

EXECUTIVE SUMMARY

The Wetting Front Detector (WFD) was originally developed as a simple irrigation scheduling tool to fill a perceived gap in the market. This ‘gap’ was perceived to be for a tool that made ‘intuitive’ sense to farmers and linked water management with salt and nutrient management. The FullStop WFD is a funnel shaped device that is buried in the soil and provides a visual signal when the soil water suction falls to 2 kPa during an irrigation event. The FullStop collects a water sample from the wetting front, which can be analyzed for water quality parameters, such as electrical conductivity (EC) and nitrate levels (see www.fullstop.com.au).

Much progress was made between 2000 and 2003 through the Water Research Commission Project no. 1135 “Building Capacity in Irrigation Management with Wetting Front Detectors” (Stirzaker et al., 2004b) which involved the testing of the device under controlled conditions, on-farm evaluation, and obtaining feedback from irrigators. The initial research and on-farm experience showed enormous promise and the device was commercialised in a relatively short space of time. In 2003, the FullStop won the international prize for “Outstanding contribution to water saving and water conservation in Agriculture” presented by the International Commission on Irrigation and Drainage in France. It was released onto the market in 2004 and over 13 000 units have been sold world-wide.

Results from WRC Project 1135, together with a follow-up WRC consultancy and experiences from the early stages of commercial release, have highlighted three areas requiring further work. These three areas form the subject of this project report.

1. NEW DESIGN OF WFD FOR FURROW IRRIGATION

The commercially available FullStop design was well suited to drip irrigation and had been used with some success under sprinklers, but it was not particularly well suited to furrow irrigation. A design that could be placed deeper in the soil, was more sensitive to weak wetting fronts, and caused less soil disturbance, was needed. Fronts get weaker as they move down through the soil as each soil layer retains and slowly

releases some of the infiltrating water. When the flux is low, a funnel shape is not the best option for producing free water from unsaturated soil. When there is low flux, convergence is less effective, and the shallow depth of the funnel does not counteract emptying by capillarity. In these cases, a pipe-like design is more appropriate than a funnel, since sensitivity at low flux rates is determined by length of the detector.

The modified WFD, called a Tube Detector (TD), was developed and tested in the laboratory, at the Hatfield experimental farm, at UNIVEN and in farmer's fields at the Dzindi irrigation scheme. The research evaluated i) the properties of the material needed to fill the Tube Detector, ii) the sensitivity of the several Tube Detector designs, iii) a comparison of FullStop and Tube WFDs, iv) different placements within a furrow irrigation setup, and v) the usefulness to small-scale irrigators.

The Tube Detector proved to be an extremely sensitive wetting front detector and operated exactly according to theory. A robust understanding of how to build and use the Tube Detector, something that was considered essential before embarking on another commercialisation venture was developed. Tube Detectors identified severe over-irrigation in farmer's fields, although more work is needed to fully evaluate their potential for the small-scale furrow irrigation sector.

2. SOIL SOLUTION MONITORING

The second objective of this project was to provide a basis for interpreting the soil solution electrical conductivity and nitrate measurement. From the start, surveys showed that leading irrigators were more interested in the WFD as a solute measuring device than an irrigation device. The FullStop can be considered as passive lysimeter, since no suction force needs to be applied to collect a water sample, as is required for the standard ceramic suction cup. The task of this study was to compare the performance of the WFD to the standard, but more cumbersome technique of obtaining a soil solution sample by suction cups (SC).

This work was carried out both in the field (stone fruit and citrus orchards) and in large outdoor drainage lysimeters. The lysimeter data lent support to the theory that SC solute concentrations are more indicative of what crop roots are exposed to

(resident water), while WFDs are more indicative of solute concentrations in the percolating soil water (moving water). However, there were other factors involved, which could lead to the two methods giving somewhat different results. For example, the WFD collects water over a short period as the front passes and picks up salt or nitrate ‘bulges’ if they are present, which the slowly collecting SC appears to miss.

