Improving whole farm and infield irrigation efficiencies using Irrimate™ tools

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Introduction

Whole farm irrigation water includes all pumped, delivered, captured, distributed and/or stored water within the farm gate. Utilisation of rainfall, recycled irrigation water, and harvested overland flows are included in the on-farm water volume. In assessing the performance of on-farm irrigation systems it is necessary to recognise that there are both agronomic and volumetric components of the system and that both contribute to the overall productive output. Evaluation of irrigation performance at the whole farm scale using total volumetric inputs and total production outputs provides a benchmark for comparative purposes but fails to provide an adequate diagnostic tool to identify either the source of inefficiencies or appropriate strategies to improve performance. Hence, diagnostic performance evaluation requires the measurement of the inputs and outputs for each sub-component of the system in a way which enables the partitioning of losses and the identification of the importance of specific loss mechanisms.

Volumetric inefficiencies typically derive from losses associated with either evaporation, deep drainage or surface run-off. The magnitude and importance of each loss mechanism varies significantly between the volumetric system sub-components. The system design and the management practices adopted are also important determinants of total losses. The volumetric component (Figure 1) of the whole farm irrigation system is typically divided into the following water management sub-components:

- Supply systems (e.g. harvesting or lifting from river and captured overland flows; pumping groundwater from bores; and/or supply from irrigation scheme dams, channels and/or pipes);
- On-farm storage systems (e.g. ring tank storage cells; buffer holding dams; or catchment dams);
- On-farm distribution systems (e.g. earthen channels; gated pipes; or pressurised enclosed systems);
- Application systems (e.g. surface, spray, micro-systems); and
- Recycling systems (e.g. tail drains and tail water recycling channels and utilising supply harvesting pumps; or catch drains feeding into holding dams).

The efficiency of water use can be defined for each of these sub-systems based on the volumetric water inputs and outputs, or uses and losses. Potential volumetric losses (or inefficiencies) within each of these sub-systems must be measured or estimated accurately to quantify whole farm water use efficiency. Volumetric measurements of the water flows into and out of each unit are required and include groundwater and riverine flows, scheme supplies, rainfall, seepage (or percolation), evaporation, overland flows and tailwater recycling. However, the largest losses of water on irrigation farms are (a) storage seepage and evaporation, and (b) in-field irrigation application. The National Centre for Engineering in Agriculture (NCEA) has been working with Aquatech Consulting for the last five years on the development of accurate field measurement tools to improve management in these areas.

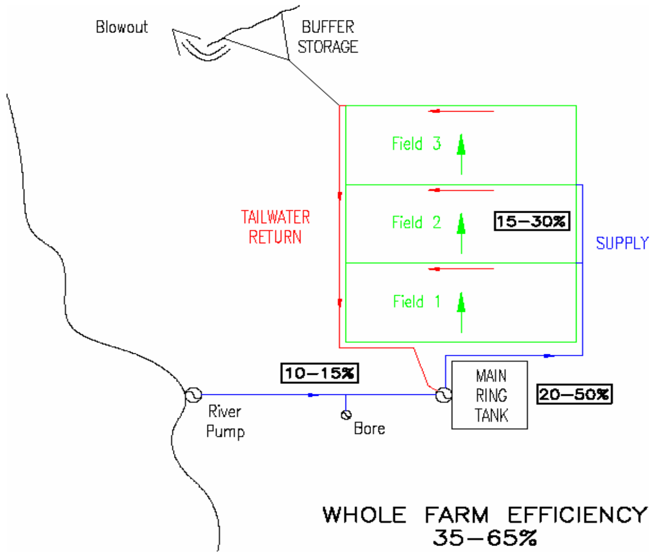

Figure 1. Typical water balance for whole farm irrigation flows (common volumetric losses shown in boxes)

Storage/Channel Seepage and Evaporation

Assessing the performance and water volume balance of a large scale water storage and extensive distribution network is not an easy task. Major components of a typical volume balance model for a water storage are shown in Figure 2 and are similar for channels. The major system losses in open farm water storage and distribution systems are evaporation and seepage. These losses occur on a continual basis and depending on the local evaporation potential, soil types, design parameters and period of storage, may be as high as 50% of the total water stored.

