest corner the sides of the square are established to align with magnetic North-South and East-West. This can be done using an accurate sighting compass.
4. The line from the Southwest corner to the southeast corner (southern line) forms the plot baseline.
5. Using two 50m reel tapes mark out the plot perimeter. With one reel tape measuring 25m from the southwest to the northwest corner and then at right angles to the adjacent northeast corner. The layout is a square, therefore two sides of the square will be at a right angle if the diagonal of measures 35.36 m (25^2m + 25^2 = 35.36^2). Therefore, at the same time use a second reel tape to form the diagonal of a right-angled triangle for the southwest corner to the northeast corner to assist with keeping the square at right angles by intersecting the first tape at 50m to locate the corner. The southeast corner can be located by either flipping tape 1 over or using a third 50m reel tape to mark the other two sides and complete the square.
6. The 4 corners are marked with posts/flags that are visible above the vegetation to define the sampling area for photographs.
7. With a GPS (sub-meter accuracy) record the site origin (southwest corner) and the position of the other three corners. These readings will be used to place the site spatially and more importantly used to relocate the site and plot layout for future sampling events.
8. Photographs should be taken that show the sampling area, its position in the paddock and relationship to some features which would assist with relocating if there was uncertainty with relocating using the GPS coordinates. These photographs must be recorded in the field app.

Guidance Note: If a square shape or plot orientation is not suitable. Then the dimensions should be adjusted to maintain a total area of 625m^2. Record the reason and describe the new shape. The corner nearest to southwest of the shape should be the site coordinate origin. Record all other corners that are needed to define the shape. For some sites, for example in forested or heavily bushed areas the sample plot may be radially from the origin, with random direction and distance – this approach will require further scoping if required.

Guidance Note: Marker to assist relocation. The National Soil Monitoring Program does not require a marker to be placed in the soil or on surrounding structures to assist with future identification of the site position. An accurate coordinate position obtained by a GPS unit with sub-meter accuracy should provide sufficient information to allow the site to be relocated.

Internal Layout

1. If the site is an existing one used for monitoring, then consider maintaining its predefined internal layout for sampling or overlay the recommended National Soil Monitoring Program. If the site is a newly established as part of the National Soil Monitoring Program, then the recommended internal layout approach is described here.
2. The southwest corner is defined as the origin.
3. The north-south grid lines are numbered as rows 1 through to 5, and the east-west grid lines are numbered as columns A to E. The 0 metre lines are not used for sampling as these line areas will become disturbed during site layout and particularly near the origin point (0 by 0 metres) that is used for the staging area and soil type characterisation pit/borehole. The layout is shown in Figure X.X.
4. A 5 by 5 grid allows for 25 sampling cells.
5. The approach is where each row and column are sampled only once in each sampling event. A randomised set of cells to sample for the first 5 sampling event (set) has been generated.
6. The centre of each cell is the sample location.
7. To identify the centre of each cell, a distance matrix is provided in Fig XX.
8. Place a marker flag at each of the 5 sampling locations.

Guidance Note: moving to avoid an obstacle – for some sample locations the position may need to be slightly relocated, minimise the move distance and ideally no more than up to 100 cm, e.g. gilgai area and sample location is a crack, or in a controlled traffic wheel track that is not representative of the farmed area.

Guidance Note: if an alternative grid layout is used. The above 5 sample location plot layout is the recommended approach. For various reasons alternative layouts have and may need to be used, e.g. fitting in with an existing monitoring site layout, or on a sloping landscape across several slope elements. If alternative layout methods are used, then they must select the sample location positions randomly and their locations accurately recorded to ensure future sampling events avoid sampling at that location. The sample positions are to be recorded as metres east and north of the origin corner (southwest corner), thus providing an internal grid reference in metres.

