MODERNISING IRRIGATION INFRASTRUCTURE, VICTORIA AUSTRALIA

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ABSTRACT

In response to more than a decade of sustained drought the Victorian State Government has embarked on a major infrastructure upgrade of the State's largest irrigation system. This two billion dollar investment program is being executed in two phases with the first phase, that represents A$1B focussing on improving the channel delivery systems and the second $1B focusing on farm system improvements. The primary focus of the investment is to improve the distribution efficiency and improve customer service with the first phase targeting annual water savings of 225,000 ML, which is the subject of this paper. These savings are to be equally shared between the environment, farmers via an increased allocation and an agriculture-to-urban transfer where 75,000 ML will be pumped into the Melbourne Urban system.

The paper will provide background on the project and then a high level overview of the technical challenges in implementing around 6,000 in-system regulating gates and 15,000 farm meters.

INTRODUCTION

The Goulburn-Murray Irrigation District, located in Northern Victoria is Australia's largest Irrigation district, as depicted in Figure 1. The district is partitioned into six local administrative areas and spans an area of more than 200 km in an east-west direction and 75 km in a north-south orientation. It is a large interconnected network with water supplied primarily from the Murray and Goulburn Rivers. The 6,300 km of channels are equipped with approximately 8,000 regulating bays at 6,000 regulating structures and 24,000 customer supply points. SKM[[i]] reported that the annual diversions for the decade from 1989/1990 were of the order of 3,200,000 ML with approximately 2,250,000 ML delivered to farms, which equates to a distribution efficiency of the order of 70%. SKM indicated that this annual loss of 950,000 ML was comprised of the following components

- Channel outfalls (spills)
- Leakage (point source)
- Seepage (diffuse)
- Evaporation
- Meter error
- System filling
- Unauthorised use

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More than a decade of drought has demonstrated that the volume of water available for diversion into the channel network is significantly less than the "wet" 1990s. For the 15-year period from 1993/1994 to 2007/2008 Goulburn-Murray Water (G-MW)[ii] documents the average annual diversion as 2,562,000 ML with deliveries to the farm gate of 1,816,000 ML which equates to a "System Operating Requirement" (losses) of 746,000 ML per annum for the period. For the 2007/2008 season the impact of the prolonged drought is stark with a diversion of 1,010,000 ML and deliveries of only 638,000 ML. The 372,000 ML operating requirement is attributed to the lower deliveries, the partial implementation of channel automation, reduced irrigation season and shutdown of parts of the channel network where there was no seasonal demand.