The solute movement data, or solute signatures, can be used in their own right to give feedback on irrigation performance. Generally, a build-up of salts lower in the root zone indicates that excess irrigation has not been applied. No build-up or sudden drops in nitrate concentrations indicate that the crop is being over-irrigated.

Good data from SC and WFD were obtained in the orchard trials, with both devices usually indicating very similar trends. An advantage of the WFD was that the operator did not have to prime the cup with suction to obtain the sample – it was collected and stored automatically by the WFD. The latest development of installing prototype electrodes in the reservoirs of FullStops enabled the successful automatic reading and logging of soil water EC. This continual EC logging provided further insights into the movement of solutes in the soil, and is a significant advance to the deployment of WFD in agriculture.

3. TRAINING GUIDELINES

The phenomenal adoption of the WFD in the first couple of years has had its downside. So much was happening so fast that it was impossible to respond to user experiences, especially those from soil-irrigation combinations for which there were no previous personal experience. Now, in the fifth year since product release, two trends were observed. First, overall sales have declined to around 1000 units per year. Second, farmers who were keen at the very start, and with whom direct interaction constantly took place, have continued to use the WFD successfully.

Meanwhile the project team’s research experience continues to grow with improvement to the interpretation guidelines and the focus on situations where the WFD can make a major contribution to irrigator practice. With almost a decade of experience, an understanding has been reached which, it is believed, can unlock more

of the potential of the device within the irrigation industry. This understanding is built around the following three findings:

1. When people first see a WFD it looks incredibly simple. Most feel they know exactly how it works and that it should be a simple solution to the difficulties of managing water, salt and nitrate.
2. The physics underpinning operation of the WFDs is difficult. It even takes highly trained soil physicists some time to grasp how the two versions actually work, how the shape relates to sensitivity and how the sensitivity relates to deployment and interpretation in different situations.
3. Definitive instructions on how to use the WFD for each particular situation cannot be provided. All other tools come with an interpretation method, such as threshold suction or a refill point. Yet it is not possible to say *a priori* how frequent a detector at each soil depth should respond to irrigation.

The above seems like a paradox. If the WFD looks simple to farmers, why is it not immediately apparent how to deploy it (depth and frequency of response) and to interpret the response? Why do some growers find them extremely useful and others lose enthusiasm? We believe the answer is that the WFD must be a learning tool before it can become a 'solution'.

The WFD helps the irrigator to understand their current irrigation strategy, and to organise their experiential knowledge. Irrigators build their own rules of thumb around the response of the WFD. They combine their existing knowledge, built up within the constraints of their own systems, to come up with WFD responses that help them to balance accuracy with risk. They use the WFD to evaluate different fertigation or leaching strategies in a learning-by-doing approach.

Since the WFD is a learning tool combining water, salt and nutrients, a comprehensive training package for farmers and advisors was developed. This package is laid out as a PowerPoint presentation containing 10 modules with five slides each. Each module is a concise summary of principles, followed by real on-farm case studies. It is believed that this simple training package will help many irrigators to understand their craft, and to get much more benefit from their detectors.

4. KEY POINTS

1. This ability to detect weak fronts together with the cheap cost of constructing Tube Detectors means that these detectors could be deployed to guide irrigation management in furrow irrigation systems.
2. Monitoring EC using FullStops has provided valuable practical information on soil salinity, leaching fractions and nutrient leaching.
3. The use of simple electrodes inside the WFD for continuous logging shows promise as an easy, cost-effective method of monitoring wetting fronts and soil solute levels.
4. WFDs can play an invaluable role as a learning tool, complimenting years of farmer experience.
5. A training package has been produced around the WFD as a learning tool. It will help to organise irrigator's existing knowledge, help them to make sense of new information, and help them to develop management strategies that will improve water, salt and nitrate management.

5. RECOMMENDATIONS

1. Although the Tube Detector performed exceedingly well, commercialisation at this stage is not recommended until more feedback from users has been received. Any number of Tube WFDs can, at short notice, be provided for further evaluation.
2. Research learning over a 10 year period was captured in the training course. This knowledge was grounded in farmer experience and it is strongly recommend that the course be presented to irrigator groups to help improve water, nitrate and salt management.