FAST FARM-SCALE SOIL MAPPING FOR SOIL AND NUTRIENT MANAGEMENT USING LIDAR IN THE MANAWATU

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Abstract

Soil information is very important to both farmers and resource managers such as regional councils. Soil characteristics influence farm management factors such as; whether the paddock is dry enough to graze without causing pugging or bypass flow to waterways, potential pasture or crop production, tillage costs; e.g. tractor energy and/or number of passes required to get a good seedbed, number of days after rain before the paddock is grazeable, plowable or able to be irrigated with shed effluent and ability of the soil to store or filter nutrients. Therefore good soil information is vital for sound nutrient management planning and grazing management. However, regional scale soil maps are often not accurate enough for use at farm scale, meaning that important soil units or critical nutrient hot spots may be missed. With soils frequently varying within paddocks, there is always tension between the need to minimise costs and the need for accuracy. Horizons LIDAR derived elevation data was tested for its utility for predicting soil type on Tony Collis' cropping farm near Kairanga. Soil profiles were investigated at eleven sites on the farm; initially to determine the range of soil types on the farm and later to associate them with elevation ranges and check these for accuracy. Soil structure was also described using the VSA drop test method. We found a good relationship between elevation and soil type and were able to quickly use the LIDAR to map soil units on the farm. Using the visual soil assessment data from this and previous surveys we were also able to demonstrate a relationship between soil type and soil physical quality; (aggregate size and visible porosity). This is important because structural vulnerability has been associated with potential for phosphate leaching. There is scope for more work in this area; to confirm and document soil-elevation relationships in the Manawatu and around New Zealand and to use this information to enable high resolution farm management plans to be delivered cheaply.

Introduction

This poster paper describes an example of the use of a detailed digital elevation model, derived from LIDAR, to assist with delineation of soil units in the preparation of a Soil Health Farm Plan. Horizons Regional Council staff prepare Soil Health Farm Plans for farmers who are interested in better understanding the soils on their property and how to best manage them to enhance profitability and benefit the environment. Note that Horizons' soil health programme is quite small and operates in the plains environment in contrast to its Sustainable Land Use Initiative, which is large and concerns preparation of Whole Farm Plans and provision of grant assistance in hill country. The basis of the Soil Health Farm Plan is a farm scale soil map. Existing soil units from regional scale soil maps are remapped at farm scale, based on soil profile descriptions. Soil quality is also assessed using the Visual Soil Assessment (VSA) technique. Soils are grouped into management units based on their strengths and weaknesses, and recommendations are made for sustainable management. Examples of where soil characteristics influence farm management include;

- whether the paddock is dry enough to graze without causing pugging or bypass flow to waterways,
- potential pasture or crop production,
- tillage costs; e.g. tractor energy and/or number of passes required to get a good seedbed,
- number of days after rain before the paddock is grazeable, plowable or able to be irrigated with shed effluent and
- ability of the soil to store or filter nutrients.

These factors vary on a scale of metres to hundreds of metres, but regional scale soil maps are often only accurate to hundreds of metres or kilometres. When mapping soil, a critical issue is how to quickly understand the distribution of soils in the landscape (in other words form a soil-landscape model) and then map it. However, digging soil profile pits and accurately describing them can be very labour intensive.

A detailed digital elevation model (DEM) has the potential to accelerate this process because it provides a ready made model of the landscape. The soil mapper can therefore better locate soil profile sites, and get away with digging less holes. The DEM also makes delineation of soil unit boundaries far easier.

Mapping

We visited the farm armed with the regional scale soil map printed over the farm boundary and aerial photography, and spent some time talking to Tony about the different soils he knew were present and inspecting them together. We then returned to dig and describe several soil profiles, use the VSA technique (Shepherd 2000) and to begin drawing lines on the map based on the soil-landscape understanding we had gained. Soils were classified and named based primarily on texture and depth to mottles.

The flat topography on the farm made it difficult to determine from the aerial photo where to draw the soil boundaries (figure 1). We decided to test a LIDAR derived 0.1m DEM for its ability to help delineate the soil units we had already identified. The DEM had been prepared for Horizons flood management purposes.

It seems that another effect of the flat topography was that the DEM contours had a particularly good fit to the soil boundaries. By plotting the soil profile points and DEM together (figure 2) we were able to pick heights above sea level that corresponded to where the boundaries should be based on the data (figure 3). Based on work done by Landcare Research we then produced maps of vulnerability to structure loss and compaction (Hewitt and Shepherd 1997) and susceptibility to nutrient leaching.

LIDAR derived DEMs were displayed over four other previously mapped soil health farm plans, to determine whether they would have been useful at the time of mapping.

