

FARM-SCALE SOIL MAPPING PROTOCOLS FOR NEW ZEALAND

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Abstract

Farm Environment Management Plans and nutrient budgeting is now a compulsory regulatory requirement in a number of regions across New Zealand, and are reliant on quality soil information as a key input. The soil mapping protocol presented here provides standards and guidance to be used nationally for collecting and presenting soil map information. This Envirolink tools project was initiated by Regional Councils to address the need to provide: a framework for consistent soil mapping, identification of appropriate methods, a process to determine if the work has met minimum standards, and guidance on the level of detail required for different land use applications. This was to overcome the variety of soil maps generated and differing standards of work that could otherwise be provided.

The generic approach used to prepare the soil mapping protocols is based on a quality assurance / quality control process that are applicable at a range of scales and land use applications, allowing the document to be a New Zealand Soil Mapping Protocol.

Standards for different land use applications (these can be expanded as required) are established for 6 procedures (site density, site distribution, soil characterisation, soil variation, provider, and review) that are necessary components of soil mapping. Each of these procedures has 3 levels of detail (low, medium, and high) that are defined along with accompanying guidance information. This provides a framework to determine what is expected to be conducted to construct a soil map for applying to a particularly land use application.

Following on from this, the work outputs can be inspected using a listing of what is expected to be provided. Finally, a self-assessment matrix allows for a summary of the level of work detail to be evaluated.

The entire protocol is contained in 4 tables, with the remaining text providing detailed guidance, rationale and explanation. The protocol is freely available online at <http://www.envirolink.govt.nz/assets/Envirolink/Tools/R12-4-New-Zealand-soil-mapping-protocols-and-guidelines.pdf>.

Purpose of the New Zealand Soil Mapping Protocol

The soil mapping protocol presents a framework and guidance to support the preparation of soil maps and supporting documentation, and to facilitate assessment of the soil map quality.

The protocol document aim is to help New Zealand implement a nationally consistent approach to conduct soil mapping. Using the protocol should produce defensible soil maps that are fit for purpose to support land management decisions by providing clarity as to what procedures and level of detail is required, and against which an assessment of the mapped output could then be made. The protocol document is *not intended* to provide instruction on how to construct a soil map.

The protocol is generic and applicable for all soil mapping scales. However, the focus in preparation was for farm-scale soil mapping (about 1:500 to 1:20,000 scales). The approach and guidance provided is also likely to be applicable to other non-farming applications requiring soil maps, e.g. urban and peri-urban development, mine sites, effluent disposal schemes, and industrial sites.

How do we know the soil map presented is of sufficient quality?

The quality of a soil map could be determined by an independent separate field survey verification process to evaluate the descriptive and predictive outputs of the work. This would be conducted by an experienced soil surveyor using knowledge and structured sample design to check the soil map. In some cases this would be required where the map is to support significant investment decisions or environmental concerns to provide confidence in the soil map generated. However, in most cases this would be considered too much of an overhead expense, particularly for a small area farm soil map.

Therefore, the approach in this protocol is aligned to Quality Assurance/Quality Control process. The quality of the work can be managed by the following:

1. **Procedures** for survey work activities have accepted documented guidance (prior to work starting) and when followed provide confidence that the soil map will fulfil requirements for quality and fit for purpose. The process can be referred to as Quality Assurance, making sure you are doing the right things the right way.
2. **Inspecting** the soil map outputs and verifying that they satisfy the specified requirements. The process can be referred to as Quality Control, making sure the outputs of what you did are what are expected.

Structure of the protocol

This soil mapping protocol is in two parts:

- First, the **key procedures** are identified and the level of detail required for different applications of the map are documented. **See Table 1 and Table 2** for a summary and **Section** Error! Reference source not found. of the primary report for detailed guidance.
- Second, the **inspection checklists** ensure that necessary information is provided in the soil map outputs. **See Table 3** for information to be provided and **Table 4** for evaluation of the work conducted.

For people using the protocol, a workflow is presented in Figure 1:

- **Clients** can refer to **Table 1** to assist with preparing the survey work scope.
- **Providers** can refer to **Table 2** to help confirm minimum standards for procedures, **Table 3** to determine what is to be provided, and **Table 4** checklist to evaluate what has been provided.
- **Users** can refer to **Table 3** and **Table 4** to help evaluate the soil map outputs and compare this against recommended guidance in **Table 1**.