Guidance Note: alternative to using reel tapes to layout. Given the field team may be sampling many monitoring sites then the 50m reel tapes could be replaced with pre-marked wire or rope. Reel tapes are susceptible to breaking particularly if windy and sometimes difficult to tension for accurate measures, a wire or rope may overcome this.

Using a GPS unit

1. The GPS unit will need submeter accuracy, this will require access to differential adjustments or averaging function on the unit.
2. Determine and preloaded site location (origin), calculated sample plot corners, and using the internal grid design (Figure 4-1) then determined sample location positions.
3. These can be navigated to using GPS unit and/or with a tablet.
4. Locate and mark with corner posts and sample location flags as described above.

Guidance Note: Work occupational health and safety.

Your employer has obligations to you under relevant Occupational Health and Safety legislation. If you are self-employed, you also have duties under this legislation. These procedures, including driving to the site, are to assist with conducting the work, it is you and your employer's responsibility to assess the risks and implement controls whilst conducting the work. You must follow your employer's policies and procedures as they apply to the tasks that you are involved in throughout the project work. This assessment should also include any risks to the public, landowners, and environment, and if any occur then they should be identified, and action taken to mitigate the risk.

NSMP sample location for each monitoring event (set)

Grid cell location (cells are 5 by 5 m)

	set 1	set 2	set 3	set 4	set 5
	(A, 4)	(A, 1)	(A, 3)	(A, 2)	(A, 4)
	(B, 1)	(B, 2)	(B, 4)	(B, 5)	(B, 3)
	(C, 3)	(C, 5)	(C, 1)	(C, 4)	(C, 2)
	(D, 5)	(D, 3)	(D, 2)	(D, 1)	(D, 5)
	(E, 2)	(E, 4)	(E, 5)	(E, 3)	(E, 1)

Centre of cell location, meters

	2.5, 17.5	2.5, 2.5	2.5, 12.5	2.5, 7.5	2.5, 17.5
	7.5, 2.5	7.5, 7.5	7.5, 17.5	7.5, 22.5	7.5, 12.5
	12.5, 12.5	12.5, 22.5	12.5, 2.5	12.5, 17.5	12.5, 7.5
	17.5, 22.5	17.5, 12	17.5, 7.5	17.5, 2.5	17.5, 22.5
	22.5, 7.5	22.5, 17.5	22.5, 22.5	22.5, 12.5	22.5, 2.5

meters - to cell centre	Row - south to north						
22.5	5	5	4	2	1	3	
17.5	4	1	3	4	5	2	
12.5	3	3	5	1	2	4	
7.5	2	4	2	5	3	1	
2.5	1	2	1	3	4	5	
	origin	A	B	C	D	E	Column - west to east
0		2.5	7.5	12.5	17.5	22.5	meters - to cell centre

Figure 4-1. Showing the plot site sampling locations, for 5 sampling events. The first sampling event for 2024 to 2028 is shown as 1 (orange coloured cell).

5 Soil Sample Collection

Standard Operating Procedure

Project:	**National Soil Monitoring Program for Australia**
Title:	**Soil sample collection**
Version Date:	30 October 2024
Version:	0.8 Initial draft

Purpose

This procedure describes the types of soil samples to be collected and their requirements. The soil samples collected will used for chemical, physical and biological testing, and storage in a soil archive for future use. Collection of soil samples needs to be consistent so that analysis between sites, and at the same site between different times can be conducted and compared.

Scope

The Soil Sample Collection occurs at the predetermined locations within the monitoring plot. The centre for 5 cells has been identified, samples are collected from defined set intervals down the profile. The 3 types of soil sample collected are for:

- Chemical and soil archive: A composite sample from the 5 cells, at 10 cm depth increments down the profile to 100 cm or refusal. Collected using a core with a known diameter so that volume estimates can be calculated for each depth increment. Conducted at all sites.
- Biological: A composite sample from the 5 cells, at 0-10 and 20-30 cm depths. Conducted at all sites.
- Physical: Bulk density rings collected from the soil pit, outside the plot where the soil is characterised. Collected for 5 depth increments, 0-10, 10-20, 20-30, 40-50, and 70-80 cm. Triplicate samples collected for each depth. Conducted at selected sites, anticipated to be 1 site per monitoring unit.

