The use of ground penetrating radar to map soil physical properties that control water flow pathways in alluvial soils

A thesis presented in partial fulfilment of the requirement for the degree of

Master of Science

in

Agriculture

at Massey University, Manawatu,

New Zealand.

Angela Louise Lane

2016

Abstract

Soil drainage models are vital for informing smart agricultural practices. Predicting soil drainage and zones where denitrification occurs, requires knowledge of the spatially varying subsurface features, for example soil-thickness, flow pathways, and depth to water table. Obtaining information about these features rapidly and non-invasively requires the use of geophysical techniques such as ground penetrating radar (GPR). While applications of GPR are diverse, ranging from geotechnical to archaeological investigations, to mineral and groundwater exploration, GPR has not been extensively applied in soil mapping for agricultural purposes across alluvial soils. The potential use of GPR for identifying subsurface features, such as the depth to gravel and water table which both influence soil drainage and denitrification processes, could benefit future developments in precision agriculture. To assess applicability of GPR for this purpose, this thesis presents research conducted on the alluvial soils at Dairy 1 farm, Massey University, Palmerston North. Radargrams were collected on two 0.4 ha plots, one arable and one pasture, using 200 MHz and 100 MHz antennas, in a 2-m grid pattern. Radargrams were ground-truthed with 13 soil cores and 21 auger holes, targeting different layers detected by GPR. The soil cores were analysed for bulk density, soil moisture and particle size. Using the 200 MHz antennas, soil textural banding was identified with specific reflection configurations within individual radargrams. These were represented when a contrasting textural boundary appeared as a continuous line of two to three bands. However, finer layering features were not identified. The 100 MHz antennas were able to detect depth to water table in the pasture plot. Soil moisture conditions were identified by a change in radar wave velocity. This appeared on radargrams as a difference in depth and radargram configuration shape. The use of Slice View images compiled from radargram data, assisted with identifying potential flow pathways and the depth to the water table across the pasture plot. Validation of radargrams with soil core samples indicates that GPR can obtain meaningful results from alluvial sediments ranging from sandy loams to silt loams. The use of GPR for

delineating subsurface features in alluvial soils is a promising tool that could assist with precision agricultural practices.

Acknowledgements

I would like express my appreciation to my supervisors Dr Sam McColl, Dr Carolyn Hedley and Associate Professor Ian Fuller for your advice, rewording, restructuring, the handy journal articles and chats that I somehow made sense of to form this manuscript. Thanks to the Brian Aspin Scholarship, Colin Holmes Dairy Scholarship, George Mason Sustainable Landuse Scholarship, Helen E Akers Postgraduate Scholarship and Horizons Advanced SLUI Scholarship for the financial support through my postgraduate degree.

Thanks to Paul Peterson and John Dando, for your assistance in the field, measuring plot areas and undertaking soil coring and augering. I appreciate your accurate record keeping and measurements. Thanks also to Eric Breard and Anja Moebis for your assistance with the Horiba Partica Analyzer. This formed such a crucial part of the thesis and I thank you Eric for your time over several months in setting up the Analyser. Thanks also to James Veitch for your assistance with GIS.

I would also like to thank other staff and students based at Massey University, Palmerston North who I came across, whether it was you assisting me with my work or me assisting you, I thank you for your time and the odd chat to keep me sane!

Mum, Don, Gerald and Mike for your positivity and keeping me on track, thanks for the 'check-up' phone calls Mum! Dad, thanks for your support and giving me the determination to complete a Masters.

Finally, Gareth, thanks for being my wing-man through this crazy adventure. Your love, support, strength and encouragement made me realise you can do anything you put your mind to, once the procrastination stops!

I never imagined I would ever write a thesis. I guess it's one of those paths in life…You're never lost, you're just exploring, and what an exploration it's been.

Angela

August 2016

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