

GOULBURN-MURRAY
WATER




RUBICON
SYSTEMS AUSTRALIA



Prepared by

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1. Executive Summary

1.1. Background to the Pilot

The Department of Sustainability and Environment (DSE), Goulburn-Murray Water (G-MW) and Rubicon Systems Australia (Rubicon) entered into an agreement (The Agreement) to trial Total Channel Control™ (TCC™) technologies. These technologies resulted from extensive research and development by Rubicon in partnership with the University of Melbourne in the application of control technologies applied in other industry.

The basis of the technology is a new range of control gates with automation and control software that delivers smart control of multiple regulating sites, rather than individual control of stand-alone sites as is common across the rural water authorities within Australia.

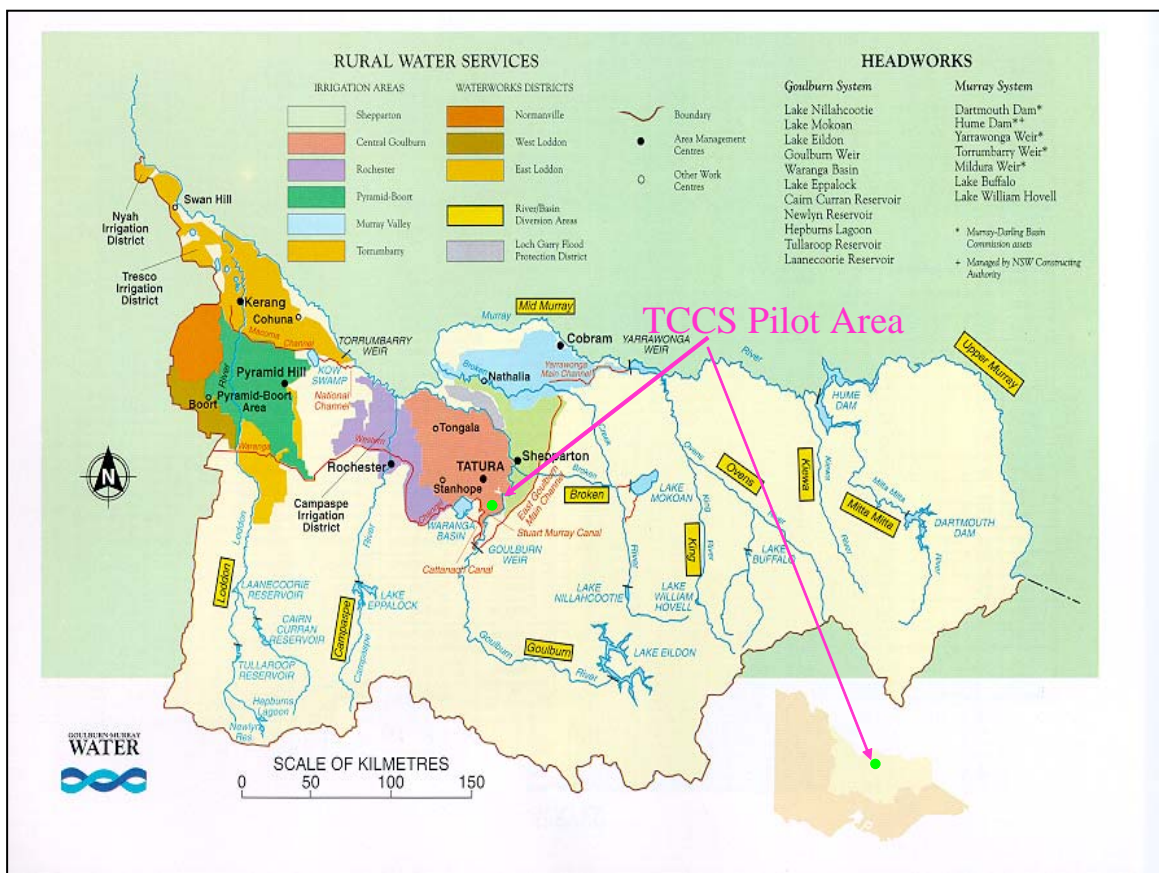


Figure 1 - Pilot Locality Plan

The site chosen to facilitate the Pilot was on the Central Goulburn No2 Channel located near Murchison, as shown in Figure 1, which is within Goulburn-Murray Water’s boundary of responsibility.

In February 2002 agreements were signed forming an alliance between Rubicon Systems Australia Pty. Ltd., Goulburn-Murray Water and the Department of Sustainability Environment to deliver this project. A time frame of up to two years was allocated to build, install, develop and evaluate the potential of this technology for wider application.

