SAVING WATER WITH TOTAL CHANNEL CONTROL® IN THE MACALISTER IRRIGATION DISTRICT, AUSTRALIA

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ABSTRACT

Southern Rural Water is undertaking a major automation project on the Main Northern Channel System in the Macalister Irrigation District, Victoria, Australia. The objectives of the project are to save water by reducing operational losses and to significantly improve customer service. The Victorian State Government is funding the project in exchange for the water savings, which they will use to increase environmental flows in the Macalister River. This paper predominantly looks at the water saving aspect of the project, and focuses on one spur channel, which has the most detailed measurement.

Commencing in 2004, the first stage of the two-year project involved a trial of the automation technology (Total Channel Control®) and establishment of a water measurement network at a sub-system level. A water balance study supported the business case to progress to Stage 2 and provides a benchmark to verify the savings achieved by the project.

The study's water accounting framework identifies the main components of the water balance. The study provides an opportunity to improve the understanding on how channel losses can vary both spatially and throughout the irrigation season.

INTRODUCTION

The introduction of Total Channel Control® (TCC®) has revolutionised the operation of the Main Northern Channel system. Prior to this project the channel operation was typical of most earthen channel systems, with one main regulation per day on the main channel and its offtakes to spur channels. A combination of its slow responsiveness, poor measurement facilities, basic control functionality and focus on maintaining customer service levels led to a conservative manual operation regime, that in turn resulted in significant outfall losses. TCC® has broken the historic service-efficiency dichotomy; that held the view that it is only possible to improve operational efficiency by reducing customer service.

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BACKGROUND

Macalister Irrigation District

The Macalister Irrigation District (37.6^0 South and 148.6^0 East) is located in Gippsland, 175 kilometres southeast of Melbourne (**Figure 1**) and is the largest irrigation district that Southern Rural Water (SRW) manages. Its main source of water is the 190,000 ML Glenmaggie Dam located on the Macalister River. The District spans three river catchments and has significant groundwater resources (typical use 24,000 ML/year) and rainfall (595 mm/year). Within the District approximately 33,500 Hectares are irrigated predominantly (90%) for pasture, which supports the main business enterprise of dairy. Other enterprises include beef and vegetable production.

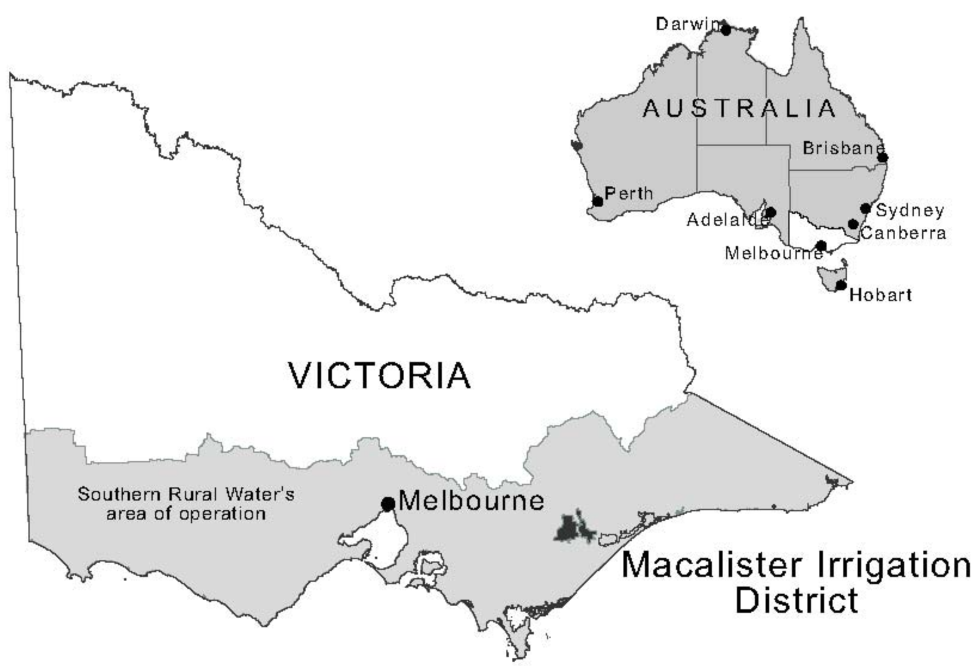

Figure 1. Locality Map.