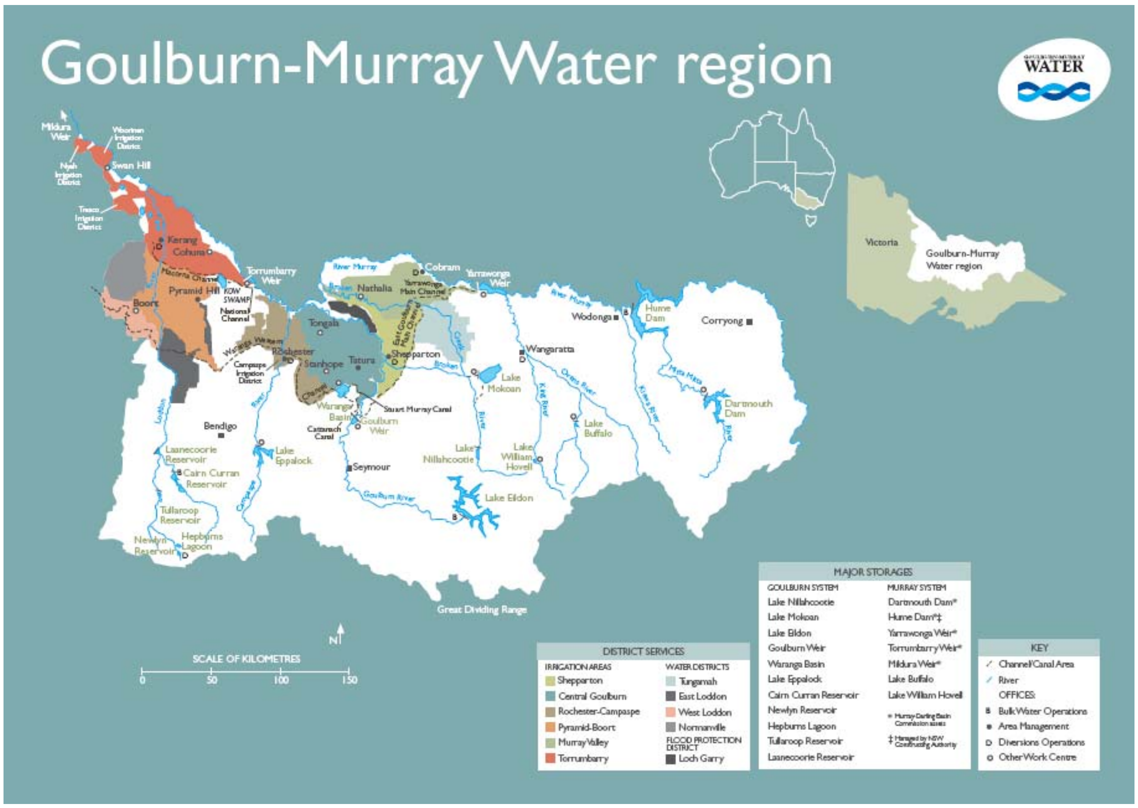

Figure 1. Goulburn-Murray Irrigation District

A key goal of the massive modernisation investment is to reduce system losses to mitigate the impact of reduced resource availability. Additional benefits accrue from improved customer service by providing near on demand supply with high reliability flow rates to farm justifying significant investment in on farm technologies to improve productivity and reduce water use.

BACKGROUND

Total Channel Control® (TCC®) was first introduced on a pilot basis to the Central Goulburn No 2 channel system in 2002. TCC® is an integrated system of intelligent automated gates, advanced communications technology and sophisticated modelling and control software. It transforms manually operated open channel systems from labour intensive, conservatively operated, high water loss irrigation supply systems into responsive, flexible and efficient systems that enable irrigators to get water at the flow rate and time they require.

In this pilot implementation manual drop board structures at 38 sites were replaced with automated FlumeGate™s and 136 Dethridge Outlets were also replaced with a further 136 FlumeGates. This pilot project demonstrated that automation of open channels was both technically and economically feasible at this scale and considerable insight was provided into the understanding of the losses – as detailed in [iii]

A significant expansion of this pilot was implemented in 2004 [iv] and after detailed consideration and evaluation of the success, the Victorian Government committed to implement the channel control and complimentary technology across the whole system. This paper provides a high level overview of key aspects of this massive project and details from the implementation during the 2008/2009 irrigation season. At the time of writing the 2009/2010 (1,100 regulator gates) works have just been installed.

GATES

The FlumeGate™, an advanced automated measurement and control device, is the cornerstone of the TCC® system. The gate is fully self-contained with a high degree of integration between the actuation, instrumentation and control components. The gate is designed to retrofit into existing regulating structures. Figure 2 shows nine gates installed at the heading of the CG No 8 channel in the Central Goulburn Irrigation District. Figure 5 shows the SCADA screen used to present the information transmitted from this site.

A total of 1,530 FlumeGates were manufactured during 2008 and they were installed during the winter of 2008 by FutureFlow Pty Ltd, an alliance of Transfield Services, Comdain, SKM and Goulburn-Murray Water. At most sites the gates were retrofitted into the existing structure, as in Figure 2, which shows the offtake to the CG No 8 channel system. Minor civil works were undertaken at some sites, but in general few new structures were required.