References and Related Documents

Monitoring Site locations register

Authorisation Form for Data Use and Sample Collection

Roles and Responsibilities

- NSMP Project Leader – to provide site location to Field Team Leader and ensure they understand the soil sampling requirements for each site.

- Field Team Leader – to evaluate the site for sampling and determine the best approach to collect the soil sample. Understand the sampling requirements and ensure that they are conducted correctly. Ensure health and safety for field operations and safe operating procedures for all equipment is understood.
- Field team member – conduct the soil sample collection as instructed.
- Landowner or their representative – provide permission to work on their land, sign data use agreement, advise on access, discuss land use, advise team on buried infrastructure and any health and safety concerns.

Equipment

The list (Table 5-1) is not exhaustive but provides guidance as to the equipment and minimum number of items to collect soil samples at the monitoring site. Note, separate lists are provided for site establishment, soil description, additional equipment may be needed for remote area and camping.

Table 5-1. Equipment list providing guidance as to what equipment would be required to collect soil samples at a site.

Item	Number	Comments
Portable post-hole driver with coring kit adaption	1	Including fuel, spares, safe operating procedures document, and follow maintenance needs
Core tube, 50mm diameter to approx. 1.5 m length	5	A selection of cutting tips attached to the core should be carried and the right one selected for the soil and moisture conditions. A 38mm diameter may work best for most soil, reliant on local knowledge and operator experience to guide. These items will wear, ensure cutting edge is maintained in good condition. Replace as needed
Tools for maintenance and operation	1	File for sharpening cutting edge, pipe wrench, paperclips, wood blocks
Core retrieval foot lever	1	For extracting core from ground. May need a pipe to fit over and extend lever to increase leverage

Item	Number	Comments
Soil extruder, pushrod	1	For example, a broom stick longer than core tube, with a bung (doorstopper) slightly less than the cutting edge diameter.
Core tube cleaning	1	Round push rod wire brushes. Rags and cleaning equipment
Half-pipe pvc tubes	10	For holding soil sample core when extruded from core tube. Have marked up for easy of identifying depth increments to slice out
Buckets, plastic	5	2 for mixing biological samples prior to placing in falcon tube. 3 for cleaning equipment
Plastic sample bags – for chemical composite sample	10/site	For collection of about 2kg of soil per sample. Bags to be provided by CSIRO.
Falcon tubes – for biological sample	4/site	For collection of samples, sealing, and ready for freezing. Tubes to be provided by CSIRO.
Bulk density cylinders and end caps – for physical sample	14/site	For sampling at 1 site per monitoring unit. Cylinders to be provided by CSIRO.
GPS unit	1	Sub-meter accuracy, for recording sample locations. Using project standardised datum
Device (tablet or mobile phone) running the sample collection application	1	For recording sample locations, and registering the sample bag barcode number with site identification number and sample depth
Sample recording sheet	1/site	Backup to manual record sample data if device is not working
Tape measure, 2 m	2	For measuring core hole depth, extruded soil core length, and identifying sample increment to slice off for bag
Stationary, permanent marker pens,	5	Recording information and marking sample bags

Item	Number	Comments
Plastic tub, 20l	1/site	For chemical samples
Cooler box and frozen blocks	1	For biological samples
Box (or bags)	1/site	For bulk density cores (to be determined)
Field personal gear – boots, hat, clothing, coat		As required for field conditions and to satisfy health and safety requirements
Personal protection – sun protection, insect repellent, first aid equipment, water, food		As required for field conditions and to satisfy health and safety requirements