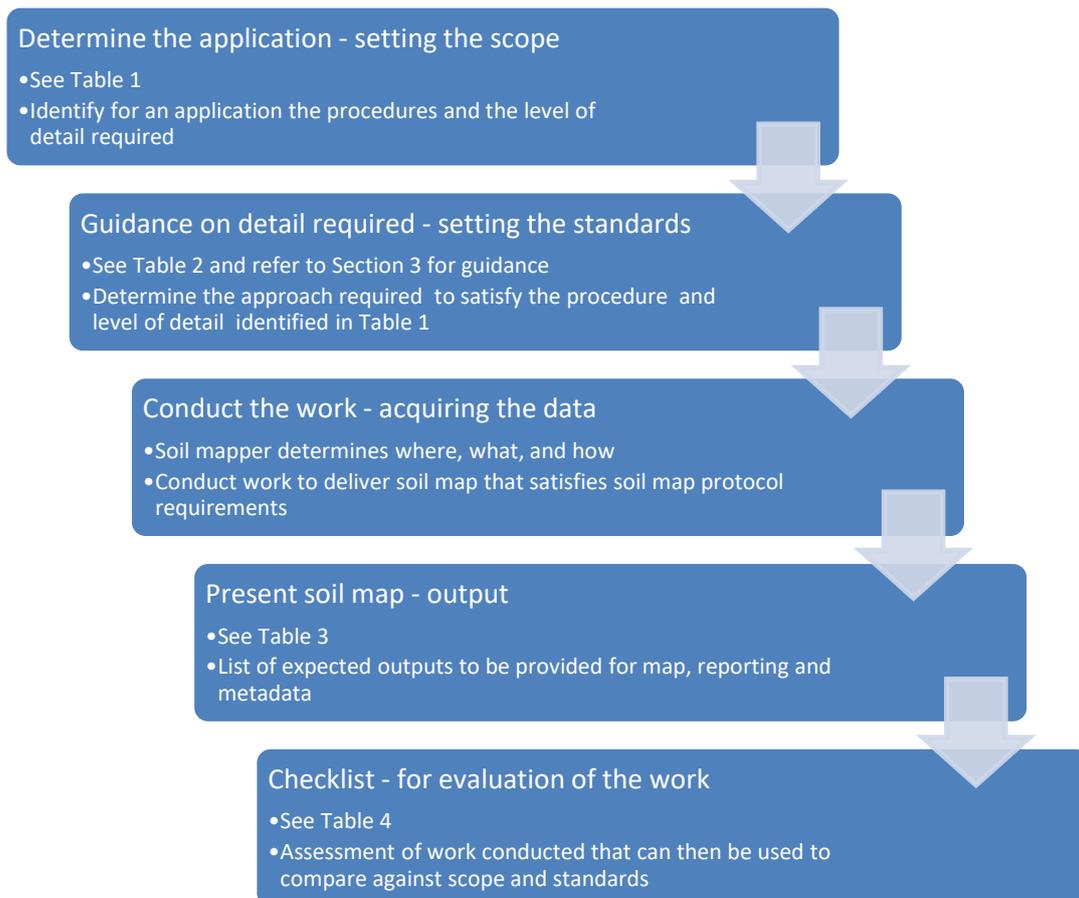


Figure 1. Presents a workflow and identifies protocol tables that provide standards and guidance.

Primary report

The entire protocol is contained in 4 tables, with the remaining text providing detailed guidance, rationale and explanation. The protocol is freely available online at <http://www.envirolink.govt.nz/assets/Envirolink/Tools/R12-4-New-Zealand-soil-mapping-protocols-and-guidelines.pdf>.

Protocol approach – procedures and inspection

The list of procedures required to construct soil maps will generally remain the same for all soil mapping efforts. The level of detail to be provided and methods to be followed would be determined by the application or purpose that the soil map is to be used for.

Applications, procedures and minimum level of detail

A selection of applications that soil map information could be used for are listed along with the procedures and their recommended minimum levels of detail required (Table 1). The table is set up so that new applications or subsets of existing ones can be established as needed by adding extra rows for the application and level of detail required for the procedures.

The minimum level of detail required has been determined by expert judgement. However, the client or user of the soil map may specify in their project work scope a higher level of detail. Given one of the purposes of this protocol is to document accepted standards, it is not recommended that work be conducted below the minimum level of detail identified.

Procedure information required to satisfy a level of detail

The level of detail required for each procedure is described in Table 2, where three categories are described (low, medium, high). Note that the level of detail does not necessarily imply level of quality, but describes the level of information provided to support the procedure, from high (or optimum) level and decreasing to a low level (or minimum).

Discussion and description about the Table 2 criteria are provided in Section 4 of the primary report.

Inspection check list – requirements for a soil map output

The aim of the check list is to provide guidance as to what a soil map output should provide (Table 3). This guidance is necessary to ensure there is sufficient supporting information: (i) for the soil map, and (ii) to provide data that can be used to evaluate the soil map quality.

Self-assessment summary list of work conducted

This one-page table allows a self-assessment of the soil map to be summarised and documented (Table 4).

This serves as a guide for quick evaluation of the work conducted. The level of detail identified here can then be used as a check against the original work scope and minimum level of detail requirements for the soil map application (Table 1).

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Table 1. Soil map applications and the minimum level of detail required for each procedure (see Table 2 for description of codes).