Figure 2. 9 FlumeGate™s at the CG No 8 Channel Offtake

COMMUNICATIONS

A critical element of the project was to design and install a communication network to support communication between equipment in the field and the office. A total of 50 communication nodes were deployed across the district as depicted in Figure 4. Key features of the design were to use FHSS (Frequency Hopping Spread Spectrum) radio systems from each node to cover a radius of approximately 15-20 km. In the initial implementation, the design objective was to "load" each node with 200 remote units, with provision for a further 200 units by collocating another master radio at each node. FHSS technology was chosen for the following reasons:

- No requirement for licensing, as they operate in the 915MHz – 928MHz ISM band
- High speed air interface running at 19,200bps
- Low maintenance requirements
- Excellent sensitivity -116 dbm
- Designed for robust communications in an unlicensed band
- Ease of deployment

Data distribution to each node site is via two independent communication links, to provide full backbone redundancy in the event of a single link failure. The primary link is provided by Motorola Canopy point to point broadband link equipment. The canopy TCP/IP links provide data at a rate of up to 30MBit per second to each of the nodes. These links have been arranged in a tree fashion to minimise propagation delays in the system. The alternative link is provided by a 3G GPRS modem connecting to the 3G mobile phone system. This system provides excellent bandwidth and maintains a true IP path as a secondary link to the node site. Routing across the primary and secondary links is provided by the Motorola MDLC protocol, as depicted in Figure 3.

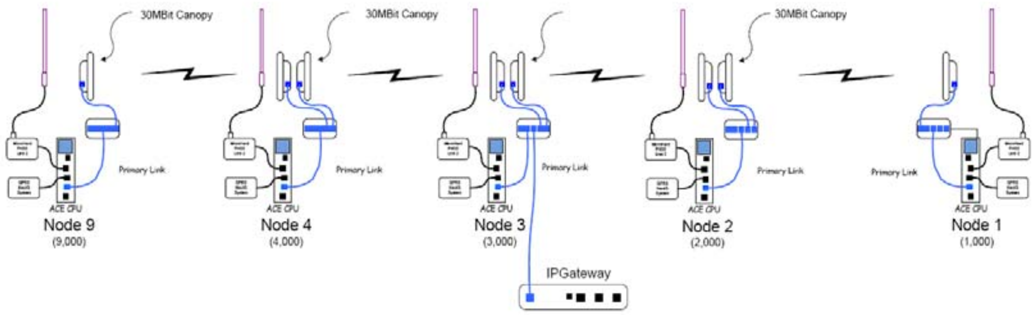

Figure 3. Communications Node Architecture

A key requirement was to use solar power for both the node and remote sites.

Figure 4. Communications Node Site

SCADA

The requirement to install 1,530 gates necessitates an efficient strategy for the rollout of the SCADA system. The address of each gate was assigned in the factory and the host system engineered using specialised "batch" style facilities, prior to the installation of the gate. Gate installation and dry commissioning was undertaken in a couple of hours and this includes the completion of the host system commissioning Inspection and Test Plan (ITP) to demonstrate and test remote operation and control. In addition to a full functional check of the gate, this dry commissioning process fine tunes the gate position to take account of any site specific geometry to ensure the gate tip can be reliably positioned with the required mm accuracy.

Figure 5. SCADA Screen Interface

The primary mechanism for operators to access the SCADA screen for each site is via the schematic representation of the water network- the tool operators use to plan and schedule orders prior to the introduction of channel automation. This arrangement provides a smooth transition for operators as the primary user interface remains unchanged, but in addition to planned information on water orders, operators now have seamless access to real time flow and water level information and plant status. The schematic interface for a small section of network is shown in Figure 6.

Operators can also access site specific screens through a more traditional menu system and summary screens. Access to all information contained in the SCADA database is available to the enterprise through a flexible WEB based interface, which also provides the delivery mechanism for customised reporting.

