IMPLEMENTING TOTAL CHANNEL CONTROL® TECHNOLOGY AT OAKDALE IRRIGATION DISTRICT — CASE STUDY

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ABSTRACT

Oakdale Irrigation District (OID) is a 72,345 acre irrigation district located in both the northeast foothills and valley floor of the San Joaquin Valley of Central California. OID has a 12 year history of marketing conserved water to willing buyers and using that revenue to finance capital improvements. Those revenues are used in a self-perpetuating program to rehabilitate, modernize and further more water conservation in order to generate and market more water. Those efforts have served OID well, generating some $41.2 million in water transfer revenues since 1998.

As its next tier of conservation projects, OID and Rubicon Systems America Inc. (Rubicon) embarked on a demonstration project to bring Total Channel Control® (TCC) Technology to the OID delivery system. The OID system is a 100 year old gravity flow system delivering about 250,000 acre feet per year to a mix of irrigated pasture, almonds, walnuts, rice and both small ranchette and large agricultural field sizes. All these variables lead to difficulty in the efficient management of irrigation water.

To address these issues with modern technology, a $3 million project was agreed upon by Rubicon and OID. The coordinated in-house constructed and managed project involved the replacement of 28 check structures and the design and installation of 31 gates on the 6.5 mile Claribel Lateral and the 8.5 mile Cometa Lateral. The works of improvement were completed during the winter of 2010/2011.

This paper will detail some of the institutional challenges, technological hurdles and construction experiences learned during the implementation of this project.

INTRODUCTION AND BACKGROUND

Overview — Oakdale Irrigation District

In 1909 OID was organized under the California Irrigation District Act by a majority of landowners within the district in order to legally acquire and construct irrigation facilities and distribute irrigation water from the Stanislaus River (ref. Figure 1). In 1910 OID and the neighboring South San Joaquin Irrigation District (SSJID) purchased Stanislaus River water rights and some existing conveyance facilities from previous water companies. Both districts continued to expand their operations over the ensuing decades.

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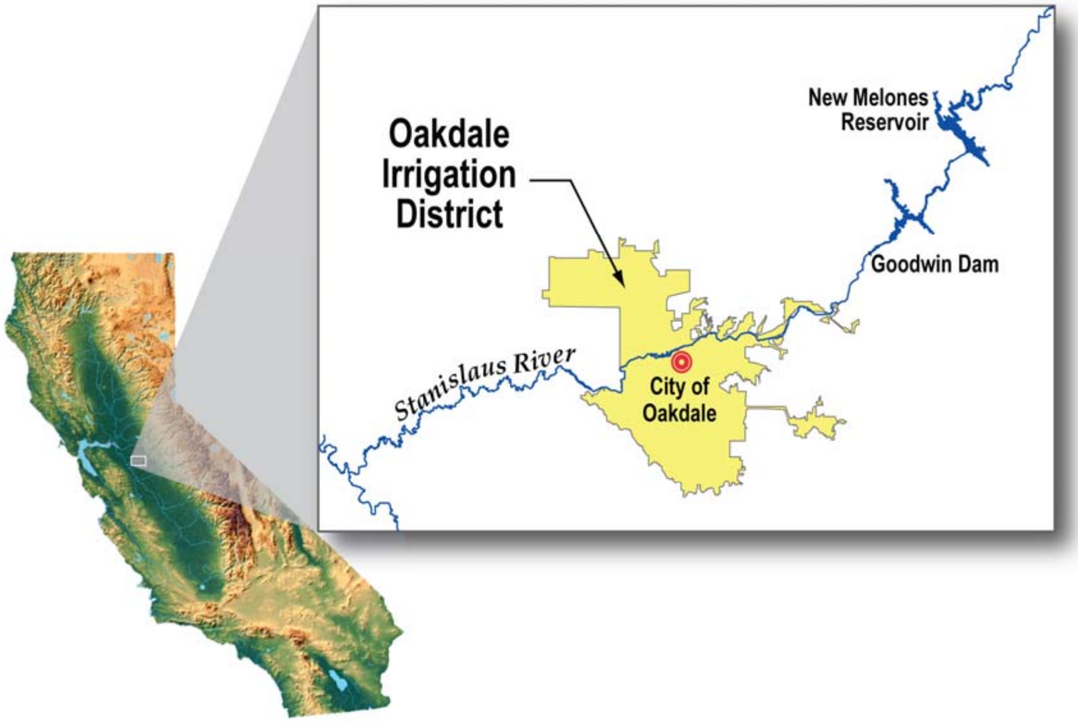