Procedures

Composite sample for chemical analysis

1. The five cells within the monitoring plot for this sampling visit are predefined and marked at the centre of the cell, see SOP Establishing a Monitoring Site.
2. Preference is to use a coring tube to collect the soil sample, as the known cutting tip diameter along with soil core length allows an apparent density to be calculated. For some soil materials (stony, sandy) this may not be appropriate to obtain the soil sample and therefore other options should be used such as digging a small pit or/and using a hand auger.
3. The location to collect the sample should be as close as possible to the marked cell centre.
4. Depth should be to 100cm or when there is refusal due to hard layer (rock, extremely hard layer, stones)
5. Extrude soil core onto a half-pipe.
6. With tape measure obtain the depth of the core hole and the length of the soil core. This is to evaluate if there has been compression or loss of soil material. There will likely be some differences between the two measures, however field operator experience should guide if the sample recovery is satisfactory for that soil type.
7. This is repeated until each of the 5 cells for this visit are sampled.
8. Composite samples will be collected from the cores at 10cm intervals from surface. With same soil depth samples being placed in same bag.

9. The aim is to obtain about 1.5 to 2kg of soil in each bag. This assumes for need of about 500gms of <2mm fine earth for analysis, 1000gms for soil archive, and remainder (0-500gms) will be >2mm coarse fragments.
10. To obtain sufficient material (when using a 38mm cutting tip) that two core holes will need to be collected from within each of the 5 cells = 10 soil core samples collected.
11. Plastic bags to have pre-printed labels attached, the labels will contain a unique sample identifier number and barcode, and a location to write the Site ID and Sample Depth Increment.
12. Layout the 10 bags scan individual the barcode with device that runs the soil sample app, ensuring that the site ID and depth increment match the recorded information.
13. Separate guidance will be provided on the use of the Sample Data entry application

Composite sample for biological analysis

1. Within the same 5 cells and adjacent to the chemical sample location the biological samples are collected.
2. Samples from two depths 0-10 and 20-30 cm, using the coring tube or digging a small pit and extracting.
3. Soil from each depth increment is homogenised in a bucket/bag to form a composite sample.
4. Fill 50 ml Falcon tube with soil (remove fragments >2mm), leaving 1-2 cm of space at top of tube.
5. Collect 2 tubes per depth increment. Attached sample identification labels.
6. Freeze tubes as soon as possible, keep chilled in cooler box while in the field.
7. Hygiene is very important when collecting and handling these samples, avoid touching the soil with hands and clean all equipment that contacts the soil to avoid contamination.

Bulk density ring samples for physical analysis

1. Soil samples in bulk density rings are collected for two purposes: i) calculation of soil bulk density, and ii) for placing on pressure plates to obtain soil water retention characteristics.
2. Bulk density ring samples using small cylinders are to be collected from a location outside the site plot area, to reduce disturbance in the monitoring area.
3. The best option is to co-locate this sampling with the soil characterisation pit.
4. Bulk density cylinders will be supplied, with end caps.
5. Follow the method described in McKenzie et al. (2002) for small cores Method 502.03. Assumption is that step down the pit can be incremental cut at the required depths, and

there is the option to use devices for collecting cores at depth from the base of augered holes.

6. Samples to be collected from 5 depth increments – 0-10, 10-20, 20-30, 40-50, 70-80.
7. Replicate samples collected for each depth increment, 3 cylinders per depth.

Data collected in the field about the sample

Data about the soil sample collected in the field will be via an App that operators on an Android device (mobile phone or tablet) that has data connection. The application will be supplied to the field team along with information on use.