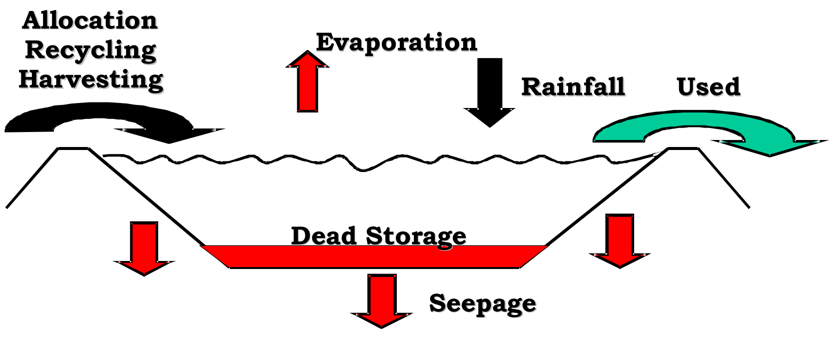

Figure 2. Components of the water storage volume balance

This season the Irrimate™ range has been expanded to include two new water level meters for measuring volumes and losses in storages and channels. The first, the calibration meter (Figure 3a), is an accurate sensor which can directly measure seepage and evaporation and can detect water level changes of less than 1 millimetre. The second, the storage meter (Figure 3b), is designed for permanent installation in a storage and continuously measures water level to commercial accuracies of 5 to 10 millimetres.

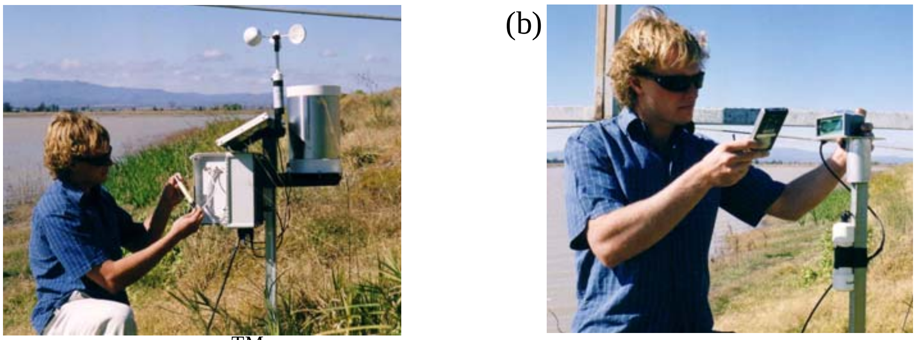

Figure 3. The Irrimate™ (a) storage calibration meter and (b) storage volume meter

Storage Calibration Meter

It is important to know how much seepage and evaporation is lost from storages, channels and drains. To facilitate this, an accurate water level sensor (plus or minus 1 millimetre or less in water level) has been developed by the NCEA. This unit is based on a pressure sensing unit and is packaged with an automatic tilting rain gauge, wind speed meter, water temperature probe (to ensure the range of temperature variation is within the compensation range of the pressure sensor), datalogger, power source and solar panel.

The unit continuously logs water level variation and averages every 15 minutes to remove wave “noise”. The water loss between say 10:00 pm and 2:00 am is nearly all seepage and can be separated out from losses due to evaporation. Tests in lined steel tanks at USQ have proved that some “evaporation” occurs from a free water surface even at these times and AWS data is used to estimate this night time evaporation component.

Allowing for this small night evaporation, the remaining loss is a direct measurement of seepage. Subtracting seepage from the total daily loss results in direct evaporation losses (Figure 4). The sensor can be placed in a storage, channel or drain and directly measure seepage and evaporation. Use indicates that leaving the unit in a storage or channel for 6 – 8 weeks is sufficient to obtain reliable measurements.

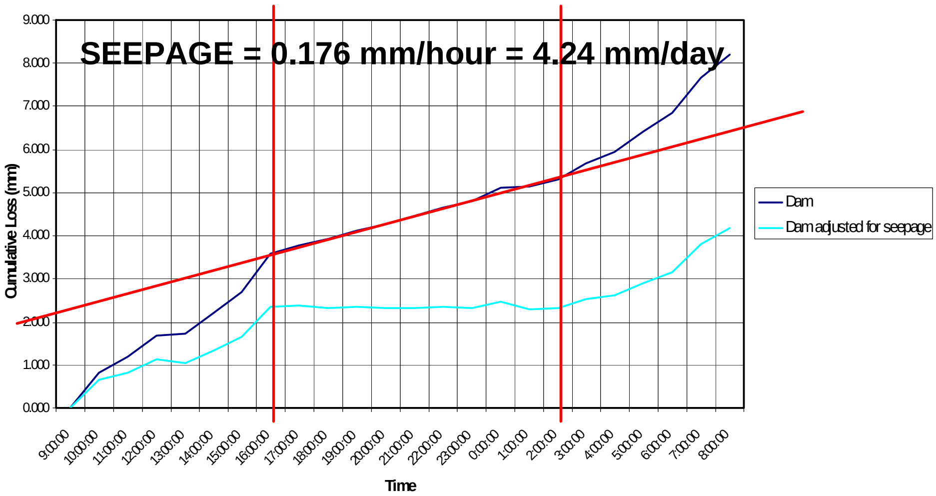

Figure 4. Seepage measurement using logged pressure depth sensors

Storage Meter

The Irrimate range also includes a low price continuous storage level sensor with accuracy of plus or minus 5 to 10 millimetres. This meter is suitable for permanent installation into storages. It comes with its own data logger, small solar panel and liquid crystal display and continuously reads water depth. The data logger communicates via an infrared link directly to a hand-held computer. The storage depth to volume and water surface area relationship is downloaded to the datalogger. The meter then records water depth (m), storage volume (ML), and storage surface area (ha). The logging interval is adjustable (usually 30 minutes) and the data can be downloaded onto the hand-held computer. At any time the unit can display the depth, volume and surface area by simply pushing a button on the data logger.