Results and Discussion

Tony Collis' farm is located on the outwash fan of the lower Oroua river and Taonui stream, west of Palmerston North It is mapped in Cowie (1978) as Kairanga series; gley recent soils developed in alluvium. Cowie's map showed the occurrence of Kairanga fine sandy loam along the northern edge of the farm and Kairanga silt loam in the middle and two fingers of Kairanga peaty silt loam coming in from the south east (figure 4). Discussion with Tony confirmed the location of sandy soils at the north of the property but revealed additional areas of peaty soil. Despite Cowie's map being one of the most accurate soil maps in the Manawatu-Wanganui Region, it was still deficient at farm scale in this case.

Table 1: Main features of soil types on Collis farm.

Soil Unit	Drainage Class	Depth to 50% gley layer (cm)	Vulnerability to Pugging
Kairanga clay loam	poor	19-26	very vulnerable
Kairanga peaty clay loam	poor	0-19	vulnerable
Kairanga sandy clay loam	poor	22	vulnerable
Kairanga fine sandy loam	imperfect	35	medium

Topsoil textures seemed to be more clayey than when they were mapped by Cowie, indicating organic matter loss from conventional cultivation. Soil aggregates have merged into quite large blocks in some areas. Individual components of the VSA score are shown below. A score of 0 indicates poor soil quality while a score of 2 indicates excellent quality. Figure 5 shows how this data was presented to the farmer.

Table 2: VSA results

Texture	Structure (0-2)	Porosity (0-2)	Worms Number.	Worms Score (0-2)	Colour (0-2) Mottles	Colour (0-2) Greyness	Surface Relief
clay loam	0	0.2	6	0	1	0	1.5
slightly peaty clay loam	0.3	0.5	46	2	0	1	2
slightly peaty clay loam	0.1	0.5	0	0	0.5	1.5	2
fine sandy loam	0.8	1	11	1	0.5	0.5	1

Although not statistically significant, due to a lack of sample sites, the observed structure and porosity scores correspond with what has been observed in previous surveys (Todd 2006) – that macroporosity and aggregate size can be predicted by vulnerability class. (Figure 6).

Figure 7 shows a farm map of vulnerability to pugging. Vulnerability to leaching is the same, as the soils with the most clay have the largest aggregates and are therefore the most susceptible to bypass flow to the mole drains.

Of the five farms where soil has been mapped at detailed scale, and LIDAR DEMs are available, the DEM would have been useful in speeding up soil mapping on three. The farms where the DEM was not useful were all one soil type. Figure 8 shows a LIDAR derived DEM over farm-scale soil mapping at Foxton Loop. The DEM clearly shows the dunes and the boundary between the Awahou sand (orange) and Kairanga soils (yellow). Figure 9 shows the same near Marton. The DEM contours clearly differentiate sloping gullies with Marton soils from flat ground with Kiwitea loam. More accurate lines could have been drawn if the DEM was available at the time of mapping.

Conclusions

Detailed DEMs will usually be very useful for farm-scale soil mapping and will enable an increase in accuracy while decreasing the cost of mapping. There is scope for more use of LIDAR derived DEMs by Regional Council staff and other soil mappers but for this to happen the DEMs need to be made available. There is also scope for more research in this area; to confirm and document soil-elevation relationships in the Manawatu and around New Zealand.

Acknowledgements

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References

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Figure 1: Aerial Photo of Collis farm showing difficulty in reading landforms on photo.