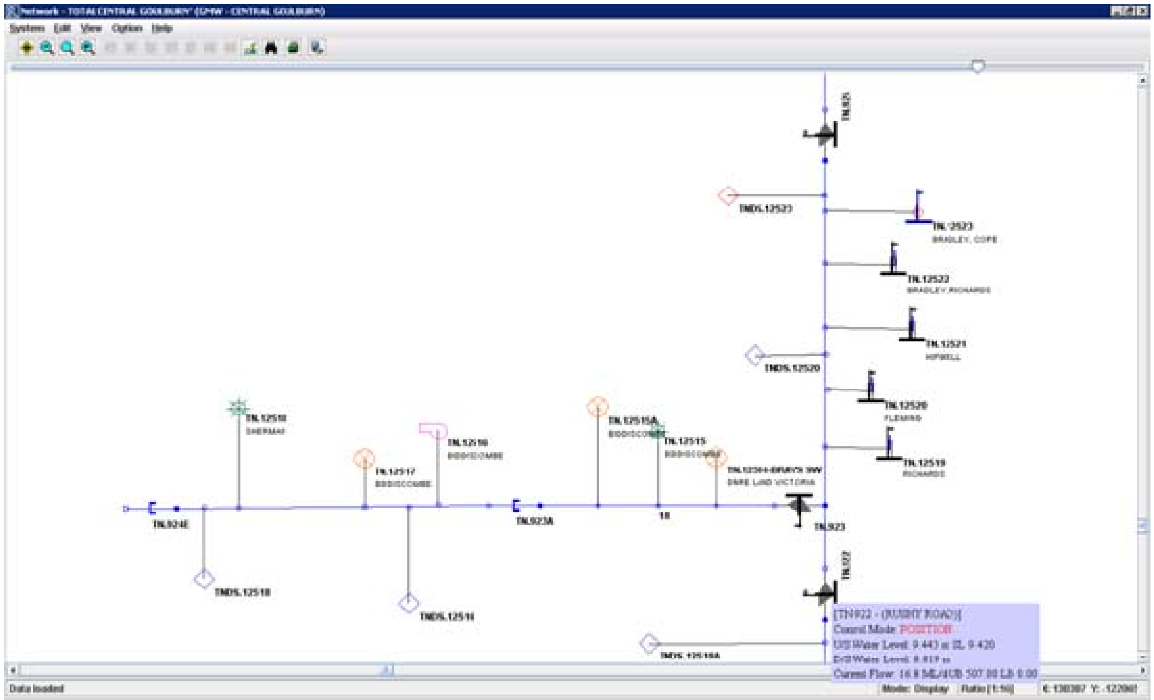

Figure 6. Schematic Interface

CONTROL ENGINEERING

Transforming a large manually planned and operated irrigation network to completely automated operation is a non trivial exercise. Customers in the district have been required to lodge their water orders directly into the system for more than 15 years, initially using Interactive Voice Response technology, but more recently with an alternative to use the WEB. After lodgement these order requests are scheduled by “planners” to meet the constraints of manual operation and the scheduled commencement times are “confirmed” by the customer the day before operation commences. In terms of the customer there two key changes; firstly the scheduling of the order is done on-line to meet the constraints of the automated control system and secondly the customer supply point operates automatically at the approved times and flow rate(s).

However, for the irrigation district staff, the transition from manual operation to automated control is done on a step wise basis with a prime focus on smoothly migrating to fully automated operation on the following basis.

1. The channel offtakes or headings are operated in automated flow control mode with the flows determined using the traditional planning process. Note that there is no tuning required for automated flow control.
2. The in-line gates are operated in position mode either from the field using the local keypad interface or from the office using the SCADA system. In both cases the operators have a flow “calculator” available to quickly determine the required gates position for the planned flow. Note that operations continue on the basis of the supply driven or upstream control paradigm associated with manual control

systems. The operators have the advantage of continuous water level and flow computation and can configure alarms to draw attention to specific conditions. This provides significantly more insight into the system than traditional manual operation.