Figure 1. Location of Oakdale Irrigation District

Since their creation, OID and SSJID have constructed dams and reservoirs to regulate surface water storage and deliveries. Most dams were constructed in the 1910s and 1920s, including Goodwin Dam (1913), Rodden Dam (1915), and Melones Dam (1926), which provided 112,500 acre-feet (ac-ft) of shared capacity. To provide supplemental water storage for OID and the SSJID, the Tri-Dam Project was created and built in the 1950s. Tri Dam is a 3-dam network of facilities; Donnells Dam and Beardsley Dam on the Middle Fork of the Stanislaus River, and Tulloch Dam on the main-stem of the Stanislaus River. Hydroelectric generation was also a part of these facilities and today Tri Dam power generation is just over 100 MW per year. This power is sold wholesale on the open market. In total, the three reservoirs comprising the Tri Dam Project provide a storage capacity of 230,400 ac-ft.

In the early 1970s Reclamation replaced the Melones Dam with the larger 2.4 million acre-foot New Melones Dam and Reservoir. The districts have an operations agreement with Reclamation to utilize the federally owned New Melones Reservoir.

These historic and significant capital investments have led to a stable, plentiful water supply for OID. Hydropower revenues have been the main revenue source for day-to-day bill paying. Over the last 50 years, OID has focused its financial resources principally on paying off these capital investments; as a result, OID had invested little in replacement, modernization, automation or rehabilitation of its existing system over the years. That needed to change.

Water Resource Planning

Since its formation on November 1, 1909, OID has watched as water statewide has progressed from being a local resource, fueling the areas' mining and agricultural businesses, to a commodity aggressively sought statewide by municipalities representing millions of people. Wary of these shifting priorities, OID took it upon itself to develop a Water Resources Plan (WRP), a plan focused on protecting OID's water resource over the next 20 years. This two and a half year effort came to an end with the certification and adoption of the WRP in June of 2007.

Key components and the local benefits to be derived from the WRP included;

1. Protection of OID's water rights by defining the uses and purposes of OID's water over the next 20 years.
2. An infrastructure modernization and replacement program that will involve the expenditure of $170 million dollars in construction work to replace, rebuild and modernize OID's water infrastructure.
3. A financial strategy to pay for these improvements with urban water sales and transfers. Thus incurring little or no burden to current customers by way of water rate increases. Keeping water rates low is OID's way of providing our farming community a return on their investment.
4. Protection of the groundwater resources serving the City of Oakdale and local businesses and industries relying on this resource. Good quality drinking water is a priority protection focus in Oakdale.
5. Securing surface water supplies for the Cities of Oakdale and Riverbank should such a demand present itself in the coming years.

The WRP's Overview and Financing

The Preferred Program coming out of the planning process was a roadmap outlining how OID was to meet the long-term rebuilding and modernization needs of the district. Those needs and costs include;

1. Main Canal and Tunnel rehabilitation projects totaling ($44,553,000);
2. Canal and lateral rehabilitation ($24,418,000);
3. Flow control and measurement structures ($13,856,000);
4. New and replacement groundwater wells ($10,460,000);
5. Pipeline replacements ($45,366,000);
6. North Side Regulating Reservoir ($6,264,000);
7. Delivery turnout replacements ($4,680,000);
8. Outflow management projects ($10,947,000);
9. Reclamation projects ($5,813,000); and
10. Miscellaneous in-system improvements ($2,386,000).

In 2007 dollars these improvements represent nearly $169 million over a 20-year window. To finance these improvements the WRP relied on the continuation of revenues derived from water transfers.

Since 1998 OID has had about 41,000 acre-feet committed in water transfer contracts: two to the federal government and one to the Stockton East Water District for delivery of domestic water to the City of Stockton. As mentioned in the abstract, OID has benefited to the tune of $41.2 million in revenues from those transfers. OID has spent all that money on rebuilding and modernizing its water infrastructure to the benefit of the agricultural community it serves. On top of that dollar amount, OID bonded for $32 million in 2009 to pay for some large scale conservation, modernization and rehabilitation projects; bringing OID's total CIP project budget expenditures on infrastructure to over $73 million, about 2/3rds of which was spent from 2007 forward. Based on the WRP's Financial Model, OID needed to continue to invest around $6 million a year in infrastructure to stay current on both lifecycle replacement costs and modernization upgrades.

