

# LOW IMPACT HIGH PERFORMANCE IRRIGATION

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## ABSTRACT

Irrigators achieving 'Low Impact High Performance Irrigation' is the aim of an exciting research project underway in the South East of South Australia. Jointly funded through the Federal Government's Water Smart Australia Programme and the South Australian Government, this project seeks to benchmark the performance of local irrigation practices and assess the potential impacts of irrigation upon the underlying groundwater resource.

Benchmarking the performance and impacts of irrigation is fundamental for sustainable groundwater management and in promoting best practice irrigation. Outcomes from this benchmarking process will be used to help develop Best Practice Irrigation Guidelines in partnership with the local industry. Innovative methods for assessing the on-farm water and salt balance are being used, which are proving to be useful tools for irrigators and resource managers.

## INTRODUCTION

The Limestone Coast region in the South East of South Australia supports a diverse and growing irrigation industry built upon an extensive regional groundwater resource. The unconfined aquifer is generally shallow, high yielding and good quality, with over 1000 GL available for allocation. Irrigation accounts for approximately 80% of the allocated volume with over 2500 irrigation water licences and some 4000 metered bores. The wide range of irrigated commodities produced from this region include winegrapes, potatoes, dairy, olives, apples and small seeds.

Over the past three decades the groundwater resources in the region have experienced considerable development and there are now clear signs of resource stress. Furthermore the shallow and transmissive nature of this regional aquifer make it particularly vulnerable to human induced degradation.

A four year National Water Initiative project titled 'Integrated Water Resource Management in the South East of South Australia', is now underway to pilot new approaches to achieving sustainable water management. The irrigation benchmarking component is intended to provide realistic information for adaptive groundwater management and facilitate best practice irrigation.

A total of 13 irrigation trial sites are currently being investigated with the aim of quantifying the on-farm water and salt balance. At each site an array of monitoring equipment is being trialled including logging soil moisture sensors, soil water extractors, wetting front detectors and groundwater piezometers. These devices will be used to help measure and model water and salt fluxes through the crop root zone and quantify returns to the aquifer.

Outcomes from this research will be used in developing Best Practice Irrigation Guidelines, to be tailored to the unique conditions and practices within the region. It is intended that the guidelines, to be developed in partnership with industry, will help provide irrigators with the tools and knowledge required to achieve 'Low Impact High Performance Irrigation'.

This targeted investment in irrigation research has been welcomed by the region's irrigators whom are facing a challenging period ahead with the conversion of their area-based water licences to volumetric allocations, dealing with the implications of declining water levels and increasing groundwater salinity, coupled with ever increasing production costs.

Direct industry involvement is critical to the success of this project and will help ensure the guidelines are practical, meet the needs of irrigators and therefore more likely to be adopted. Key areas to be addressed by the project will be those same difficulties faced by many irrigators including:

**1. System capacity**

Assessing the ability of the irrigation system to match peak crop water use and still avoid excessive deep drainage.

**2. Soil water holding capacity**

A reliable guide can provide base information for understanding irrigation scheduling requirements.

**3. Crop water use**

Understanding of the rate of crop water use combined with soil water holding capacity can be used to determine the number of water storage days available to the crop.

**4. Scheduling**

Knowledge of the parameters above provides a good starting point for determining the size and frequency of irrigations required.

**5. Efficiency**

Assessing the application efficiency and distribution uniformity of an irrigation system provides crucial performance information.

**6. Salt leaching**

Having the flexibility and capacity to leach excess salts from the root zone (if required) and understanding how this can be best achieved.

**7. Monitoring deep drainage**

Using soil water extractors, wetting front detectors and groundwater piezometers to track the movement of deep drainage water and the solutes it contains.

**8. Managing irrigation impacts**

To avoid the risk of long-term soil degradation and groundwater pollution.

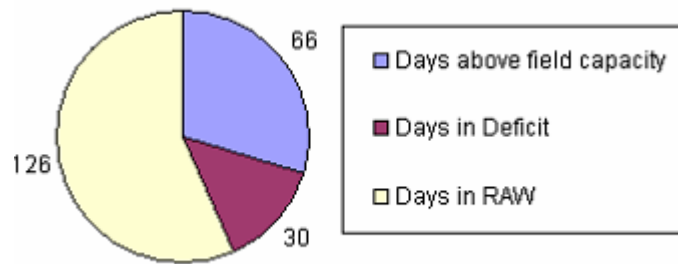
**CASE STUDY: THE VALUE OF CONDUCTING AN ON-FARM WATER BALANCE**

The potential of this project to provide benefits to the irrigator and facilitate real practice change were first realised from earlier research conducted by Pudney (2006). An on-farm water balance assessment was conducted during 2004/05 on an irrigated dairy farm near Mount Gambier SA. The intensive dairy farm, one of the largest in the region, irrigates 450 ha of pasture with eight centre pivots on very shallow soil over limestone (soil depth ranging from 5 to 20cm).