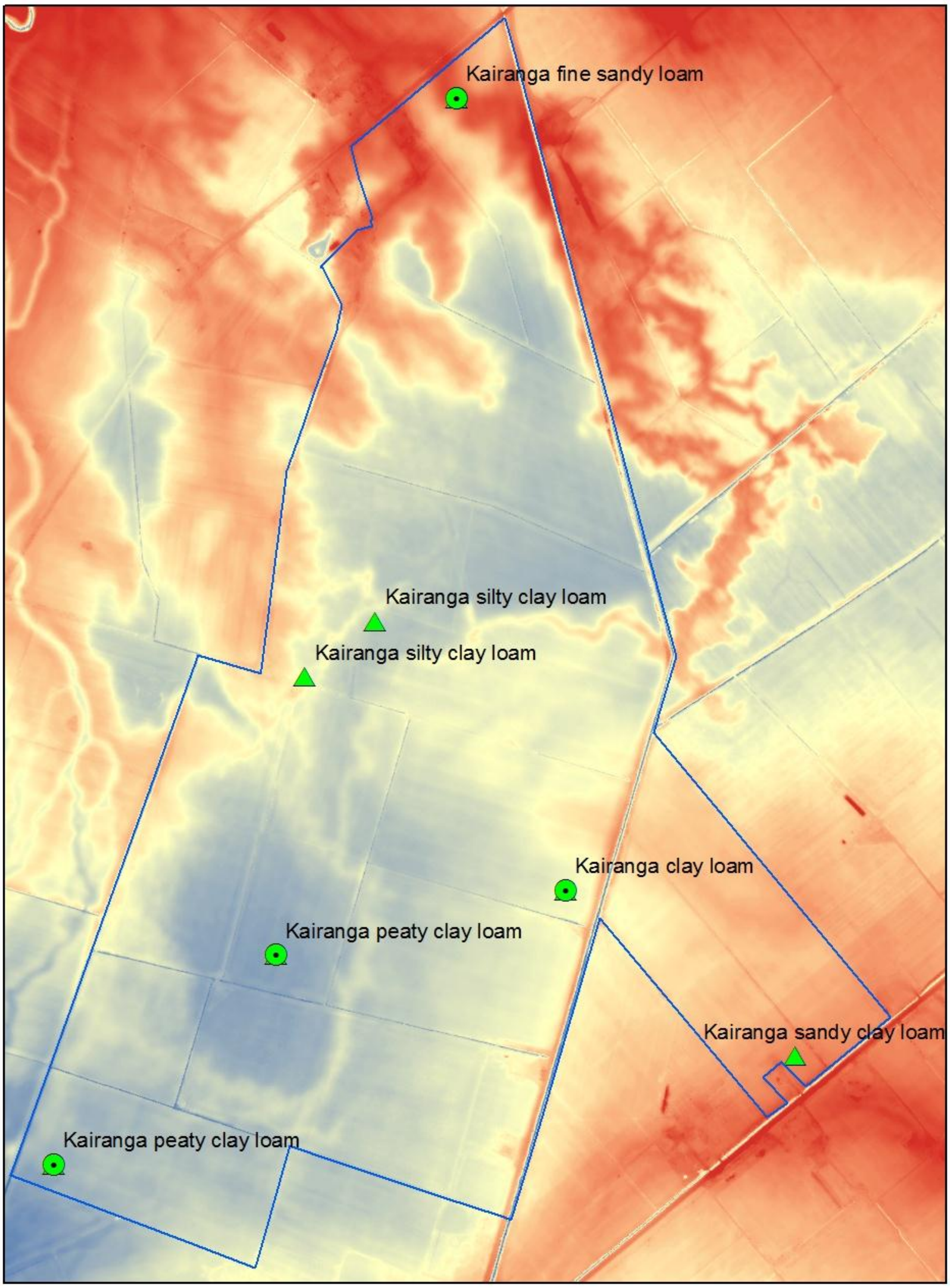

Figure 2: Soil profile locations in relation to the DEM

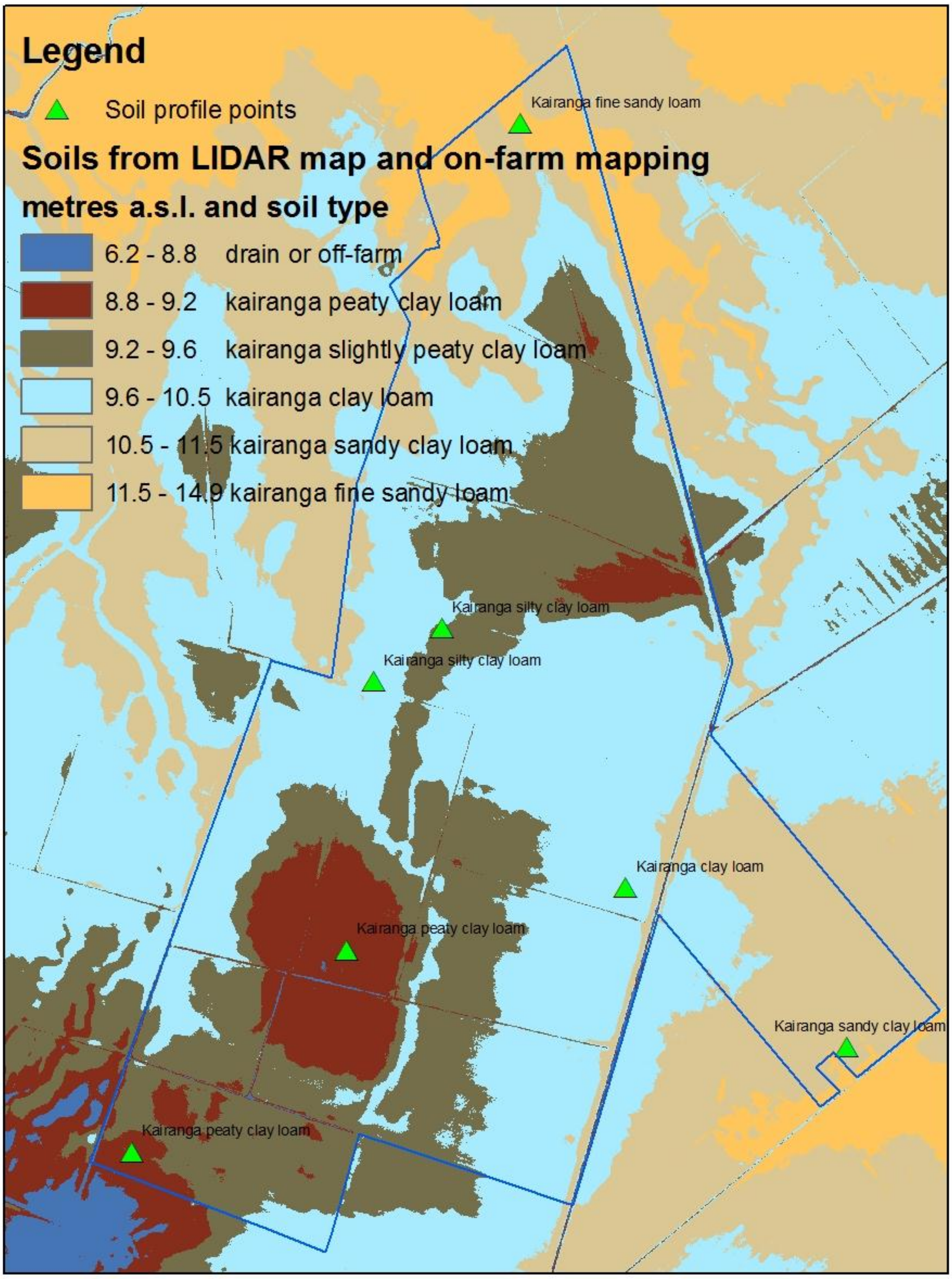

Figure 3: The resulting soil