Total Channel Control®

TCC® is an integrated system of advanced communications, modelling and control software. The FlumeGate®, a uniquely designed overshot gate, which is the subject of several patent applications, is a key component of the TCC®. The gate has been designed for mass production, ease of installation and support, high duty cycle, long life and incorporates a proprietary system of flow measurement**.** This measurement system provides high accuracies in both free and submerged flow conditions and independent testing by the Manly Hydraulics laboratory has demonstrated accuracies of ± 2% for the 626*620 model gate by referencing it to a high-accuracy magnetic flow meter, as shown in **Figure 2** following.

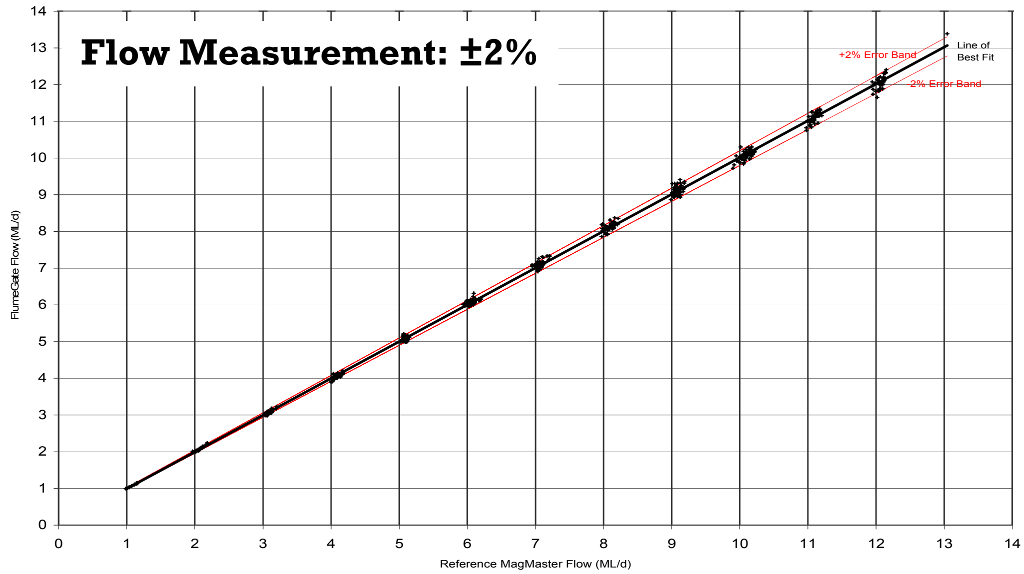

Figure 2. FlumeGate® Flow Measurement Accuracy.

<u>Main Northern Channel</u>

The Main Northern Channel system delivers approximately one quarter of the water in the District and diverts an annual average volume of 55,200 ML. Historical distribution efficiency ranged from 61% to 63%. The system contains approximately 260 regulating structures and has 600 customer outlets.

Constructed in the 1920s the channel offtakes from Glenmaggie Dam with a maximum capacity of 550 ML/d. It traverses eastward mainly following an escarpment and then crosses from the Macalister River catchment to the Avon River catchment via the 900-metre Boisdale tunnel. The channel has a range of characteristics that result in it being the most difficult channel to operate in the District. These characteristics include:

- Long flat channel pools (4.5 to 12.5 km long with grades of 1:7000)
- Complex hydraulics due to 11 siphons and one partly submerged tunnel
- Major and uncontrolled inflow during rain events
- Regulators that operate under highly submerged conditions at high flows
- Very uneven customer demand on one of its major spur channels (Valencia Creek channel)

Valencia Creek Channel

Valencia Creek channel is a major spur system in the Main Northern system. The channel has a peak flow of 100 ML/d and is the main source of supply to the Boisdale pipeline, where most customers place orders to pump over-night, to take advantage of lower electricity tariffs. The 6.5 km channel only has two operating pools; the first pool is 4.3 km long and includes three siphons; the second pool is 2.2 km long and includes one siphon. The channel generally follows a contour, receiving significant uncontrolled inflows during rain events.