Clear objectives were developed for the Pilot by the Members to demonstrate the areas of interest of each.

In presenting TCC™ to G-MW and DSE, Rubicon indicated that it expected benefits to accrue in the following areas

- **Improved customer service**
 - Close to “on-demand” supply to customers
 - Supply of flows as ordered.
 - Automated opening and closing of outlet.
 - Orders confirmed at the time lodgement.
 - Ability to interface to on-farm automation equipment

- **Water Savings**
 - Channel system outfalls can effectively be eliminated whilst delivering significantly improved customer service.
 - The “on demand” service combined with assured flow rates onto farm facilitate on-farm savings and improvements.

- **Productivity Savings**
 - The TCC™ system operates automatically without a traditional field operator
 - The Planner’s role changes from routine scheduling to supervision, exception handling and emergency response.

- **Occupational Health and Safety**
 - The TCC™ system eliminates the manual lifting of drop bars and meter outlet doors.
 - The TCC™ system eliminates the OH&S risks associated with lifting of the Dethridge Outlet door and the rotating wheel.

The implementation of such new and innovative technology was clearly an ambitious and high risk project and the Pilot Agreement and commercial terms were structured to reflect this position. The Pilot Agreement defined a number of specific objectives to assess the performance against the benefits Rubicon purported and also the establishment of a Pilot Management Board, comprised of Senior Managers from the respective organisations, to oversee the execution and reporting of the Pilot against the objectives. The Pilot Agreement defined up to a 2 year period for the execution of the pilot with final reporting to be completed no later than the end of the 2004 calendar year.

1.2. Project Management

As there were three parties to the project a Management Board was formed with one representative from each Member organisation making up the membership of the Board. A project manager was appointed from within Goulburn-Murray Water’s team, and while this position reported to the Pilot Management Board (PMB) no voting rights were given.

The PMB met regularly and considered progress of the project, and when required, made decisions to progress the objectives of the Pilot.

A project team was formed of representatives of management and interest areas within G-MW plus the project manager of Rubicon's team.

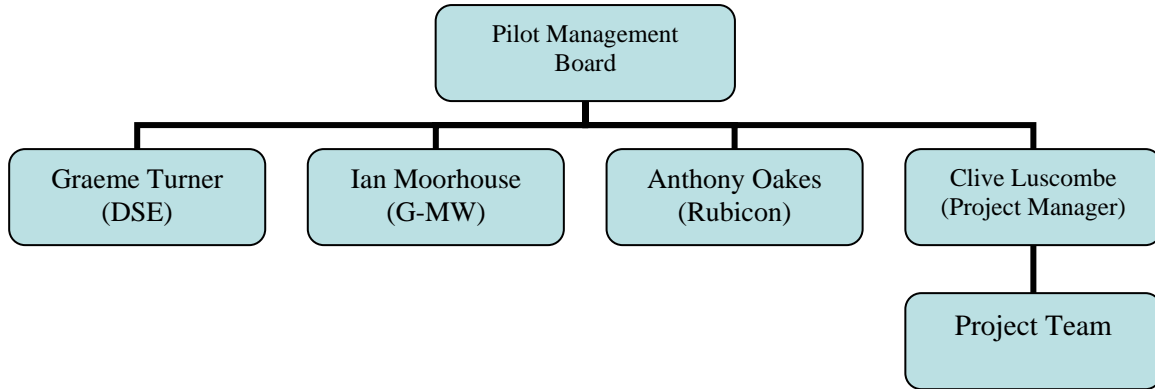


Figure 2 - Organisation Chart of Pilot Management Board Structure

1.3. Program of Works

The works program commenced with the selection of the site to host the Pilot. A set of criteria was established to measure the appropriateness of any area to be considered. Commitment was sought from local Area Management to support the project and to be part of the project team to deliver the program of works. As shown in , the site selected was the CG2 channel system located near Murchison within the Central Goulburn Irrigation Area.