So in summary; OID sells water to generate revenues to invest in its infrastructure. Those projects result in more conserved water which is then sold again through market transfers in order to generate more revenues to meet the needs of its water delivery system. A simple plan that has brought OID to a decision point on its next level of water management control and conservation; one OID believes can be provided by Rubicon Systems.

THE PROJECT SETTING

OID Setting

OID has a diversion volume off the Stanislaus River for 300,000 acre feet. Since 1998 OID has committed to transferring 41,000 acre feet for municipal and environmental purposes to contracting agencies. The remaining 259,000 acre feet are available to satisfy a crop water demand, a demand in the order of 160,000 acre feet. The difference between the crop water demand and delivered volume of water on an annual basis is lost through operational spills, tail water runoff from farming, deep percolation to groundwater, canal seepage and other less significant losses.

OID's topography varies from gently rolling to the east and south of Oakdale to nearly flat around Riverbank. Approximately 75% of the land within the OID service area consists of irrigated agriculture. The cities occupy about 10% of the balance, the river riparian corridor is about 10% and the remaining 5% has never been plowed or intensively farmed. OID experiences mild, moderately wet winters and warm, dry summers typical of the Central Valley. Average temperatures range from the mid-forties in winter to mid-nineties in summer. Precipitation averages about 12 inches annually, over 85% of which occurs between November and March.

Currently the OID maintains over 330 miles of lateral, pipelines and tunnels, 24 production wells, 42 reclamation pumps to serve local customers. Nearly all canals were constructed in the early 1900's. OID currently serves 2,800 agricultural parcels covering about 57,000 acres. Principle crops are irrigated pasture for cattle, dairies, almonds and walnuts, rice, corn and oats. A driver for the OID is the conversion of about 1,000 acres per year from pasture/corn/oats to nut crops, which once converted, requires a different water demand to meet irrigation needs.

THE DECISION ON AUTOMATION WITH RUBICON

The Rubicon Selection

OID had been a user of the Rubicon FlumeGates™® products for a number of years as it worked its way through various canal gate automation products on the market. The past experience with Rubicon was a beneficial one, not without growing pains as Rubicon evolved their product line, but OID saw a product with potential that shortly matured into a low maintenance, user friendly, accurate flow measurement and control gate.

Total Channel Control® (TCC)

OID had been installing and using the "stand alone" FlumeGates™ from Rubicon at various locations within its canal system for enhanced water control for a number of years. During the initial funding of the WRP it became a focus of OID to replace all its main canal control gates and lateral headings beginning in 2006 with FlumeGates™s. After completing that program in 2009, along with completion of a major regulating reservoir serving farmland on the north side of the Stanislaus River, it was at that point that OID began looking at enhanced flow control within its laterals.

While OID was confident in the stand alone FlumeGates™ it was not aware of the TCC technology provided by Rubicon. In short: TCC provides a high level of water control by using a combination of sophisticated software and control engineering techniques along with wireless communications technology to integrate large networks of remotely controlled, solar powered FlumeGates™.

It was after OID's efforts to automate its main canals and lateral headings that TCC technology came into the picture. Soon after discussions with Rubicon regarding advantages of implementing TCC technology, OID staff visited Australia and more specifically, irrigation districts with the same physical setting as OID, who had implemented TCC. As with most technologies, seeing and talking to water professionals who have a history of use in the practical application of that technology was invaluable.

The major benefit seen by OID was the scalability of the technology provided by Rubicon. From main canal control, to lateral heading control, to pond to pond control within the lateral, to farm gate control at the turnout, to water order entry, tracking and scheduling, to Rubicon's on-farm system monitoring of soil moisture; it is an impressive array of conservation options for an irrigation district.