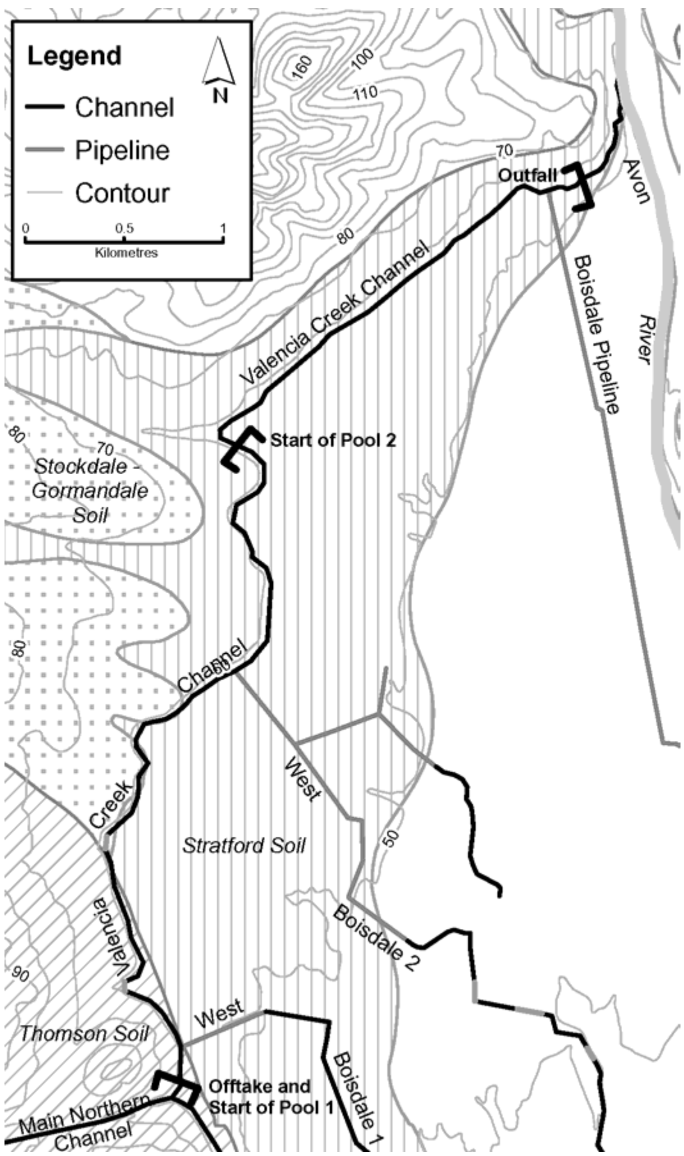

Figure 3. Valencia Creek Channel Locality Map.

The channel in the first pool intersects three soil types, whereas the second pool only has only one soil type. From a channel loss perspective, the first pool includes two soils (Stockdale-Gormandale[3] and Thomson[3]) with relatively moderate permeability characteristic plus one type with very low permeability (Stratford[3]), whereas the second pool's only soil type is Stratford. Figure 3 shows the location of the soil types and the channel.

In 2001 SRW engaged consultants Sinclair Knight Merz to undertake a seepage study on the Valencia Creek (SKM, 2002). This involved an electro-magnetic survey (EM34) of the first channel pool and then a subsequent pondage test on the 530-metre section (Stockdale-Gormandale soil) that the survey indicated had the highest seepage. The pondage test undertaken at the end of the irrigation season in May 2002 showed a seepage rate of 13.5 mm/day or 0.13 ML/day/km. By international standards this seepage is relatively low and is below the performance threshold for adequately lined channels of 30 mm/day as specified by FAO, as cited in by Plusquellec (Plusquellec, 2004).