The program of works involved the following key activities

- Manufacture and installation of 38 FlumeGate™ model R “in-line” regulating gates
- Manufacture and installation of 136 FlumeGate™ model M “farm meter” gates
- Design and installation of 3 radio repeaters, with redundant links
- Adaptation of TCC™ software to operate with G-MW’s Irrigation Planning Module (IPM) product
- Configuration and tuning of the control system
- Communication and training of staff and customers in the use of the system
- Ongoing support

While teething problems with such a major step in technology were expected, the difficulties encountered with the implementation proved to be greater than anticipated at the outset of the Pilot. The tight implementation timetable combined with the unprecedented drought conditions required that the system start delivering water on the 15th August 2002, an unusually early start to the irrigation season. At this stage all of the in-line channel regulating gates had been installed and could be operated either locally on site or remotely by the SCADA system. However, the farm meter outlets (gates) had not

been installed at this time and deliveries in the early part of the season were via outlets with consumption not metered. The last of the meter outlet gates were installed in early November 2002 and the TCC™ system was formally ‘turned on’ on the 14 November 2002, a significant milestone given that a completely automated open channel control system of this scale had not at this time, and has not since, been implemented outside Australia. The system operated for the balance of the 2002/2003 irrigation season with minimal outfalls whilst requiring customers to provide only 1 hours notice to lodge and modify orders.

The initial technology difficulties were mainly associated with relatively minor design faults with the FlumeGate™ and software faults with both the FlumeGate™ and host (office based) computing systems. These faults had serious repercussions for G-MW customers who were already battling the worst drought and resulting water allocation on record. Most of these issues had been engineered out of the TCC™ product by the end of the 2002 / 2003 season. However there were also a number of ongoing difficulties with the pilot execution that related in part to the technology, in part to the configuration and use of the technology and broader policy issues regarding supply levels and measurement.

In terms of the ongoing technology issues, these relate mainly to the reliability and accuracy of water level measurements and the consequent impact this has on flow and volume calculations. These difficulties combined with the unprecedented dry conditions undoubtedly lead customers to compare the unit volume of water metered by a FlumeGate™ with that supplied by a Dethridge outlet. These comparisons lead customers to question the accuracy of the FlumeGate™ flow measurement technology. The absence of any relevant Australian or International flow measurement standards, the lack of a suitable independent NATA certified testing facility and the current exemption of irrigation meters from the Trades and Measures legislation made it difficult for Rubicon to demonstrate the accuracy of the FlumeGate™ to G-MW and their customer’s satisfaction, despite some independent testing at the Manly Hydraulics Laboratory. In an attempt to address customer concerns G-MW and Rubicon embarked on a comprehensive program of testing and evaluation assisted by Hydro Environmental Pty Ltd with expert technical advice from Dr Robert Keller of RJ Keller & Associates (Associate Professor of Monash University). This work made very clear conclusions that the FlumeGate™ flow measurement algorithms were sound. A refined flow model resulted which was more accurate across the full flow range and defined operating conditions of the gates (1 to 12 ML/d) and was installed in all FlumeGate™ M gates. The water level sensing technology was replaced on all gates during the 2003 winter due to recurring issues identified with the original sensors installed. However flow measurement accuracy still remains a contentious issue with a number of the CG2 customers.

The decision taken to operate channel water levels in the TCC™ system to the designed supply level, in many cases reduced the rate at which it can flow under gravity onto farmer’s properties. The need to operate channels within the designed water level is driven by the increased cost in maintenance and loss of water through seepage, leakage in banks above the height of the compacted clay core, flooding of neighbouring lands and bank overtopping. The higher the channel runs the greater these losses are.

Unfortunately, the ability of TCC™ to capably enforce a longstanding policy of G-MW to run channels at their design level has created an untrue perception in the eyes of some customers that TCC™ means lower flow rates and less efficient irrigation. These

customers correctly identify that TCC™ and more specifically the FlumeGate™ was presented to them prior to the commencement of the pilot as being capable of delivering higher flow rates onto farm, but in hindsight the extent of the surcharged operating levels was not anticipated. It is unfortunate that TCC™ has been confused in this way as the issues of command and flow rate are completely independent of TCC™ as it can be configured to maintain water levels at any defined set point.

During the winter of 2003 a number of changes were made in an attempt to improve the flow rate onto farm by cutting the gate further into the floor of the concrete emplacement, placing new wider gates in front of the emplacement and by installing significantly larger (wider) gates in new emplacements. With the channels operating at design supply level the most significant improvement was delivered by the new gates.



Figure 3 - Comparison of Dethridge Wheel and FlumeGate™

The decision to install the FlumeGates™ inside the Dethridge Outlet emplacement was taken primarily to ensure that the existing slide gate could continue to be used to control flow until FlumeGates™ were installed or be inserted if there was a need to remove and or replace the FlumeGate™. The encroachment of the gate frame in the water way reduces the capacity of the emplacement, although the head loss flow characteristics are still better than the Dethridge Meter wheel in the same installation. The other disadvantage of this approach is that it does not provide the opportunity to set the emplacement height at the correct level that installing a new emplacement does. The experience from the pilot is that many Dethridge Outlet emplacements are not set at the correct level and G-MW has resolved that future implementations will be based on new larger capacity emplacements.