Data collected includes

- Project identification
- Site identification
- Date of sampling
- Who is sampling/recording
- Plot corner locations – GPS readings
- Sample cell location – GPS readings
- Total depth for each of the chemical core holes
- Total length of each the extruded soil cores
- If total length is <90 cm then reason for restriction
- Register the sample label to sample type (chemical composite, biological composite, physical cylinder) and depth increment
- Photographs of the sampled core tubes and site (see separate SOP on photographs)

Guidance Notes

To Be Written – when uncertainties are identified

6 Soil Profile and Landscape Description

Standard Operating Procedure

Project:	**National Soil Monitoring Program for Australia**
Title:	**Soil profile and landscape description**
Version Date:	30 October 2024
Version:	0.8 Initial draft

Purpose

This procedure describes the minimum (mandatory) information to be obtained at a site to characterise the soil profile and landscape. Depending on the soil type additional information may be needed to assist with characterisation and classification of the soil. This observational information provides contextual data about the soil and landscape, including the soil classification, that is used to categorise and assist with interpreting the soil data.

Scope

The soil profile and landscape description will be collected following Australian standard for soil and land survey provided in 3rd edition (NCST 2009) and when published the 4th edition (NCST 202?). Soils are to be classified to the Australian standard (Isbell, NCST 2021) to at least sub-order.

Soil profile description will be by horizon, nothing that this differs from the soil sampling set depth sampling increments.

A NSMP field card is provided, this is in hardcopy form and the mimicked in the data entry app for easy of transcription. It is expected that the data entry app will be available on mobile devices mid 2025 which would allow direct entry of the data in the field, removing the need for paper recording and later transcription.

The soil profile description can be made from either a soil pit/auger or core.

References and Related Documents

Monitoring Site locations register

Authorisation Form for Data Use and Sample Collection

Australian Soil and Land Survey Handbook (NCST 2009, and when available 4th ed 202?)

The Australian Soil Classification (Isbell, NCST 2021)

Roles and Responsibilities

- NSMP Project Leader – to provide site location to Field Team Leader and ensure they understand the requirements for each site.
- Field Team Leader – to evaluate the site location, choose an appropriate position relative to the monitoring plot to place the soil description pit or core. Ensure health and safety for field operations and safe operating procedures for all equipment is understood.
- Field team member – conduct the soil description work as instructed.
- Landowner or their representative – provide permission to work on their land, sign data use agreement, advise on access, discuss land use, advise team on buried infrastructure and any health and safety concerns.

Equipment

The list (Table 6-1) is not exhaustive but provides guidance as to the equipment and minimum number of items required to describe a soil and landscape. Note, separate lists are provided for site establishment, soil sampling, additional equipment may be needed for remote area and camping.

Table 6-1. Equipment list providing guidance as to what equipment would be required to describe a soil profile and surrounding landscape.

Item	Number	Comments
Shovel	1	For digging pit
Auger	1	For auguring into base of pit if digging cannot reach required depth
Portable post-hole driver with coring kit adaption	1	Alternative approach to digging a pit, by using coring equipment. Including fuel, spares, safe operating procedures document, and follow maintenance needs
Core tube, 50mm diameter to approx. 1.5 m length	5	A selection of cutting tips attached to the core should be carried and the right one selected for the soil and moisture conditions. A 38mm diameter may work best for most soil, reliant on local knowledge and operator experience to guide. These items will wear, ensure cutting edge is maintained in good condition. Replace as needed

Item	Number	Comments
Tools for maintenance and operation	1	File for sharpening cutting edge, pipe wrench, paperclips, wood blocks
Core retrieval foot lever	1	For extracting core from ground. May need a pipe to fit over and extend lever to increase leverage
Soil extruder, pushrod	1	For example, a broom stick longer than core tube, with a bung (doorstopper) slightly less than the cutting edge diameter.
Core tube cleaning	1	Round push rod wire brushes. Rags and cleaning equipment
Half-pipe pvc tubes	10	For holding soil sample core when extruded from core tube. Have marked up for easy of identifying depth increments to slice out
Tarpaulin	1	Plastic or canvas tarp for laying out removed soil
GPS unit	1	Sub-meter accuracy, for recording sample locations. Using project standardised datum
Device (tablet or mobile phone) running the sample collection application	1	For recording the descriptive information. For early months of the project the descriptive information will have to captured on field sheets and transcribed using a desktop computer into the soil data entry application
Sample recording sheet	1/site	Backup to manual record sample data if device is not working
Tape measure, 2 m	2	For measuring core hole depth, extruded soil core length, and identifying sample increment to slice off for bag
Stationary, permanent marker pens,	5	Recording information and marking sample bags
Australian Soil and Land Survey Handbook	1	Reference book