Due to the heavily skewed demand pattern combined with its manual operation limitations and emphasis on meeting customer demands, this channel historically lost an estimated 2,000 ML per year at its outfall. The outfall volume represents over twenty percent of the channel inflow.

PROJECT BACKGROUND AND OVERVIEW

Main Northern Channel Automation Project

Like many Australian water authorities, Southern Rural Water (SRW) has been under increasing pressure to improve the efficiency of its distribution system and to provide water for environmental purposes. The Victorian Government has made funding available for infrastructure upgrades to return water to the environment through its Water Trust program[4].

Following an option assessment SRW chose Rubicon's TCC® as the most cost effective method of delivering these savings. TCC® had significant additional advantages over the other options in terms of service improvement, creating major opportunities for improving on-farm efficiencies for flood irrigation and an opportunity to gather data that enables an improved understanding of how the channel performs.

The first stage of the project invovled installing fifty-five automated regulators (FlumeGates®), of which thirteen were for customer metering applications with

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[3] Refer Department of Primary Industry web site for soil details www.dpi.vic.gov.au/dpi/vro/wgregn.nsf/pages/wg_soil_index
[4] Refer Victorian Water Trust program at www.dse.vic.gov.au

the remainder used to form the water measurement network. TCC® has been used to control and measure the main channel, its offtakes and all outfall points. The Valencia Creek channel operated under full TCC® (regulator and outlets automated) and the 20 km section of the Main northern channel from its offtake to the Valencia Creek offtake operated under TCC® mode. The automation on the Main Northern included control of three hydraulically controlled 900 mm vertical sleeve valves that release water from Lake Glenmaggie into the Main Northern channel.

The remaining 80% of the system operated along traditional manual lines, except for the operators remotely controlling the FlumeGates® located at in-line regulation sites. The operators were able to monitor outfalls and in many cases operated the FlumeGates® to control inflows to reduce outfalls.

Based on the results from Stage 1, SRW developed a targeted implementation program for TCC® across most the remainder of the Main Northern channel system. The design objective of Stage 2 is to deliver the most cost-effective savings whilst ensuring the solution is operationally acceptable. SRW reached agreement with the Government for the Government to contribute $7 million ($AUS) to fund the project in exchange for 5,000 ML of water saving.

The water savings will largely come from reduced outfalls (91%) with the remainder coming from accurate measurement of the customer outlets. The second stage of the project involves the installation of another 150 FlumeGates® with 80 of these for customer meter outlets that will be fully integrated with the TCC® water ordering software. All the works for Stage 2 will be operational by October 2005.

WATER BALANCE STUDY

Definition of water losses used for the study

A major water loss study by Sinclair Knight Merz (SKM, 2000) defined the elements in an earthen channel water balance. The following table presents the typical loss elements, grouped into two main categories, being: inherent system losses and operational losses. Inherent losses are those losses that are largely inevitable with an earthen system, whereas operational losses are largely controllable by management decisions. Inherent losses include: system filling and emptying, evaporation, leakage and seepage[5]. Operational losses include: outfalls, theft, unmetered domestic and stock supplies and under-recording of customer meters. These elements are all subject to measurement error to varying degrees.

[5] ANCID Rural Water Industry Terminology and Units – refer ancid.org.au/publications

Figure 4 following shows the estimate of the various components prior to commencing the project. The dark segment in the chart highlights the traditional poor closure in water balance studies and this high degree of uncertainty was the reason for focusing on water measurement in Stage 1.