3. The control system parameters are determined from either the physical parameter or observations of water levels associated with designed flow changes using specialised techniques as generally detailed in [v]
4. These control parameters are downloaded to the gates using the SCADA network and a group of one or more pools, starting from the top of the channel system, are migrated from manual to automated operation by remotely changing the Control Mode variable in the gate from Position to TCC mode. In practical terms this means shifting the boundary of the point where the flow is specified further down the channel until the entire channel is commissioned. At this point operation is considered to be demand driven or downstream control based.
5. The final step is to "turn on" the automatic scheduling that changes the scheduling process from a human to a machine – this is achieved by 'flicking" two software "switches". It is this final step that provides the customers with the near on demand service.

After the transformation the system is closely monitored for approximately one week, depending on demand. Any fine tuning required is generally undertaken during this period. It also provides an opportunity to identify any gross errors, usually as a result of an incorrect geometry measurement, that invariably occurs in such a large implementation.

The 1,530 gates created a total of 327 pools in the Shepparton Irrigation Area, 246 pools in the Central Goulburn Irrigation Area and 25 in the Murray Valley Irrigation area, a total of 598 pools.

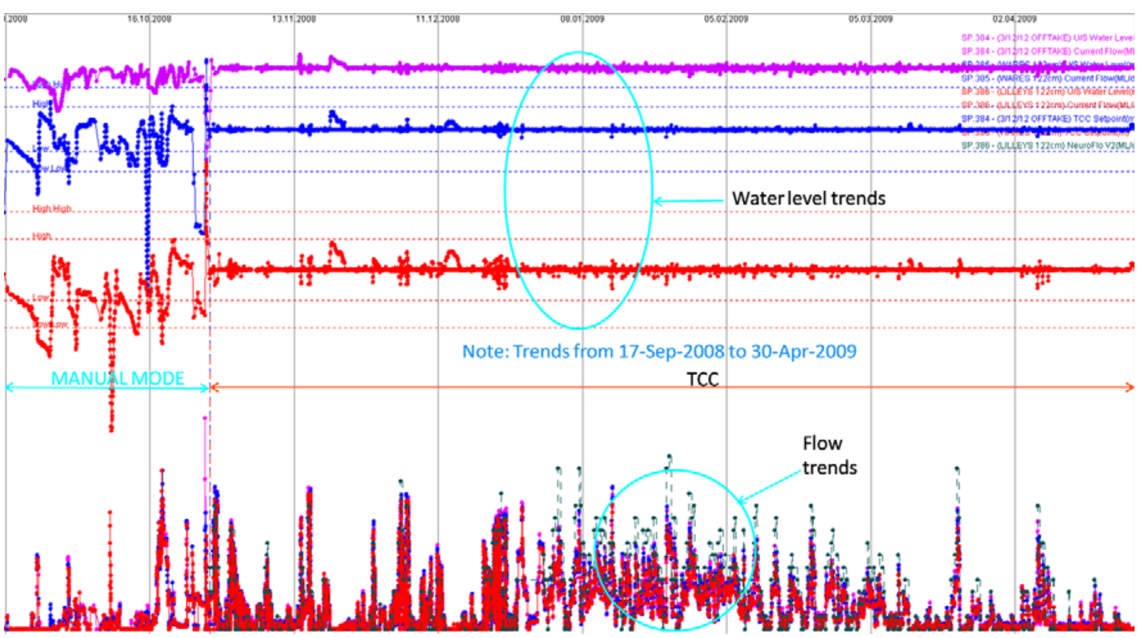

Figure 7. Transformation to Automated Control – Water Levels and Flows

There is no doubt that the installation of remotely controlled and real time monitored gates provides an opportunity to improve manual operation using the gates, particularly with the intelligent configuration of the alarm system. However, the overriding message from the transition experience is that it is exceedingly difficult for operators to make decisions on the settings required at more than 1,500 gates to minimise water level disturbances, maximise customer service and minimise wastage. Figure 7 illustrates the water levels and flows at three regulators on a channel and the water level variation before and after the commissioning of the automated control is quite stark. Note that under automated control near constant water levels are provided against a background of continually varying flows and hence customer demand.