THE RUBICON PILOT PROJECT

Project Scope

Soon after staff's return from Australia a pilot project proposal was present to the OID Board of Directors for their review. The proposal was to implement a head-to-end installation of Rubicon's Total Channel Control® automation system on two of the OID's key canals, the Claribel Canal on the south side of the river and the Cometa Canal on the north. The project scope included the following;

- Installation of 31 FlumeGates™
- Installation 6 Slip Meters at selected farmer turnouts
- Implementation of SCADAConnect Software
- On-line Water Order Entry/Ordering System
- Related Equipment inclusive of radios, antennas, solar panels, IT/Servers, etc.
- Training and Service Support and Commissioning

Both systems on the Claribel and Cometa were expected to be fully operational for the beginning of the 2011 irrigation season. The system will be evaluated over the next two irrigation seasons to gain operational knowledge prior to expansion throughout the OID delivery system.

The Project Goal

The system will allow OID to better use their water; improving distribution efficiency and enhancing service levels to farmers by providing a near on-demand supply. Farmers will also benefit from consistent flows rates, which the system is able to achieve by closely matching demand and supply. Efficiency improvements afforded by TCC will enable OID to further its ongoing efforts to conserve its water resources.

The Claribel Canal System

The Claribel Canal has a heading capacity of 138 cfs. From its heading-to-spill the canal is 6.5 miles in length. It contains 17 pools along its reach. The system is mostly earth lined with sections of concrete lining and sporadic sections of pipelines.

The Claribel Canal system was chosen to test the ability of TCC in reducing operational spill. Operational spills are an operating inefficiency of open canal systems but are a necessity to insure all water orders are fully filled. The amount of losses at the end of the Claribel ranged from about 1,500-2,000 acre feet per year depending on various factors.

The Cometa Canal System

The Cometa Canal has a heading capacity of 306 cfs. From its heading-to-end the canal is 8.5 miles in length. It contains 13 pools along its reach and is a much flatter system compared to the Claribel System.

The Cometa was chosen in the hopes of improving operational flows to its terminus; the beginning of the Fairbanks Lateral serving another water division. An operational problem is that the upper Cometa flows through and serves another water division of OID and is managed by a different Distribution System Operator (DSO). As human nature is, the upper operator insured his needs were filled and the lower operator was pretty much at his mercy for water; hence a "feast or famine" situation.

PERFORMANCE RESULTS OF THE PROJECT

Claribel Canal Performance

The Claribel System is feed from the Robert Van Lier Regulating Reservoir. The reservoir outlet is controlled by two Rotork Hydraulic Actuators. Integrating the Rotork actuators into the TCC system controls resulted in a delay in fully implementing TCC on the Claribel Canal until late in the water season. This was not a TCC or automation glitch, it was a Rotork hardware system and warranty issue that delayed turning the system over to full automation.

Despite the delay of full automation, partial automation with the limited system had promising results as seen on Figure 2.