1.4. Communication

Customer and staff communication commenced early in the project to provide as much detail as possible of the changes to be expected with the Total Channel Control System™ technology when fully installed and functional.

Customer meetings were arranged to facilitate the details of how the TCC™ was intended to work, what would change with the process commonly used by customers to order their water and to take delivery of it from the channel plus anticipated benefits for their operations. Much of the material presented was based on discussions with Rubicon and actual material Rubicon had used in conceptual presentation to DSE and G-MW.

Early in the first year of the Pilot, customers nominated a committee to work on issues with the Project Team as required. This committee has continued to work with G-MW to the resolution of issues concerning the customers.

Staff were presented with information at staff meetings, via the G-MW staff newsletter and personally with the staff directly involved in the project. Unions were advised of the project and the initial involvement of staff at an organised meeting with representatives and updates on progress provided through the formal process with Manager Organisational Development. System support staff employed in the Water Systems Support Centre and within the Electrical Services Unit, Tatura, were also informed progressively as the product was released, of the workings particularly so that they could provide the expected first level support to the end users (staff) of the system.

Information of the Pilot progress was reported through local and national media often highlighting the perceived issues rather than the strengths, although many very supportive articles have appeared in such publications as the Weekly Times, National Irrigation and Water Resources quarterly magazine, Country News and the Melbourne University News.

Within the industry, regular reports have been presented to ANCID (Australian National Committee for Irrigation and Drainage) conferences annually, USCID (United States committee meeting in Phoenix Arizona) and the Asian Pacific Regional Conference for the International Committee for Irrigation and Drainage held at Moama NSW in March 2004.

1.5. System Operations

Saving water by reducing outfalls was clearly one of the major objectives that the pilot was designed to test and this was an outstanding success. The volume of water passed through the outfall from 1 December 2002 until the end of this season was 108 ML and the total volume for the 2003/2004 season was 10 ML, with nearly all of this spilt during the manual filling period at the start of the season. These figures obviously compare most favourably with average annual estimates of the previous 5 years of approximately 1500 ML. However, volumetric comparisons of pre and post pilot conditions have proved to be problematic as illustrated by the following 5 year Average Annual Volumes for the period 1997/98 to 2001/2002

	Pre Pilot (5 year average 1997/98 to 2001/2002)	2003/2004 Season
Inflows	13,100 ML	14,011 ML
Deliveries (Metered)	10,800 ML	11,064 ML
Outfalls	1,500 ML	10 ML
Efficiency	82 %	79 %
Expected Efficiency (No Outfalls)	93 %	79 %

Figure 4 - Volumetric Efficiencies - Pre and Post Pilot

On the basis of the pre pilot records a reduction of outfalls by 1500 ML per annum would reduce the inflows by this amount and hence an increase in the efficiency to 93% would be expected. Continuous and accurate measurements at all regulators and farm outlets in the pilot area for the 2003/2004 season and the effective elimination of outfalls resulted

in an efficiency of only 79%. Clearly this result was not to be expected based on the pre pilot information and this casts concerns on the accuracy of the pre pilot conditions. Experience from other studies comparing manual and continuous measurements of outfalls shows that manual recording tends to significantly underestimate volumes. In terms of quantitative analysis the problem in comparing pre and post conditions is that there is no common measurement technology and hence no common “currency” to compare the two sets of information. This problem has obvious flow on effects to economic analysis.

The landmark Water Savings in Distribution Systems¹ study suggested that outfalls were the dominant component of the unaccounted for water in Northern Victoria and represented approximately 30% of the unaccounted for volume or approximately 9% of total diversion. The distribution of unaccounted for water determined by SKM is shown in .

Mechanism	Volume (GL)	Percentage	Volume (GL) without unaccounted component
Outfalls	298	30	387
Meter Error	110	11	143
Evaporation	101	10	131
Leakage	85	9	110
System Filling	64	7	83
Seepage	55	6	71
Unmetered D&S Supplies	38	4	49
Theft	5.5	0.6	7
Unaccounted	225	23	0
Total	982	101	981

Figure 5 - Distribution of Unaccounted Water - Source SKM 2000

System filling of CG2 commenced on 10 September 2003 and concluded on 28 September 2003 and consumed approximately 292 ML which represents about 2% of the total season inflows. It is not expected that evaporation would change as a result of TCC™ and with the effective elimination of outfalls and reductions in meter reading errors the unaccounted for component of the water balance (22.5% or 3163 ML) is expected to be dominated by