The water balance assessment was aided by using the computer model IRES (*Irrigation Recording and Evaluation System*), developed by Irrigated Crop Management Service, Loxton SA. IRES predicts water fluxes through the crop root zone and is a practical method estimating components of an irrigation water balance. The inputs required for IRES include water meter readings for individual irrigation events, daily rainfall data and reference crop evapotranspiration, crop coefficients (FAO 56), Total Available Water (TAW), Readily Available Water (RAW) and the soil moisture content at the start of the season.

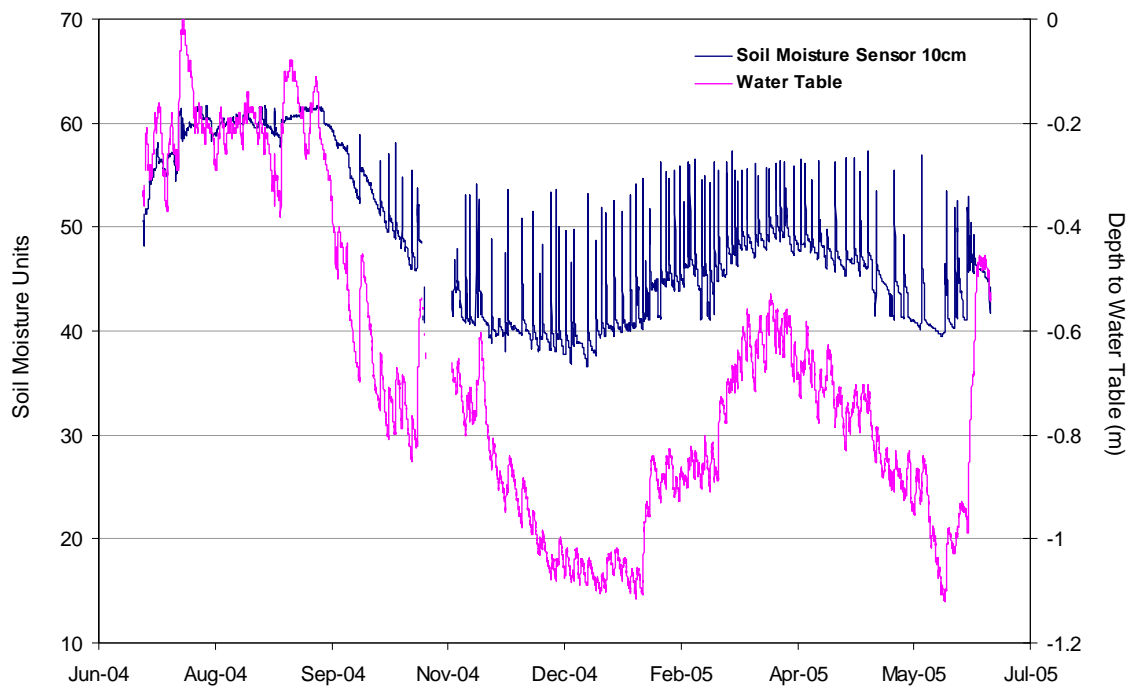
The model generates a simulated or 'predicted' soil moisture trace, which can be calibrated against 'real' soil moisture data from field devices. This data can then be used to benchmark the ability of the irrigation system (and on-farm management) to maintain soil moisture within a desired range (i.e. within RAW), and can also provide an estimate of drainage below the effective root zone.

When the predicted results from the model were summarised for the 2004/05 season (Figure 1), the number of days the soil moisture levels were optimal (within RAW) was estimated to be 126 of 222 days (57% of the season). For the remaining period, soil moisture deficit occurred for 30 days (14%) and the profile was above field capacity for the remaining 66 days (29%).



**Figure 1.** Modelled soil moisture conditions for 2004/05

Of the 10.44 ML/ha applied for irrigation in 2004/05, 2.95 ML/ha was estimated to result in deep drainage (28% of the volume pumped). The prolonged period where soil moisture levels were above field capacity indicates that excessive deep drainage was likely to be occurring. Figure 2 further supports this hypothesis, displaying the relationship between measured soil moisture content and the corresponding water table fluctuation during the 2004/05 season. Piezometer results showing water table fluctuations suggest that the limestone is highly permeable, with irrigation drainage water reaching the water table within one hour of application (Pudney 2006).



**Figure 2.** Field soil moisture and water table fluctuations 2004/05.

The issue of excessive drainage following each irrigation event appeared to be the result of poor system design in relation to site requirements. Here the minimum (nominal) application depth of the centre pivot was approximately 15 mm with a rotation time of 22 hrs (sufficient to meet peak crop water use). Application losses to evaporation and wind drift were determined from catch can tests and found to range from 10 to 15%, with approximately 13 mm the average application depth. Conversely the Readily Available Water of the shallow clay loam was estimated to be only 9.75 mm (Pudney 2006).