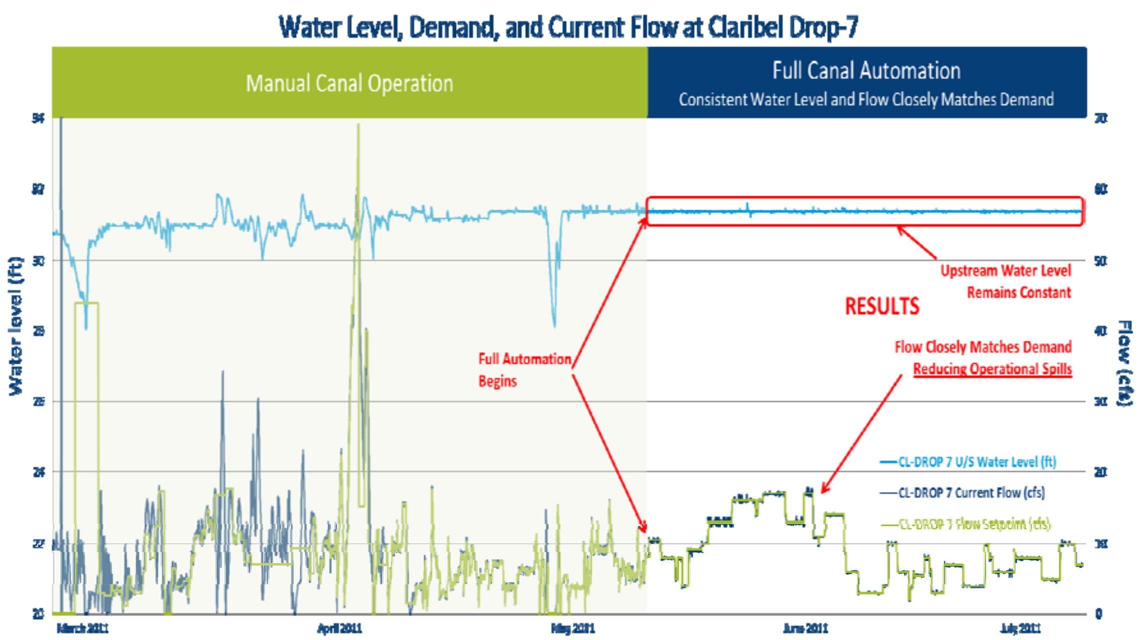

Figure 2. Water Level Demand Results on the Claribel Canal before and after TCC

Claribel Canal Operational Spill Performance

One of the goals was the reduction of operational spills on the Claribel Canal. While not a full year of implementation, for reasons cited, the anticipated benefits are graphically shown on Figure 3.

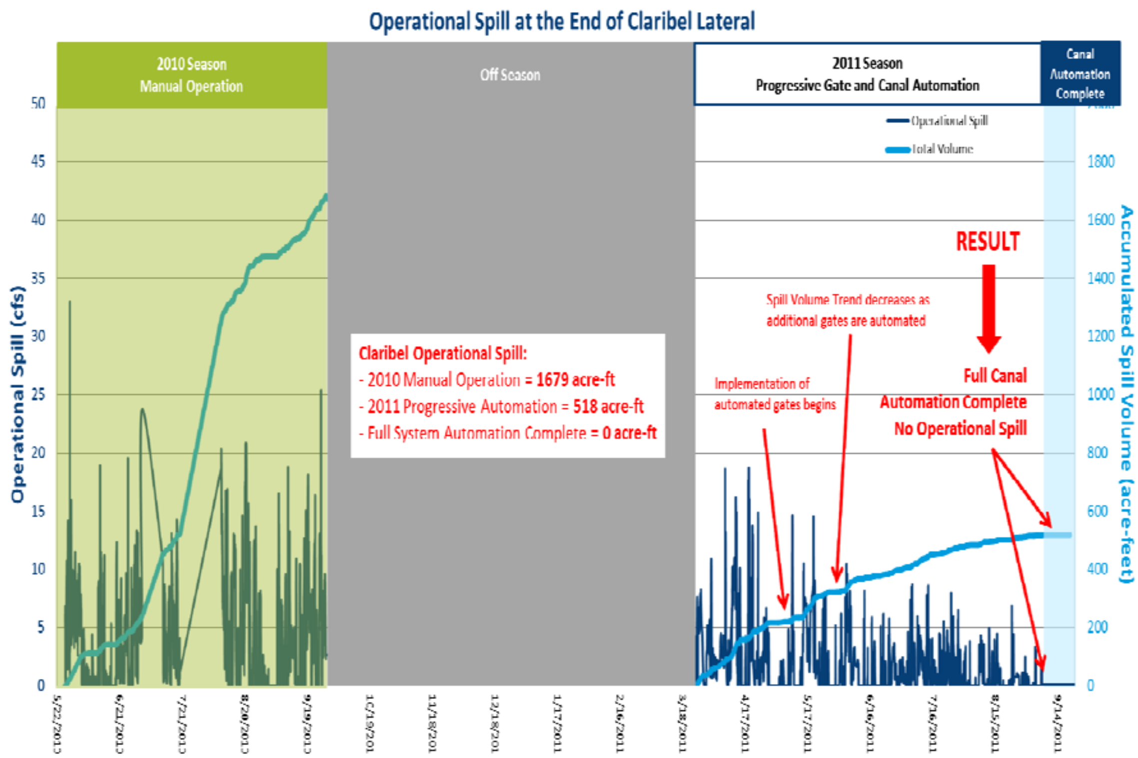

Figure 3. Operational Spill Performance on the Claribel Canal as TCC Implemented

The left side of Figure 3 represents the spill and the variability of that spill as occurred during the 2010 water season without TCC. The right side of Figure 3 presents the decreasing nature of that spill and decreasing variability of spill as TCC was incrementally implemented during the 2011 water season. Even with incremental implementation during the 2011 water season, spill at the end of the Claribel Canal was reduced by 1,160 acre feet. As shown in the light blue at the far right of Figure 3, spill is reduced to zero when TCC is fully implemented on the Claribel Canal at the very end of the 2011 water season.