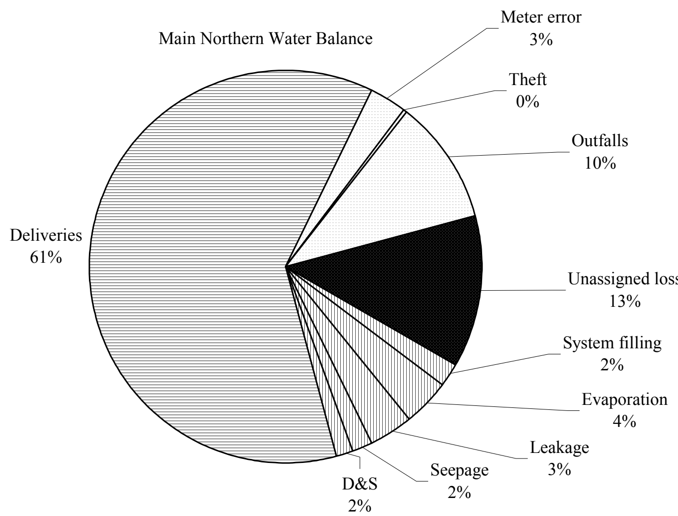

Figure 4. Historical water balance for Main Northern Channel with estimated losses.

<u>Results</u>

The water balance was undertaken on two levels. The first supports the funding-water saving agreement and looks at an aggregated water balance at a whole system scale and the second looks at a disaggregated water balance at the sub-system level. SRW engaged consultants Sinclair Knight Merz to undertake the water balance study.

<u>Whole system analysis</u>

The evidence demonstrating the project water savings is improved efficiency of the entire Main Northern system, noting that the project involved automating just 20% of the system. Table 1 following lists the system-scale water balance results for the 2003/04 and 2004/05 season.

Table 1. Water Balance 2003/04 and 2004/05.

Water balance element	2003/04 Pre-project		2004/05 Post Stage 1	
	ML	% inflows	ML	% inflows
Inflow[1]	57,574	100%	54,131	100%
Deliveries[2]	36,568	63.5%	36,243	67.0%
Outfalls[3]	5,860	10.4%	6,238	11.5%
Other losses[4]	15,146	26.3%	11,663	21.5%

Notes

1 Measured by same sharp-crested weir for both years
2 Measured by Dethridge outlets for 2003/04 and for 2004/05, except for 13 new outlets in 2004/05
3 Operator estimates for 2003/04, except for one sharp-crested weir, FlumeGate® measurement for 2004/05
4 Other losses = Inflows less deliveries less outfalls

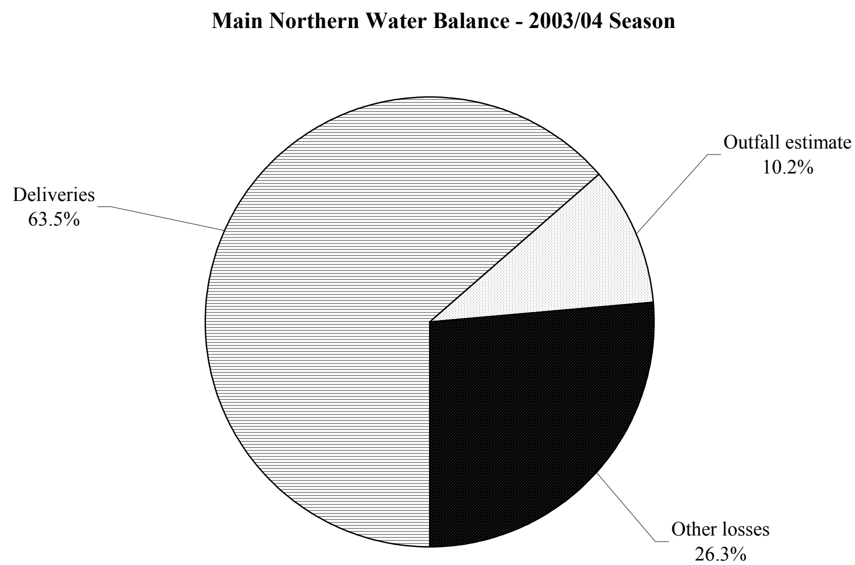

Figure 5. Water balance 2003/04.