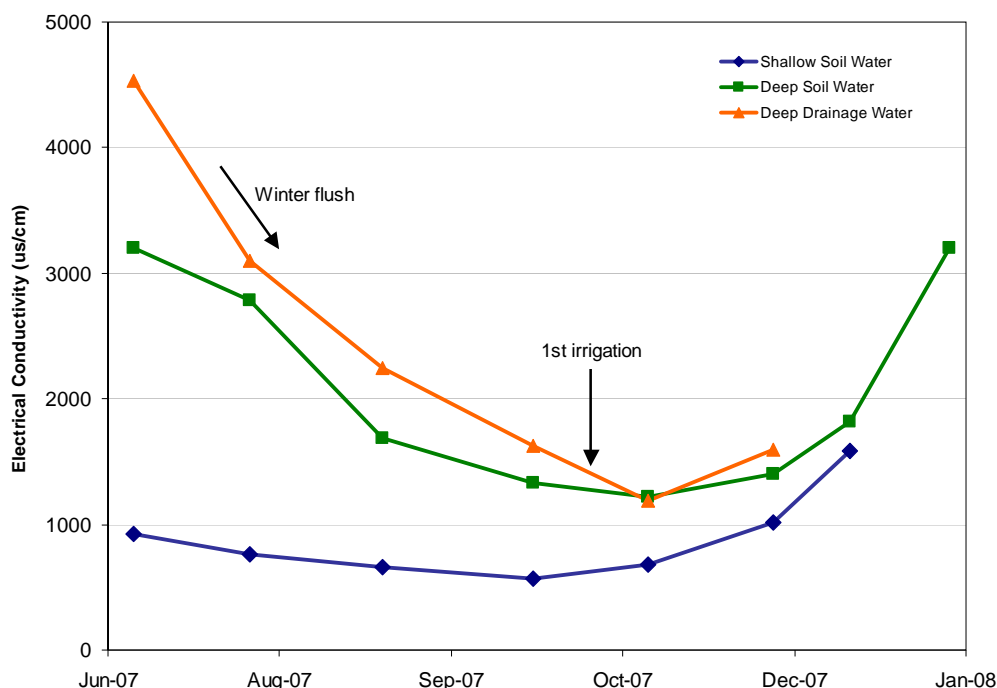
The results of this water balance assessment provided a useful perspective of the performance of this system. Almost 30% of the volume pumped was being lost to deep drainage since more water was being applied than the shallow soils could possibly hold. In response to these findings the trial participant set about reducing the minimum application depth of their centre pivots. To do this, new high-speed gear boxes were retro fitted to the hydraulic centre pivot and the capacity of hydraulic lines were also increased.

The minimum application depth has now been reduced from 15 mm per event to 10 mm and the rotation time is down from 22 hours to 17 hours. This represents an instant water savings of 30%. Additional benefits have also been achieved through reduced pumping costs, reduced fertiliser use and pasture production has also reportedly increased.

## MANAGING THE SALT

Quantifying the salt balance is the next key step in understanding the requirements for managing irrigation salt loads at the on-farm and regional level. A range of approaches are being employed to monitor salt fluxes through the unsaturated zone, including insitu testing of root zone soil water, seasonal soil sampling, groundwater monitoring and computer modelling. At each of the 13 trial sites soil water extractors have been installed within the effective root zone and FullStop wetting front detectors installed at a greater depth below. This arrangement is intended to provide comparative data between plant available water and deep drainage water.

Figure 3 displays the relationship between soil water EC and deep drainage EC for one of the centre pivot sites on a deep sandy loam over clay soil profile. Here the effectiveness of winter rainfall in flushing residual salts from the root zone is clearly seen, with both soil and drainage water salinity decreasing through to late September. This trend is then reversed following the first irrigation for the season, as salt is again added to the root zone.



**Figure 3.** Electrical conductivity of root zone soil and deep drainage water.

Monitoring root zone salinity will help improve our understanding of irrigation leaching requirements and the effectiveness of winter rainfall in flushing the salt load generated each season. When combined with groundwater monitoring data, this information will be used to assess the likelihood of these salts returning to the aquifer. Quantifying the on-farm salt balance can therefore be a useful tool for both resource managers and irrigators in managing the salt associated with irrigation.

## **SUMMARY**

Benchmarking the performance and impacts of irrigation has the potential to deliver significant benefits to both resource managers and irrigators through improved knowledge, practices and a greater understanding of the relationship between irrigation, salinity and groundwater.

This benchmarking information is now being used by irrigators in identifying system performance issues and will later form important components of adaptive groundwater management arrangements. Importantly the development of Best Practice Irrigation Management Guidelines, using outcomes from this research, will further assist irrigators find the delicate balance required to achieve Low Impact High Performance Irrigation.

## **REFERENCES**

Pudney, S. (2006). *Volumetric Conversion in the South East of South Australia: Validating the allocation model*, DWLBC Report 2006/30, Government of South Australia, through Department of Water, Land and Biodiversity Conservation, Mount Gambier.