Cometa Canal Performance

The focus on the Cometa Canal was to enhance flow deliveries to the end and to minimize flow fluctuations to the downstream water division. As can be seen in Figure 4 below, TCC implementation was successful in achieving that result. Statistically, average water level variations on the Cometa Canal improved by 92% to be within +/- 2 inches of the canal's set points for water delivery flows.

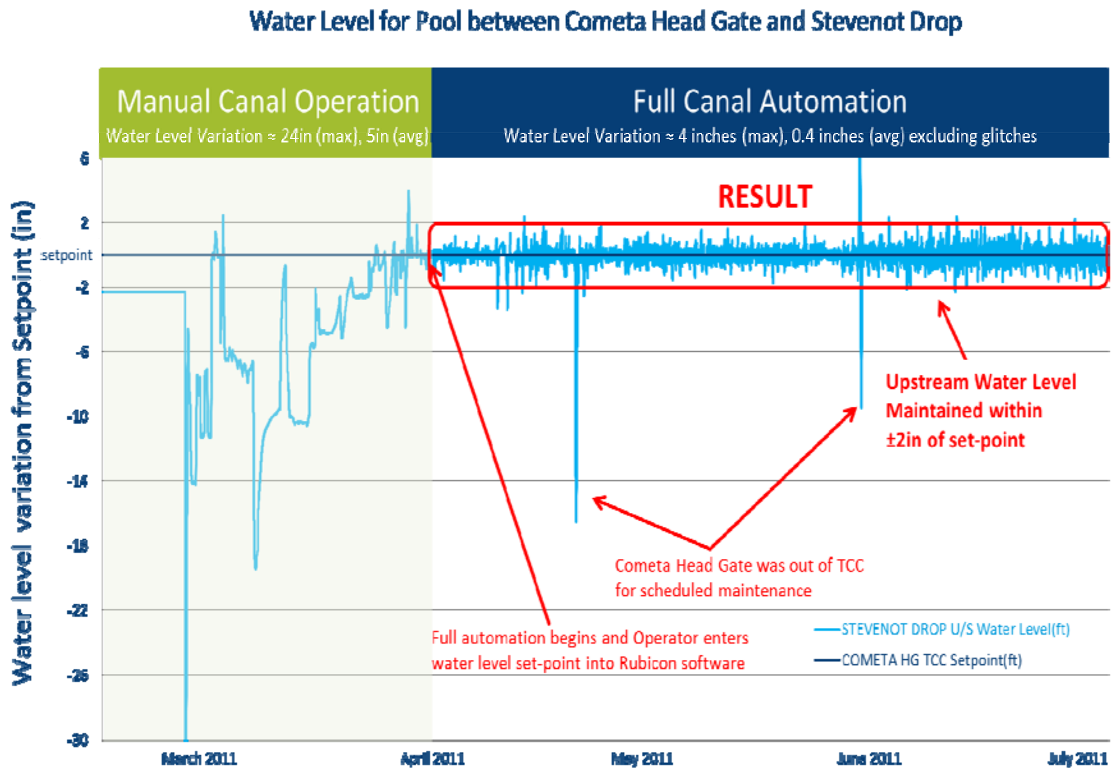

Figure 4. Water Level on the Cometa Canal after TCC Implementation

ANCILLARY BENEFITS OF THE PROJECT

Institutional Betterments and Changes

One of the concerns with implementing new technology is the acceptance of the workforce in operating that technology. Obviously, when ditchtenders went from riding horses to driving vehicles to make water deliveries, there were substantial adjustments required. Going from manually controlled water systems to fully automated systems carries with it similar adjustments and similar concerns. From a management perspective, is the workforce competent or skilled enough to make the transition and from the workforce perspective; are they working themselves out of a job?

Competent Workforce Concerns. OID had water operations employees with little to no computer skills. Many workers did not own personal computers. So the decision to implement a computerized automation system had some reservations concerning workforce acceptance and competency. Early training of a small group of DSO’s by Rubicon in setting up the flow networks on the canals proved an ice breaker to the technology.

Similarly, intensive group training, both classroom and hands-on, was part of the delivery package from Rubicon. Whether the DSOs were going to be involved or not with the

Claribel or Cometa systems during the water year, everybody went to training, another good ice breaker.