In-field Application Performance

The ability of the in-field application system to apply water uniformly and efficiently to the irrigated area is a major factor influencing the agronomic and economic viability of the production system. The major components of the infield volume balance are shown in Figure 5. The performance evaluation of in-field application systems can be divided into the two major components of water losses and uniformity of application. Although both components are influenced by system design and management practices, the losses are predominantly a function of management while the uniformity is predominantly a function of the system design characteristics. However, the irrigation system is not usually expected to supply all of the moisture required for crop production as some of the crop's water requirements may be met by pre-season moisture stored in the soil profile, rainfall during the growing season, or from shallow groundwater tables. Hence, optimal irrigation management requires not only a knowledge of the characteristics of the application system but an understanding of the environment in which it operates.

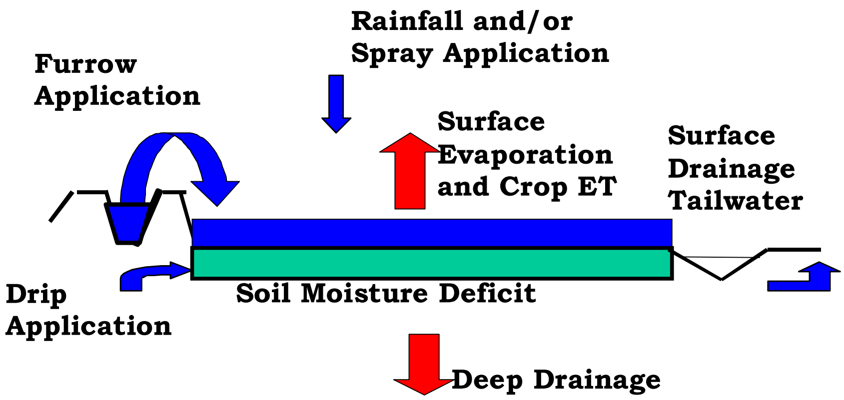

Figure 5. Components of the in-field application system volume balance

The performance evaluation of surface irrigation involves an assessment of both the volume and uniformity of the water stored within the root zone. Factors affecting surface irrigation performance include furrow inflow rate, the soil infiltration characteristic, field slope and length, surface roughness and furrow geometry. The most effective method of determining infiltration under surface irrigation is to calculate the average infiltration characteristic based on volume balance calculations using the irrigation advance rates, hydraulic cross sections and tail water volumes. This "real-time" assessment of the infiltration characteristic involves the use of a volume balance equation relating measured irrigation advance data to infiltration.

The commercial Irrimate™ in-field surface irrigation evaluation service was first introduced into the cotton industry in 2001. After one irrigation optimisation consultation, most clients were saving an average of 0.15 ML/ha/irrigation by adjusting siphon flow rates and irrigation set times. Over the last five years, with help from their clients, the range of infield evaluation equipment has been improved and is now more user friendly. A typical set of infield equipment includes: (a) siphon flow meter, (b) 6 x water advance sensors, and (c) an in-furrow downstream flume (Figure 6). In general, measurements conducted on a couple of irrigations in a field are enough to optimise the irrigation operation for that field.

Figure 6. Irrimate™ surface evaluation equipment (a) inflow meter, (b) advance sensors and (c) flumes

The accurate measurement of the soil moisture deficit over the entire field has been a problem in the past. During the last season (2004/05), calculation of crop water use from climatic data and the modified Penman-Monteith equation was introduced to better define the soil moisture deficits at irrigation. Dusting off the neutron probe for strategic measurements on cracking clay soils has also been helpful to calibrate some of the capacitance probes. Precision irrigation means knowing what the deficit is and knowing how to change the irrigation to apply only the required amount over the full length of the field.

Irrimate Services

There are now 15 consulting agents providing Irrimate tools and support in areas ranging from Emerald to Hillston in the cotton industry, and extending into South Australia and northern Victoria. There have been over 300 field optimisations conducted over the last 5 years. The standard full season evaluation service includes optimisation on three irrigations in a field by the local agent currently costs approximately $5000 where as optimisation of single irrigation events costs ~ $2000. Full sets of in-field measurement equipment cost ~$6000.