Item	Number	Comments
The Australian Soil Classification	1	Reference book
Field personal gear – boots, hat, clothing, coat		As required for field conditions and to satisfy health and safety requirements
Personal protection – sun protection, insect repellent, first aid equipment, water, food		As required for field conditions and to satisfy health and safety requirements

Procedures

To Be Written

Minimum (mandatory) data to collect

INSERT TABLE ONCE THE FIELD CARD IS FINALISED

Table 6-2. List the minimum pieces of information to be collected for a soil profile and landscape description.

Soil description field card

Data entry to database

Guidance Notes

To Be Written – when uncertainties are identified

INSERT FIELD CARD WHEN FINALISED

Figure 6-1. NSMP field card for recording soil profile and landscape information

7 Recording Field Data using Mobile Apps

Standard Operating Procedure

Project:	**National Soil Monitoring Program for Australia**
Title:	**Recording field data using mobile apps**
Version Date:	30 October 2024
Version:	0.8 Initial draft

Purpose

This procedure describes the digital tools that are to be used to record the field data. This ensures data is collected in a standard format and readily received into the project database.

Scope

To Be Written

The implementation tools and procedures to collate the identified core soil data types are shown in Figure 7-1. It is anticipated these will have upgrades and modifications as the Project progresses.

1. eDIRT - Soil profile characterisation will be recorded on field sheets and then entered into the system
2. ODK (Open Data Kit) – four bespoke forms to collect:
    a. Soil sample information including site data, the site boundary, observation locations, photos
    b. Land use and land management practices
    c. Consignment information (Set, freight, chain of custody field to archive)
    d. Failed sites information