The only significant difference at the whole system scale relates to the measurement of outfall volumes. The 2003/04 estimates, like previous years, rely on operator estimates, which at best, rely on one daily spot measurement. The measurement of outfall flow using the FlumeGate® offers significant advantages in terms of accuracy and frequency of measurement. Evidence of sites within the project area and from other sites in the irrigation district typically results in the annual outfall volumes measured by a continuous recorder, being 50% to 100% greater than the historical operator estimates. For example, the 2003/04 operator estimate for the outfall volume for Valencia Creek was 1,000 ML, whereas a rated weir recorder that covered the last four months of the season indicated that the annual outfall volume was 2,000 ML.

Notwithstanding some seasonal variations with some of the inherent channel losses, the accurate and continuous measurement of outfalls provides the most likely explanation for the major reduction in unaccounted water (15,146 ML in 2003/04 to 11,663 ML in 2004/05).

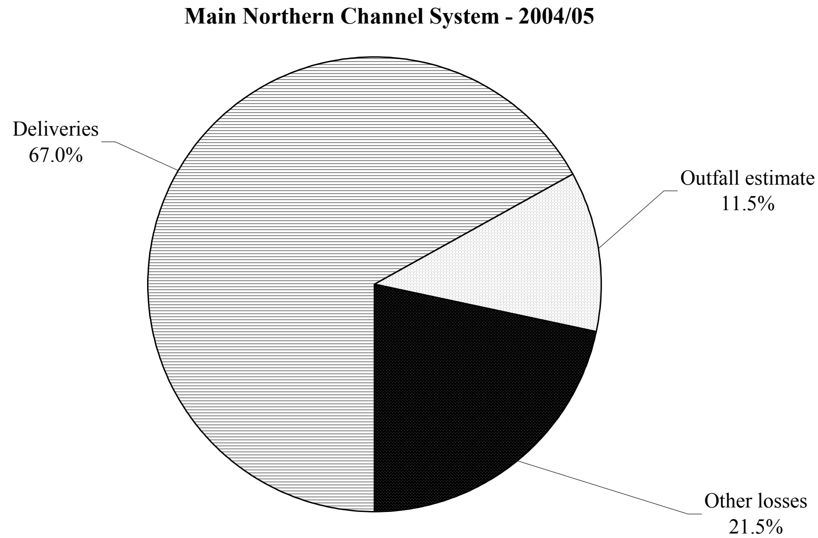

Figure 6. Water balance for 2004/05.

Sub-system water balance

The sub-system water balance is significantly more complex and has had more limitations due to a range of data issues including: delays in establishing some of the measurement sites at the start of the season, some intermittent instrument failures, inherent inaccuracy with traditional meter outlets (Dethridge wheels), sections with high rainfall run-off inflow and problems with some of the FlumeGates® operating in highly submerged conditions for parts of the season, which affected their accuracy at high flows. The next section of the report looks at the Valencia Creek sub-system in detail, as this system has the most dense measurement network and is representative of the type of analysis possible with full implementation of TCC®.

Water balance analysis for the Valencia Creek Channel

From a water loss perspective the Valencia Creek channel is unrepresentative of most channels in Australia, in that being a contour channel it receives significant rainfall runoff and most likely sub-surface inflows from adjacent recharge areas located to the west of the channel. From 1 September to 15 May the rainfall and pan evaporation was 376 mm and 1060 mm respectively. There was only one major rain event, which was 54 mm on the 3 February.

The two pools in Valencia Creek had a combination of modern and accurate measurement devices as summarised in Table 2 following.

Table 2. Measurement devices for Valencia Creek.