map with boundaries made from DEM contours

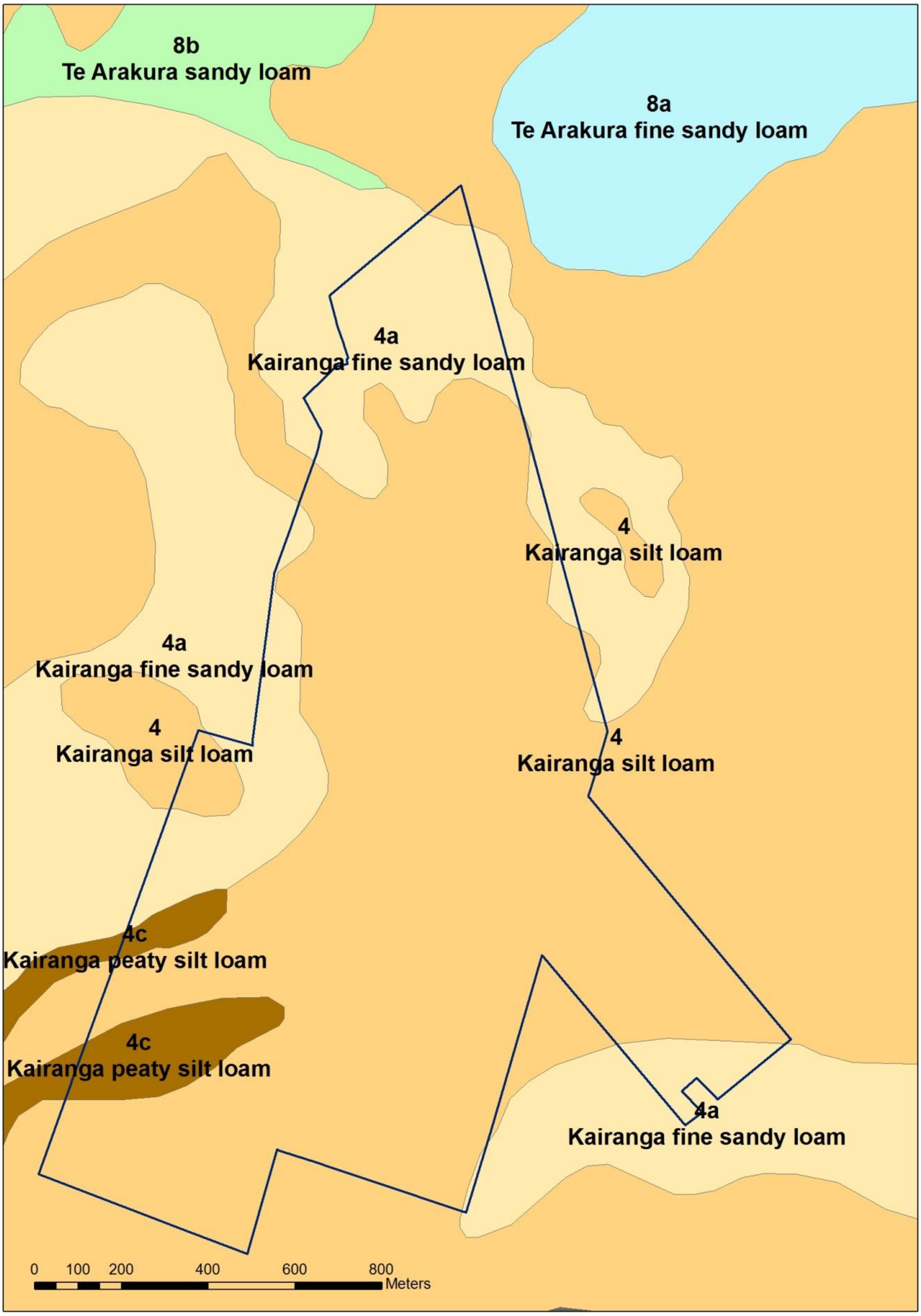

Figure 4: Regional scale soil map Soils of Kairanga County zoomed to Collis farm.