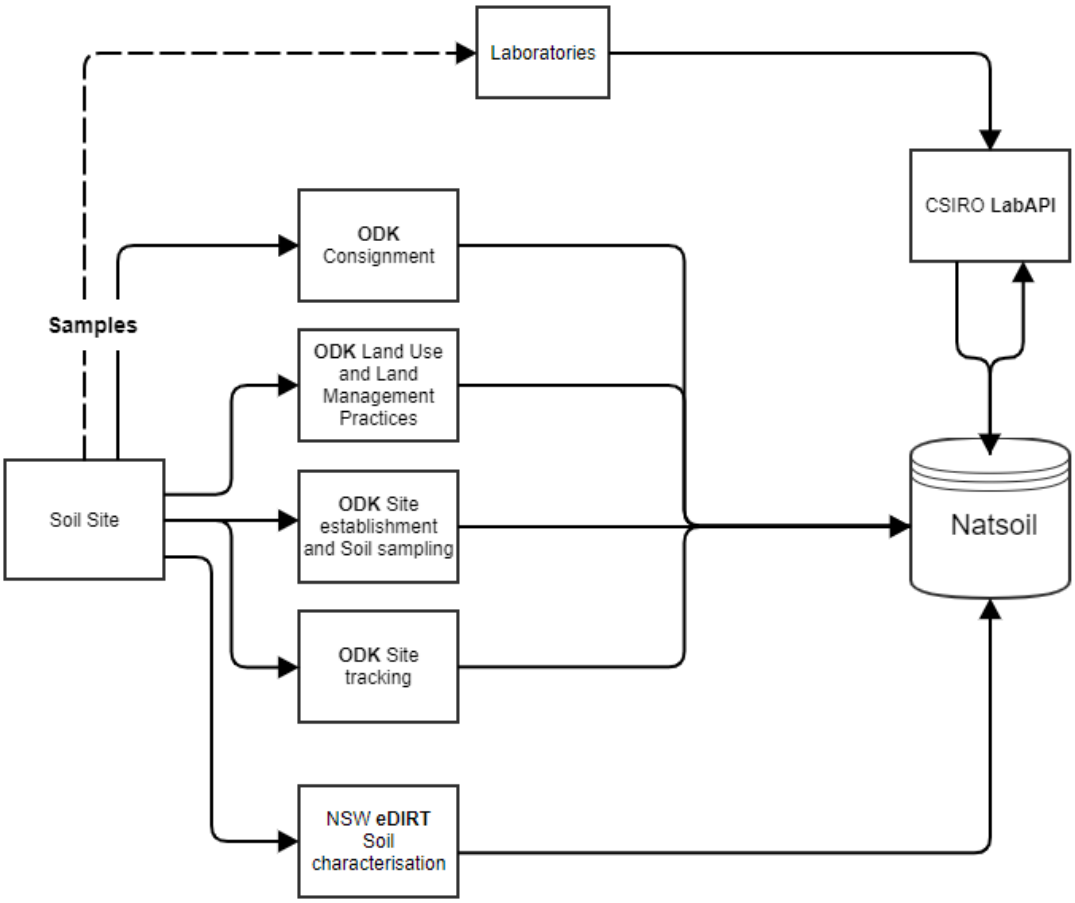

Figure 7-1. Shows the components for soil data collection

References and Related Documents

To Be Written

Roles and Responsibilities

- NSMP Project Leader – to provide overview and ensure field teams understand the process and requirements for recording field information.
- NSMP Data Leader – to provide the application to the field teams, ensure they are registered and operational.
- Field Team Leader – to ensure field data applications are operational and work with field team to use them. Ensure health and safety for field operations and safe operating procedures for all equipment is understood.
- Field team member – conduct the field data capture work as instructed.

Equipment

The list (Table 7-1) is not exhaustive but provides guidance as to the equipment and minimum number of items required to digitally record field data to facilitate transfer into the project database.

Table 7-1. Equipment list to guide what is required to record field collected data using.

Item	Number	Comments
GPS unit	1	Sub-meter accuracy, for recording sample locations. Using project standardised datum
Device (tablet or mobile phone) running the sample collection application	1	For recording the descriptive information. For early months of the project the descriptive information will have to captured on field sheets and transcribed using a desktop computer into the soil data entry application
Sample recording sheet	1/site	Backup to manual record sample data if device is not working

Procedures

To Be Written as details are finalised for the data capture and data workflow.

Guidance Notes

To Be Written – when uncertainties are identified

8 Soil Laboratory Analysis

Standard Operating Procedure

Project:	**National Soil Monitoring Program for Australia**
Title:	**Soil laboratory analysis**
Version Date:	30 October 2024
Version:	0.8 Initial draft

Purpose

This procedure lists the laboratory analysis to be conducted and identifies the preferred methods that are to be used.

Scope

To Be Written once Laboratory has been identified and contract arrangements completed

References and Related Documents

To Be Written

Roles and Responsibilities

- NSMP Project Leader – to provide overview and ensure field teams understand the process and requirements for recording field information.
- NSMP Data Leader – to provide the application to the field teams, ensure they are registered and operational.
- Laboratory Manager – to ensure

Equipment

To Be Written

Procedures

To Be Written

Table 8-1. List of laboratory analysis to be conducted as a minimum, and their requested methods to follow