	Measurement devices	
	Pool 1	Pool 2
Inflow	FlumeGate®	FlumeGate®
Passing flow[1]	FlumeGate®	No passing flow
Spur offtakes	FlumeGate®	Ultrasonic meter
Deliveries	9 FlumeGates® and 1 magnetic flow meter	3 FlumeGates® and 1 magnetic flow meter

1– Passing flow to Pool 2

Due to delays in commissioning all measuring devices, data only covers part of the year. For the top pool the water balance data starts from 1 September and so misses part of the initial filling. For the second pool, the Panametric ultrasonic meter that measures the flow leaving the lower pool into the Boisdale pipeline was commissioned in late October and so it is only possible to review the water balance for this pool from November onwards.

Figure 7 shows the water balance over most of the season for the top pool. The very high efficiency of the channel is likely to result partly from the unmeasured inflows into the channel.

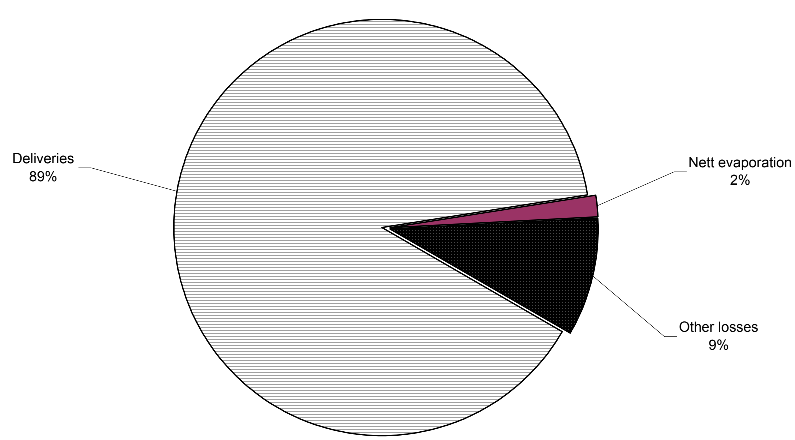

Figure 7. Valencia Creek water balance from September 2004 to May 2005.

Figure 8 following shows a more interesting picture of the channel loss characteristics. This indicates relatively high losses in the first part of the season then relatively low losses up to end of January and then ongoing minor net inflows into the system after the major rain event at the start of February. The results show that losses can vary significantly within a season and aggregation of the loss over the season, even with good measurement, could mask the actual loss performance of the channel.

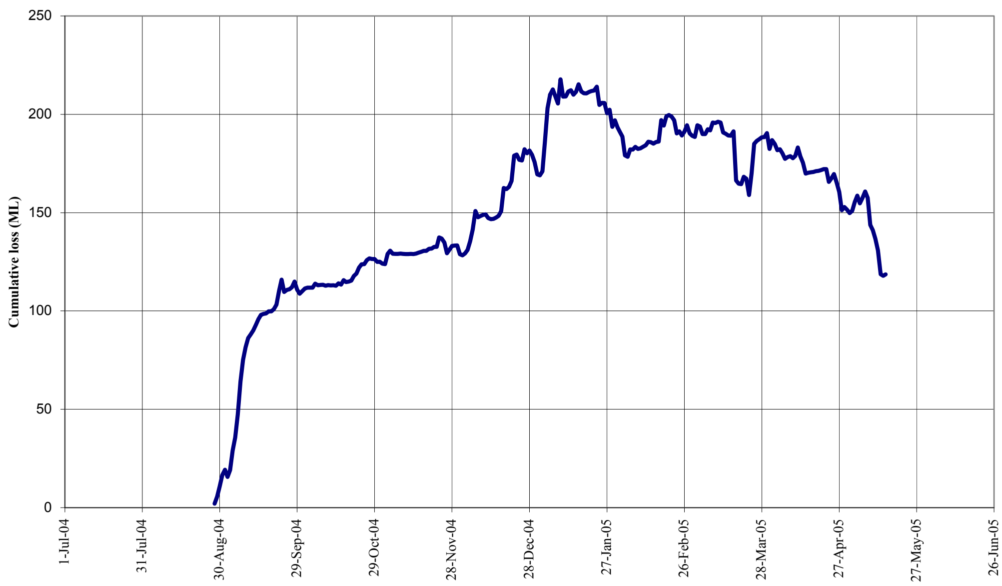

Figure 8. Valencia Creek Channel top pool– Cumulative loss September 2004 to May 2005.