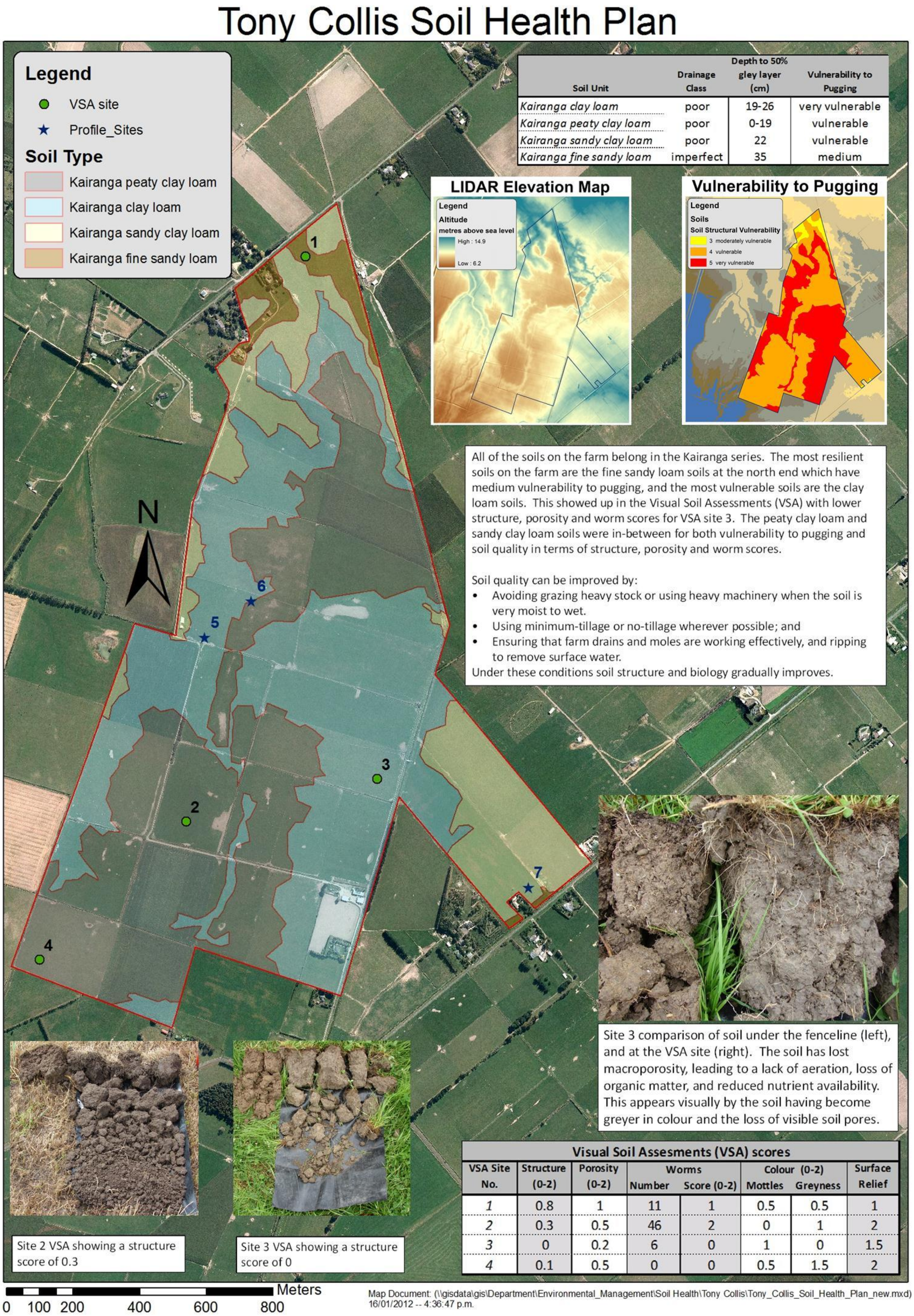

Figure 5: Collis soil health plan.

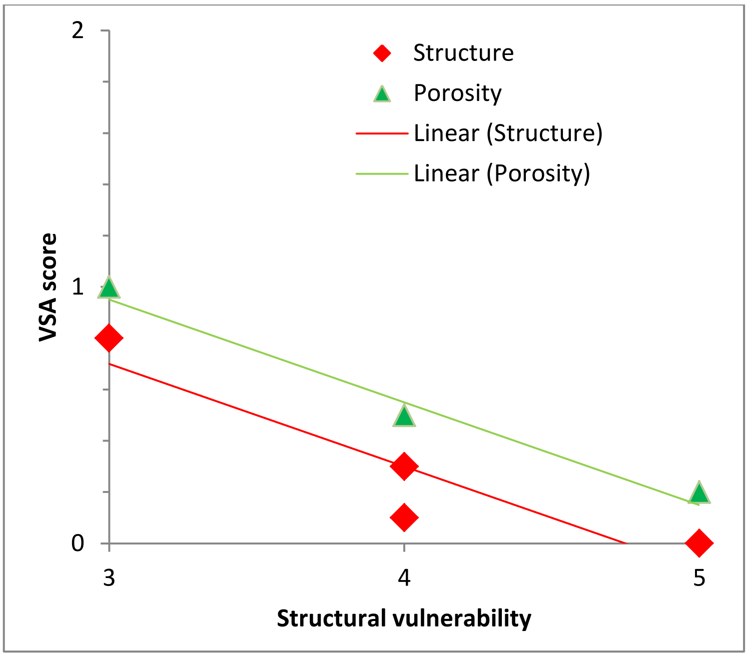

Figure 6: VSA structure and porosity scores in relation to vulnerability to pugging (3 is slightly vulnerable and 5 is highly vulnerable).