Table 1 – Required laboratory analysis and the requested method codes				
Analysis Items.	**Property**	**Method Code[1]**	**Comprehensive Set**	**Basic Set**
1	Sample preparation	Drying, griding, sieving	X	X
2.1	Sample weights and moisture content	Field moist as received total sample weight	X	X
2.2		Airdry (40oC) total sample weight	X	X
2.3		Moisture content of airdry soil compared with oven dry (105oC), achieved by subsampling	X	X
3.1	Air dried sample sieved weights	>2mm fraction	X	X
3.2		<2mm fraction	X	X
4	pH (H_2O)	4A1	X	X
5	pH (CaCl2)	4B2	X	X
6.1	Effective Cation exchange capacity (Ca, Mg, Na, K) method selected according to sample criteria	15B1 (ph <7.3, EC<0.3))	X	
6.2		15B2 (ph <7.3, EC>0.3)		
6.3		15C1 (ph>=8.5)		
6.4		15E1/2 (variable charge soils >)		
7	Exchangeable Acidity (only for samples <ph 5.5 H_2O)	15G1 ($H^+ + Al^{3+}$ ph <5.5)	X	
8	Electrical conductivity	3A1	X	X
9.1	Total Carbon and Total Organic Carbon	6B2b	X	
9.2		6B3	X	
10	Total Nitrogen	7A5	X	
11	Total Sulphur	10A2	X	
12	Available Phosphorus (Colwell)	9B2	X	
13	Phosphorus Buffer Index (PBI - Colwell)	9I2a or 9I2b	X	
14	Potentially Mineralisable Nitrogen (PMN)	7D2a or 7D2b	X	

Table 8-2. List of additional laboratory tests that may be conducted and requested methods.

Table 2 – Additional Analysis				
Analysis Item	**Property**	**Method Code Requested**	**Comprehensive**	**Basic**
15	Aggregate Stability	Emerson	X (for selected samples)	
16	Particle Size Analysis	P.517[2]	X (for selected samples)	
17	Fine grinding		X	X
18	VisNIR spectral scanning		X	X
19	MIR spectral scanning		X	X
20	Chloride	5A1[3]	X	X

Table 8-3. List of other soil analysis to be conducted on selected soil samples.

Analysis Item	Property	Method Code Requested	Comprehensive	Basic
21	eDNA		X (for selected samples)	
22	Bulk density		X (for selected samples)	
23	Soil water retention characteristics		X (for selected samples)	

Guidance Notes

To Be Written – when uncertainties are identified

9 Freighting Soil Samples

Standard Operating Procedure

Project:	**National Soil Monitoring Program for Australia**
Title:	**Freighting soil samples**
Version Date:	30 October 2024
Version:	0.8 Initial draft

Purpose

This procedure describes the process to handle, prepare and package soil samples for freighting. Including the documentation and communication required that will allow tracking

Scope

To Be Written

once there is certainty between who is collecting the soil in the field and laboratory location, which will determine how freight will be arranged.

References and Related Documents

To Be Written

Roles and Responsibilities

- NSMP Project Leader – to provide overview and ensure people involved understand the process and requirements for handling and transporting soil samples.
- NSMP Project Manager – to provide oversight and coordination.
- Field Team Leader – to package samples for freight to the laboratory, providing required documentation.
- Laboratory Manager – confirms receipt of soil samples from field teams. Prepares remaining soil sample after analysis for freight to the Soil Archive.
- Soil Archive Manger – confirms receipt of soil samples from laboratory. Stores soil samples in Soil Archive according to facilities procedures.

Equipment

To Be Written

Procedures

To Be Written

Guidance Notes

To Be Written – when uncertainties are identified

References

TO BE ADDED TO

McKenzie, N.J., Coughlan, K., and Cresswell H. (2002a) Soil physical measurement and interpretation for land evaluation. Australian soil and land survey handbook series, Volume 5. CSIRO Publishing: Collingwood, Victoria

National Committee on Soil and Terrain (2009) Australian soil and land survey field handbook (3rd edition). CSIRO Publishing, Melbourne.

Rayment G. E and Higginson F. R. 1992. Australian laboratory handbook of soil and water chemical methods. Inkata press. Melbourne.

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