Another key objective of the project is to eliminate spills from the channel system. Figure 8 shows the instantaneous flow and cumulative volume from the outfall of the Central Goulburn No 5 channel system before and after the implementation of TCC. This channel has a flow capacity of 250 ML/Day (approximately three cumecs) and a farmer allocation of 12,250 ML.

The system was operated manually from the beginning of the season until 13 November 2008 when automation was implemented. Up to that date cumulative outfalls totalled 286ML. After automation outfalls were dramatically reduced, with only 3ML passed during the remainder of the season.

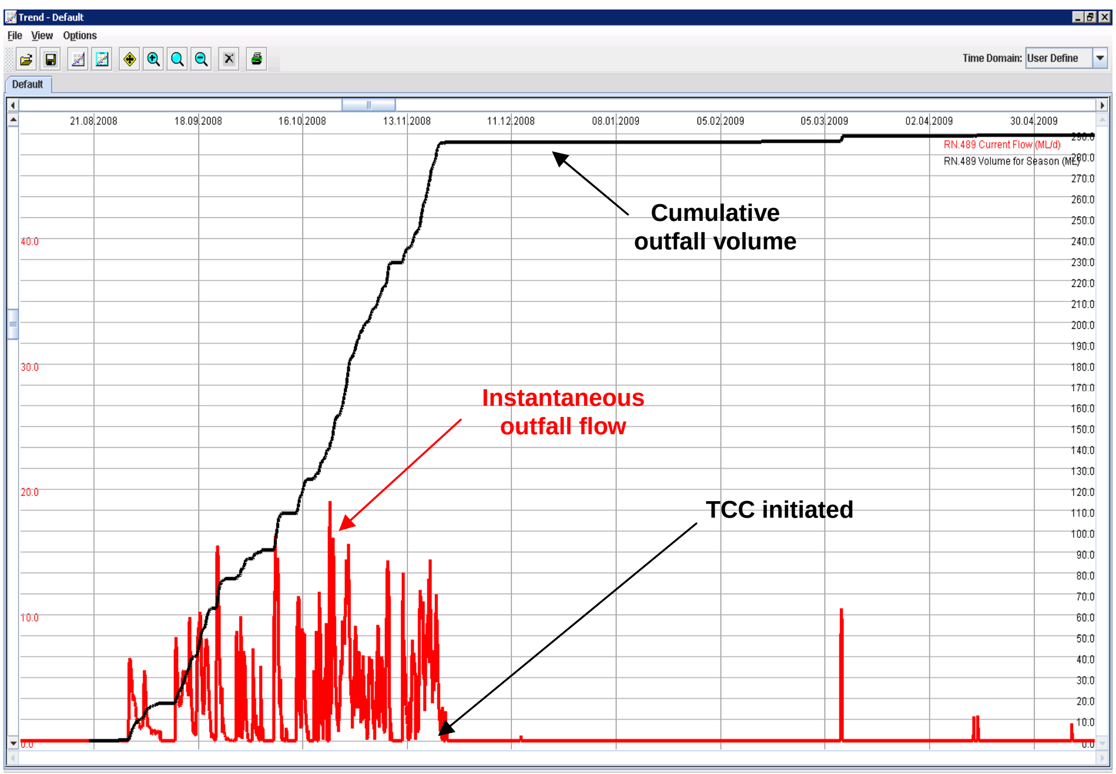

Figure 8. Outfall and Cumulative Volumes pre and post automation

This pattern is representative of the experience across the entire network.

CONCLUSIONS

The experience from the large scale implementation of open channel control technology in Northern Victoria, Australia is that significant quantities of water can be saved within the distribution system. There is clear evidence that outfalls can be effectively stopped on a large channel networks and this is a significant outcome as outfalls have traditionally been a dominant component of system loss. In addition the provision of near on demand customer service enables customers to improve the scheduling of irrigation applications with flow on water savings and productivity improvements. It is expected that this revolution in customer service will enable further improvements in on farm water use efficiency and productivity.

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