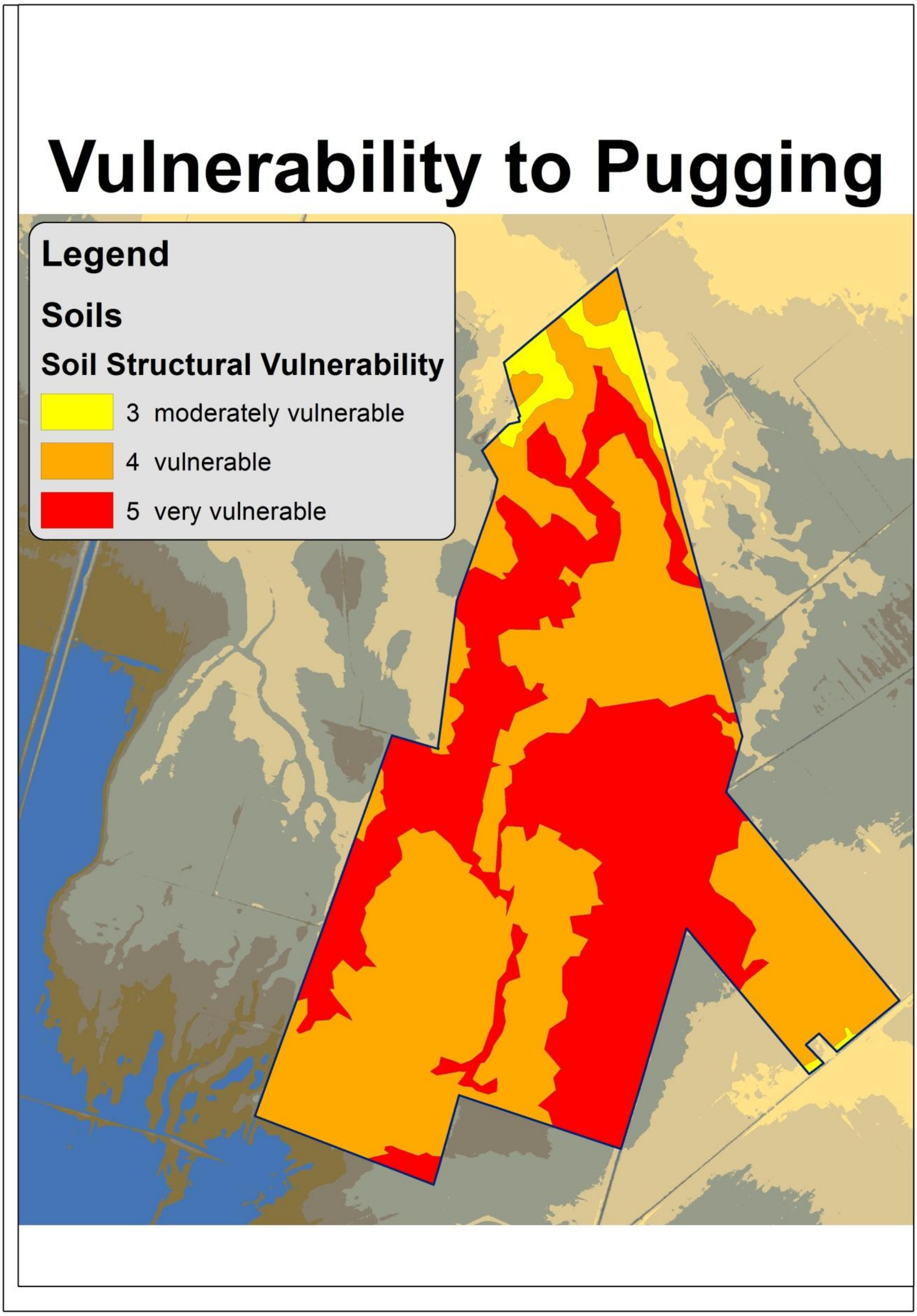

Figure 7: Vulnerability to pugging map for Collis farm.