The real benefit for this early-on worker exposure was the confidence building it provided. Another revelation to the workforce was; the technology was not that difficult. OID workers with little to no previous exposure to computers easily picked up on the simplicity of the software. The ease by which most workers were able to grasp the simplicity of the systems logic was a real plus.

During the water season, OID generally requires its DSOs to stay on their ditches during their shifts. With implementation of TCC on the Claribel and Cometa Canals during the 2011 water season management encouraged DSOs to ride along with those DSOs operating TCC to get a feel for the ease of system controls and to grant greater exposure to this automation. It proved beneficial and management was impressed and somewhat relieved with the breadth of worker adaptability and acceptance of this technology.

Workers Working Themselves Out-of-Work. In management's report back to the Board after its trip to Australia one of the underlying benefits of TCC is the potential reduction in the workforce derived from TCC implementation. What was realized in Australia was the downsizing of 20% (+/-) in the water operations area, not insignificant considering OID's water operations labor budget of $2.4 million. Outside these reductions, a portion of the remaining workforce is absorbed into other job-created benefits of TCC. SCADA technicians, troubleshooters, planners, schedulers, etc. are positions created because of technology, and generally better paying jobs over existing DSO positions.

So while you have some job position losses as a result of automation you also have job position creation as a result of automation, but to the workers, the net loss was a concern. The outright assurance from management that losses, if they occurred, would be through attrition and not layoffs, put most workers at ease. This point was put to rest at a general training meeting of DSOs. Management stated that if TCC were implemented over the next 10 years, and resulted in a net 20% reduction of the DSO workforce, the workforce would be reduced by 5 positions. Management then asked how many workers would be retiring due to age over the next 10 years and 7 DSOs raised their hands. They issue seemed to be resolved, at least temporarily.

COSTS OF TCC IMPLEMENTATION AT OID-PRELIMINARY

Project Budget and Actual Costs

Description	Budgeted Costs	Actual Costs
Rubicon (Gates, Labor, Software, etc.)	$1,702,680	$1,444,005
Surveying and Structural Calcs.	85,000	46,678
OID Material and Equip	500,000	778,392
OID Design, CM, and CM Labor	609,000	630,920
Total 2,896,680		2,899,995

Using these costs and calculating a cost/mile unit rate, the TCC system cost $193,333/mi.

Applying simple Return on Investment (ROI) calculations to the Claribel Canal system, using the range of potential water savings and assuming a reasonable California water transfer rate of $125 per acre foot, the ROI would fall somewhere between 9-11 years. A very noteworthy marketable return.

CONCLUSIONS

Take-aways from Implementation

OID implemented TCC on just 2 canals of a much larger system. It's a two-year study and just one-year has thus been completed. The results and benefits of the project are encouraging and next water season, will hopefully affirm OID's optimism.

Grower/farmer responses who were on the receiving end of TCC were minimal at best and in the irrigation district business, that's a big plus. There were no complaints from users, just casual responses on the improved service standard afforded them. On the DSO/operator side, those who were exposed were impressed. Ease of functionality and the lack of "glitches" were notable.

As with all new technology, some constraints in responsiveness were noted. With OID's small canals and relatively steeper sloped systems, sometimes the response to an order change was not as it would have been if manually operated. While in most cases, this is an adaptable and manageable adjustment, it is being evaluated in the 2012 water season. OID is evaluating the possible need of distributed small scale distributed storage systems to account for this peculiarity as a solution.

Confidence Building of Workforce

Both on the construction side of the TCC project and operations side, OID employees came away with a sense of accomplishment this last water year. Construction crews at OID did a remarkable job in putting these facilities in under the time constraints given. They honed their skill sets and improved upon their scheduling and work coordination abilities to the point that construction costs came in on budget.

Water operations staff learned more about automation, canal control and SCADA systems in one year than they ever imagined they could. Computer skills and technology are now not a foreign thought in the workplace anymore. The exposure and the accomplishments of the DSOs who were over the TCC implementation were impressive to management as well.

OID is very optimistic about Rubicon Systems and the TCC technology that has been implemented. The potential for additional water savings at a marketable rate based on TCC fits OIDs water conservation and marketing prospectus and has great promise for the future.