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The reality versus conventional wisdom of measuring infiltration in structured and layered field soils

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Knowledge of the hydraulic attributes of field soils is generally scarce, but is necessary for decisions on sustainable management practices, e.g. the application rates of irrigation and effluents required to minimise runoff or activation of subsurface preferential flow. The last decade has seen rapid expansion of intensive agriculture in New Zealand. Several NZ research studies have identified preferential flowpaths as a key mechanism for transport of a range of environmental contaminants, and also indicate that the potential for preferential flow may be the norm rather than the exception. Securing investment in more widespread measurement of hydraulic attributes has proven difficult, largely due to the perception that they are costly to measure, and that the accuracy and reliability of methods is questionable.

The dynamics of water flow in the pore network in four large 50 x 70 cm deep lysimeters has been studied. The lysimeters contain an undisturbed silt loam soil column with three distinct layers. The soil type is typical of extensive areas in NZ's South Island, and is used mainly for intensive dairy grazing. Each column is intensively monitored via 30 tensiometers and 4 TDR sensors, connected to a datalogger that also monitors infiltration and drainage rates. Behaviour of the pore network has been studied under a range of infiltration conditions including: a) controlled surface suctions between 0 to 1.5 kPa using tension infiltrometers, and b) different irrigation and rainfall scenarios using a rainfall simulator.

These experiments show that macropore behaviour can have a strong influence on the accuracy and reliability of measuring near-saturated hydraulic attributes. Key issues

that will be presented include:

- *Macropore exclusion effect*. Only under saturated conditions does infiltration consistently follow the pattern of classical infiltration theory, i.e. a rapid sorptive phase, followed by a slower steady state. These experiments indicate that unsaturated infiltration can have a slow sorption phase, interpreted as a macropore exclusion effect, where the slow sorption reflects an air-filled macropore network impeding infiltration.

- *Non-uniform flow.* The conventional, simplified interpretation of tension infiltration data assumes uniform water penetration. Replicate measurements of matric potential at set depths in the lysimeters indicate that during infiltration at suctions $<$1.5 kPa the wetting is strongly non-uniform, and follows preferential flowpaths.

- *Feedback effect*. Conventional interpretation of tension infiltration data also assumes there is sufficient time before deeper soil layers ‘interfere’. Our results indicate strong interconnection of the pore network between layers, and that a dynamic ‘feedback effect’ often occurs from the early stages of infiltration. This effect occurs where the pore network of deeper soil layers affects the behaviour of the pore network in the layers above. This is important because there is a common implicit assumption that a tension infiltrometer will control the maximum actively conducting pore size. But this is difficult to achieve in unsaturated conditions due to the dynamic feedback mechanism.

- *What is an adequate infiltration measurement time?* The time to reach even a quasi-steady state is much longer than generally accepted. At the lysimeter scale, even 10 mm of cumulative infiltration required between 55 mins and 50 hrs. This raises questions regarding the reliability of measuring infiltration parameters over short measurement times.