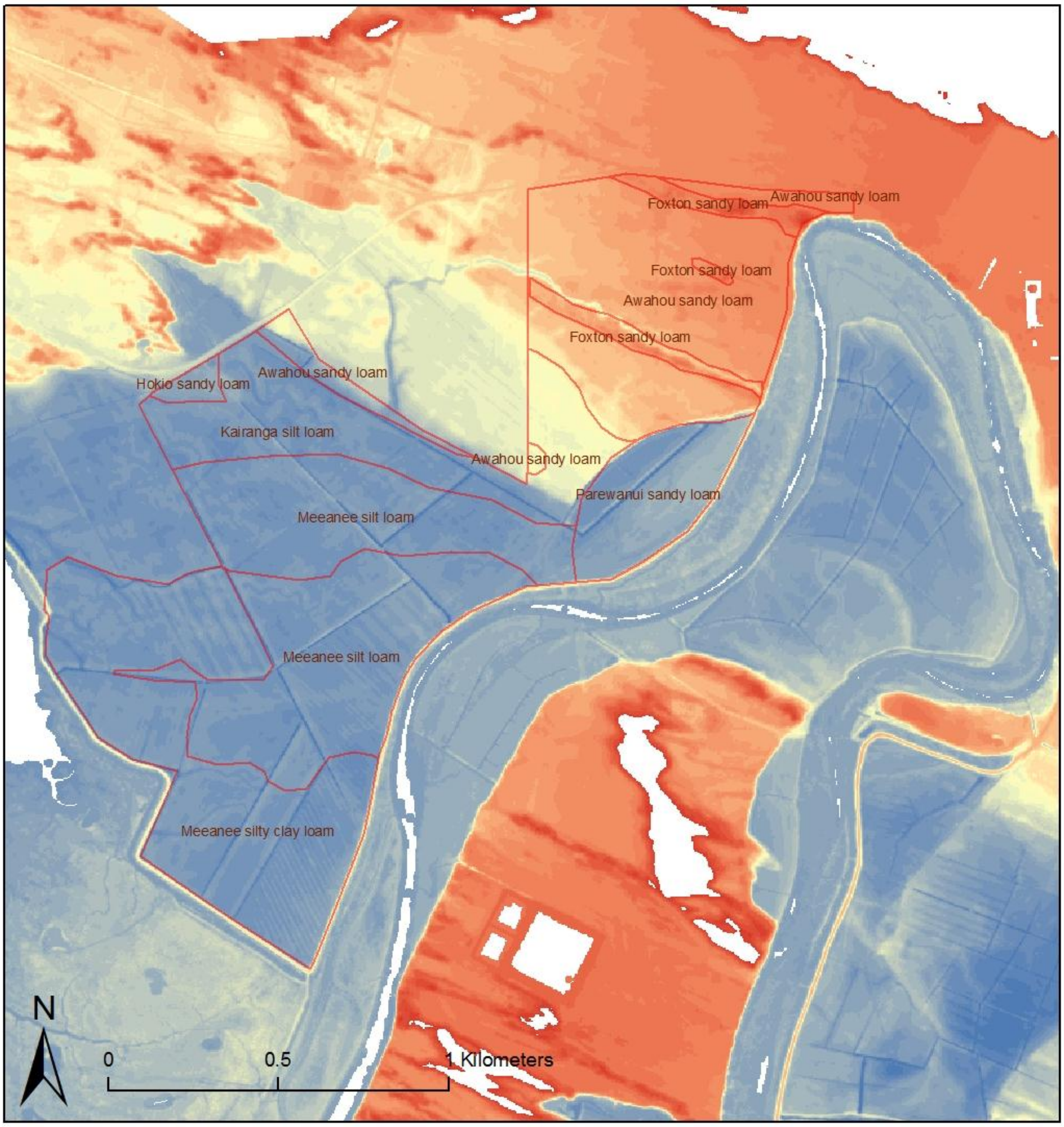

Figure 8: Detailed soil map, Foxton Loop, with DEM.