The results for the second pool showed that it received slightly more water than it lost which would mean that it has both a very low seepage and leakage rates and at times receives surface and sub-surface flows. An analysis of an eight-day period (12 to 20 March) late in the season demonstrates that the channel has very low seepage and leakage. During this period there were no deliveries in the pool, no outfalls, 6.2mm of rain spread over four days and the only water leaving the pool entered the Boisdale pipeline. Figure 9 following shows during this period that of the 195.3 ML measured entering the pool by the FlumeGate®, the ultrasonic meter recorded 194.4 ML flowing into the pipe. This indicates a conveyance efficiency of 99.5%.

This project in its early stages has demonstrated that accurate and continuous monitoring of flows can provide significant insight into quantifying channel losses and how they vary both spatially and temporally. Measurement and analysis of water losses will continue as part of the project and following its completion we plan to enhance water balance reporting tools within the system.

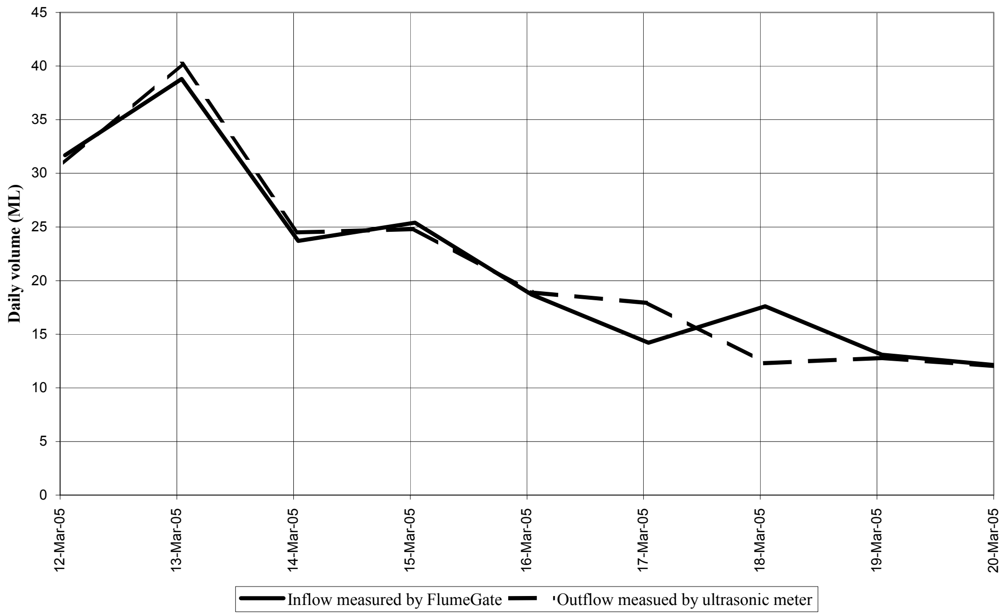

Figure 9. Valencia Creek Channel – Bottom pool inflow and outflow.

CONCLUSIONS

The TCC® has proven to be extremely effective in reducing outfalls from the system and delivering permanent water savings, whilst improving service levels. The system provides a vast amount of data that enables managers of earthen channel supply systems to monitor losses continuously and as a consequence provides an opportunity to greatly increase their understanding of the system performance.

REFERENCES

Sinclair Knight Merz (SKM), 2000, *Water Savings in Distribution Systems* – Report prepared for Department of Natural Resources and Environment and Goulburn Murray Water June 2000

Sinclair Knight Merz (SKM),, 2002 *Macalister Irrigation District, EM-34 surveys along the Valencia Creek and Northern Channels as an indication of channel seepage – Final* Southern Rural Water January 2002.

Plusquellic, H (2004), *Application of Geosynthetics in Irrigation and drainage Projects*, ICID, ISBN 81-85068-88-7