Note: level of detail is a minimum standard guide and the client or user may vary it to a higher level to match their needs

Application for soil map	Procedures to be addressed					
	Site density	Site distribution	Soil characterisation	Mapping method	Provider	Review
Level of detail codes: H=high, M=medium, L=low						
S-map online input	M	M	M	M	M	H
General farm management planning	L	L	L	L	M	L
Precision farming; irrigation planning;	H	H	M	M	M	L
Hill country grazing management; forestry establishment	L	L	L	M	L	M
Infrastructure planning, e.g. for storm-water	H	H	M	H	M	M
Determining high value soil areas	H	M	L	M	M	H
Nutrient budget – verification of existing map e.g. Overseer input	L	L	L	L	L	M
Nutrient budget – new farm soil map e.g. for Overseer input	M	M	M	M	M	M
Nutrient budget – measured soil properties e.g. for Overseer input	H	M	H	H	M	M
Land treatment – verification of existing map e.g. for dairy effluent	M	L	L	M	L	M
Land treatment – measured soil properties e.g. for dairy effluent	H	M	H	H	M	M
Land treatment – industrial or municipal wastewater	H	H	H	H	H	H

Table 2. Summary of the levels of detail applied to each procedure (see report Section 4 for explanations)

Procedure	Level of detail <<< Increasing – Decreasing >>>		
	High (H)	Medium (M)	Low (L)
Site density (read in context of map scale)	Total of 1 observation per 1 cm ² of published map area	Total of 1 observation per 2 cm ² of published map area	Total of 1 observation per 4 cm ² of published map area
Site distribution (representativeness)	Explicit (repeatable, reproducible, statistical)	Knowledge-based (environmental gradients, transect, catena, stratified)	Free survey (relies on surveyor judgement)
Soil characterisation (information collected to provide evidence)	Measured (soil properties determined by analysis in the field or laboratory)	Detailed morphological descriptions (for pedotransfer functions and determining NZSC)	Soil type identification (limited description to identify a soil type or soil property)
Mapping method (how soil was mapped)	Described explicitly, numerical or diagrams	Narrative description	No information, accept surveyor judgement
Provider (soil surveyor)	Proven experience and approved	Proven experience	Gaining experience
Review (checked by peer)	Desktop review and site visit	Desktop review	Not required, acknowledge information sources

Table 3. Check list showing information required as part of the soil map output

Item	Information required
Map	<i>Mandatory to be provided</i>
Map format	Either as GIS compatible digital data or printed hardcopy. To be determined by client and the end result of the work.
Map base	Coordinate grid with sufficient information to locate position. Usually with imagery and/or cadastre background (referencing source and date).
Map information	Title of the survey. Date survey conducted. Scale at which the survey was conducted. Information used to construct map.
Soil variation	Shown as map unit polygon boundary lines or coloured raster pixels. Map units labelled, providing a link to the map legend.
Map legend	Descriptive legend: identifying the soils within each map unit, their relative abundance, predicted location and related landscape information.
Supporting data	<i>Mandatory to be provided</i>
Survey scope	Who was the client that requested the work. Why the work was conducted, what was the intended application. Who conducted the work, affiliation, and statement of their experience. Where did the survey occur, name, and distance to nearest town or roads. What were the survey area, size, and shape.
Methods	What standards and guidelines were followed. What background information considered. Rationale for selection of survey scale. Describe approach to select sites. List field and laboratory measurements, with method code and reference. Describe how the soil map was constructed. Quality assurance and quality control procedures conducted.
Results	Number of sites investigated and types of observation made. Location of sites investigated – coordinates recorded (NZTM coordinate system recommended), marked on a map. Description of soil map units – location, landscape, soils, relative abundance of soils within map unit, and difference from other map units. Descriptions of soil classes and/or soil properties – identify typical sites and present all data. Soil description and measured data, e.g. laboratory result sheets – provide in appendix or database. Photographic record – at a minimum one photograph for each map unit and soil type. Review process – findings and how they were addressed.
Accompanying Information	<i>Not mandatory but may be requested by client</i>
Interpretation Conclusion	Project scope will identify if these sections are required and if required what should be considered and evaluated.

Table 4. Self-assessment list; providing a summary of the work level of detail conducted

Background			
	Survey title		
	Location: nearest town and region		
	Date survey conducted		
	Surveyors name and organisation		
	Client		
	Application soil map was prepared for		
Procedure	Item	Details	Level of Detail
Site density			H M L
	Land use		
	Map scale		
	Total number of sites	No. of sites:	
	Area of survey	ha	
	Site density	sites/ha	
Site distribution			H M L
	Site selection approach	Statistical / Knowledge / Free survey	
	Base data used and source (e.g. aerial photos, LIDAR, geology, EM, soil map)		
	Site distribution shown on a map	Yes / No	
Soil characterisation			H M L
	Measured data	No. of sites:	
	Detailed morphology	No. of sites:	
	Soil type identification	No. of sites:	
	Results provided and methods identified	Yes / No	
Mapping method			H M L
	Map provided as GIS compatible digital data	Yes / No	
	Map provided as hardcopy	Yes / No	
	Soil map descriptive legend provided (includes map unit composition, soil types, proportion and location of soil types)	Yes / No	
	Models (numerical or diagrams) describing soil landscape relationship provided	Yes / No	
	Written text describing process to construct soil map provided	Yes / No	
Provider			H M L
	Surveyor satisfies proven experience	Yes / No	
	Surveyor has approved status	Yes / No	
Review			H M L
	Who conducted the review		
	Desktop assessment conducted	Yes / No	
	Site visit assessment conducted	Yes / No	