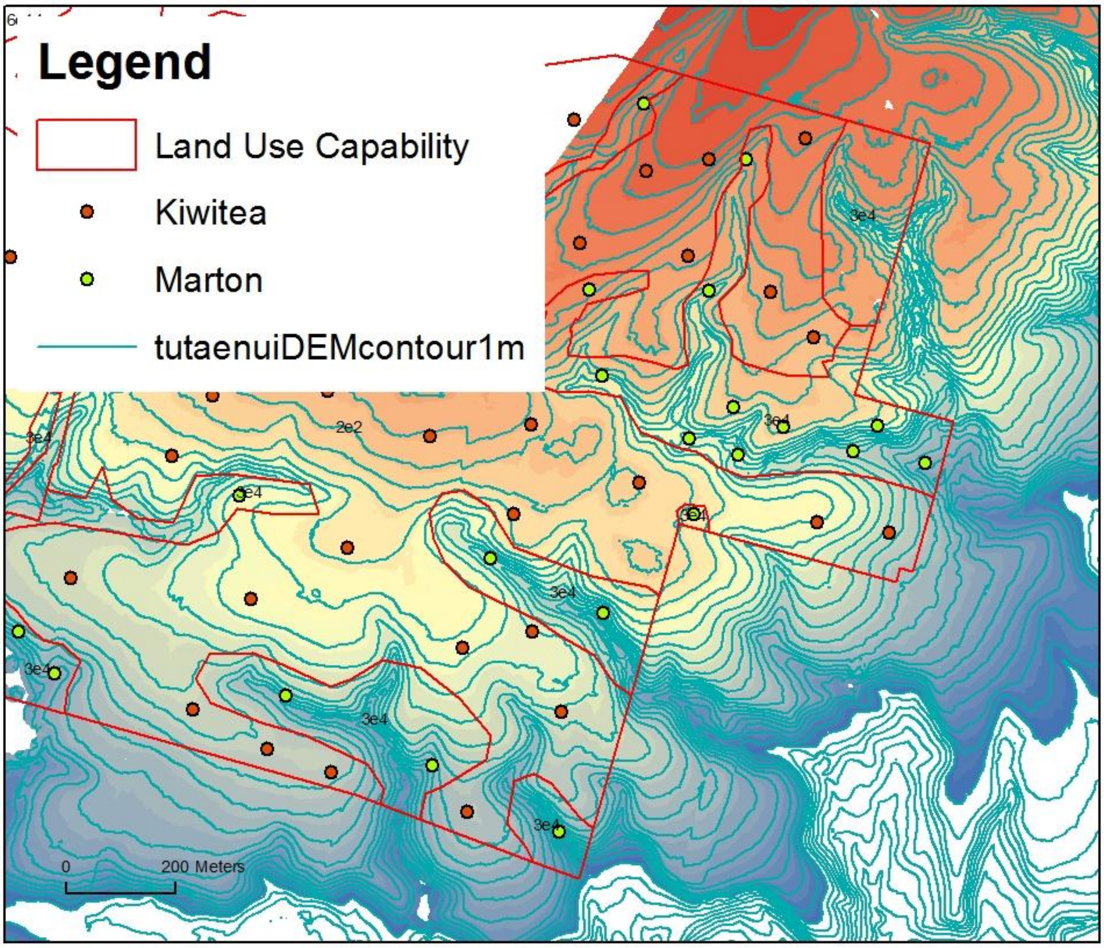

Figure 9: Detailed soil map near Marton with DEM.