- Leakage
- Seepage
- Un-metered supplies
- Theft

The ability of TCC™ to compute the loss from each pool on a continuous basis has enabled a number of significant leaks to be located and repaired and there is a clear trend in the reduction of losses towards the end of the 2003/2004 irrigation season. At the end of the season the system was kept operational without any customer demand and the

¹ 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.

volume of loss from each pool was computed over a 10 day period. Results from part of this work were published by Oakes² which showed that

- 49% of the loss was contributed by 4 of the 38 pools
- 81% of the losses were contributed by 11 of the pools
- Small spurs in general were not significant contributors
- Total inflow to system for the period was 84.5 ML whereas the sum of pool losses for period was 84.4 ML

This work suggests that targeted leakage recovery programs could prove to be cost effective water recovery mechanisms.

1.6. System Performance

The FlumeGates™ are relatively easy to install with an external frame required to be fixed in place when the regulator is dry then the gate can be fitted in either dry or wet conditions (wet being with flow in channels). Although all regulating gates in the CG2 were installed in dry conditions, a few have been removed for maintenance and re-installed with flow on the channel without any impact on operations.

Customers have responded to the use of the new system by varying their ordering patterns to better meet their on-farm requirements as they are no longer required to fit into manually scheduled of flow change. Average flow rates have increased by approximately 1 ML/day across all customers with only 6.9% of all orders not receiving water as initially requested compared with 29% prior to the Pilot.

The greatest issues for customer service have been

- lower flow rates due to the configuration of the gates as installed in the small meter outlet
- the effect of reduced channel operating levels on many of the large meter outlets
- the concern of meter accuracy with water delivered to-farm.

URS were engaged by the Pilot Management Board to undertake an economic assessment of the CG2 pilot. This study concluded that for the “base” case where reductions in outfalls were not considered to be a saving that the costs of the system exceeded the benefits. They elected not to use the pre and post volumetric data from the CG2 pilot but to formulate a table of likely water savings from a panel of experts. One key aspect of this study was the interpretation of the work by Goulburn-Murray Water³ that lead URS to conclude that reducing outfalls from the CG2 was not a legitimate water saving, because this uncontrolled discharge could be legitimately consumed further down the system. However, the URS study concluded that if outfalls are included as a benefit in the analysis then TCC™ was economically justified i.e. the benefits outweighed the costs.

² Oakes Tony (2004), Total Channel Control™ - An important role in identifying losses *ANCID Conference Tununda* October 2004

³ Goulburn-Murray Water (2002) *Water Accounting Framework for Northern Victoria*, Tatura G-MW Doc No: 708710

1.7. Conclusions

There is no doubt that the TCC™ technology has proved it has the ability to deliver new levels of service to customers only previously considered possible with pipeline solutions direct from storages where regulation of flow over distance is not required.

The pilot has been able to quite clearly demonstrate that the system can run automatically without a field operator and deliver significantly improved control outcomes, although the reductions in labour were conservatively estimated in the URS study. The equipment obviates the need to manually operate control structures and minimises other hazards such as driving and exposure to the radiation from the sun's rays associated with traditional field operator activities.

Based on the experience of the CG2 Pilot, minimising losses through outfalls can be achieved. This Pilot should be used to determine future system savings policy for the operation of channels using TCC™. This should provide clear definition, after public policy debate, of what water is saveable for the environment reserve and improved river health.

The pilot has been an undoubted success with the capabilities of the core control and scheduling technology exceeding expectations. Likewise the ability to eliminate outfalls and provide near on demand service are clearly major breakthroughs for the industry – world firsts. Measurement accuracy and available flow rates have been major issues of concern to customers as well as equipment reliability and robustness. Resolution of these issues is obviously critical to the long term success of this exciting new technology.

In summary, the Pilot of TCC™ on the CG2 has clearly demonstrated that:

- Open channels can be fully automated to operate at a level never before achieved with open channel flow control,
- Customer service can be improved to supply water on one hours notice compared to the previous 72 to 96 hours notice required,
- Supply to all customers, no matter where they are located on a channel network, can be maintained at a constant flow rate from start to end of an order delivery,
- Through accurate measurement of flow at each regulating structure, losses can be better understood and located, providing an opportunity to reduce losses from leakage, seepage and poor operation of flow control devices, previously considered too difficult or out of reach,
- The same volume of water can be delivered onto farms with less water released from storage – more efficient operation of storage and delivery networks.
