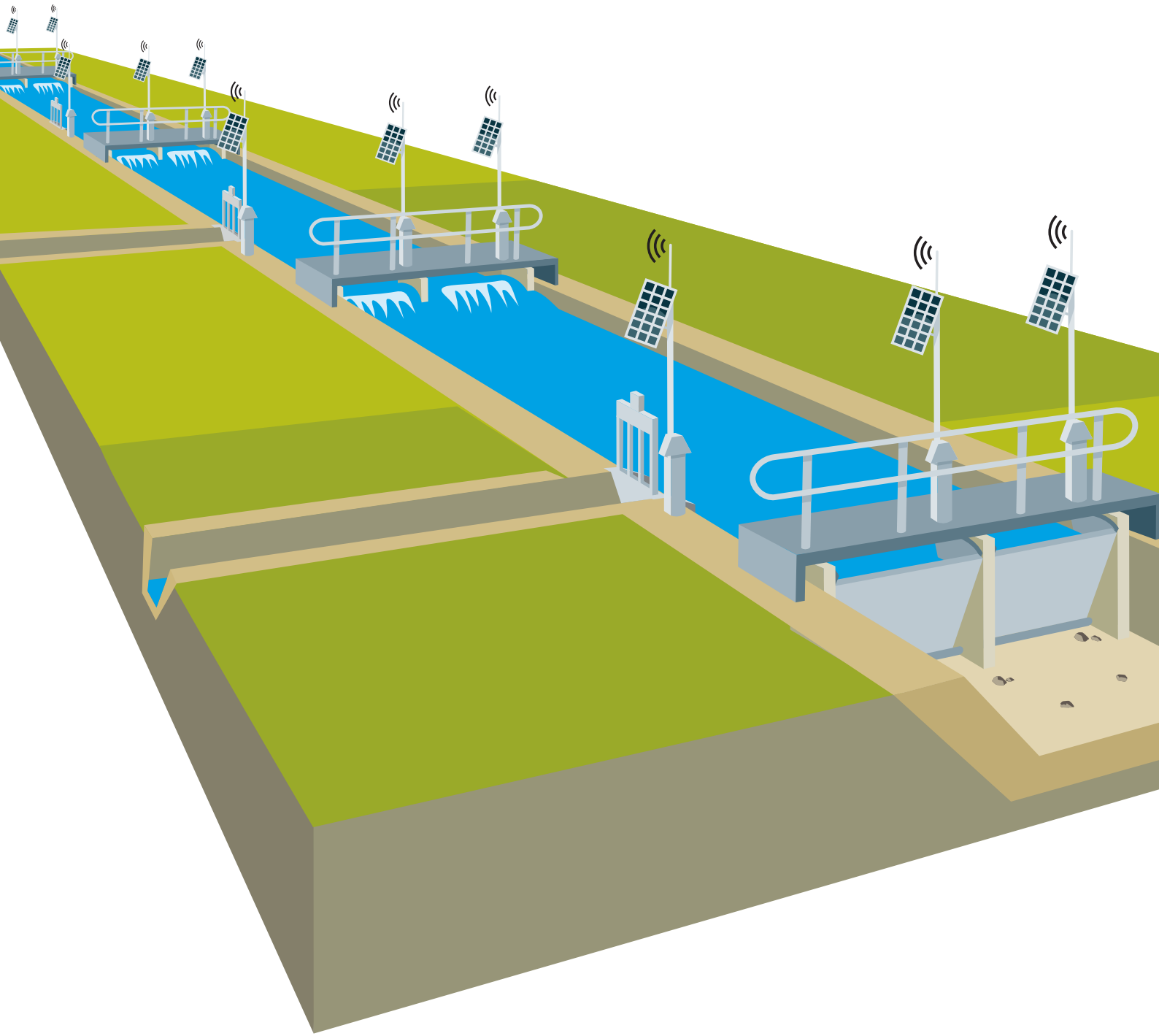
# Network Control Solution

RUBICON™



# Network Control Solution

**By automatically coordinating a sequence of FlumeGates® in a conveyance or distribution channel system, delivery of water can be optimised to maintain high and consistent flow to farmers and simultaneously eliminate outfalls at the end of the channel.**

## The advantages

### More water

By eliminating the outfalls that are common in channel operation, more water remains available in the river or in storage for irrigation at another time.

### Less energy cost

If water is pumped into the channel instead of coming from storage, eliminating outfalls can substantially reduce energy costs.

### More flexible

Instead of rigid irrigation schedules like rotations, water can be delivered when a farmer needs it because water is automatically transferred from the section of channel just upstream of the farmer instead of from the distant head-works of the channel system.

### Fairer

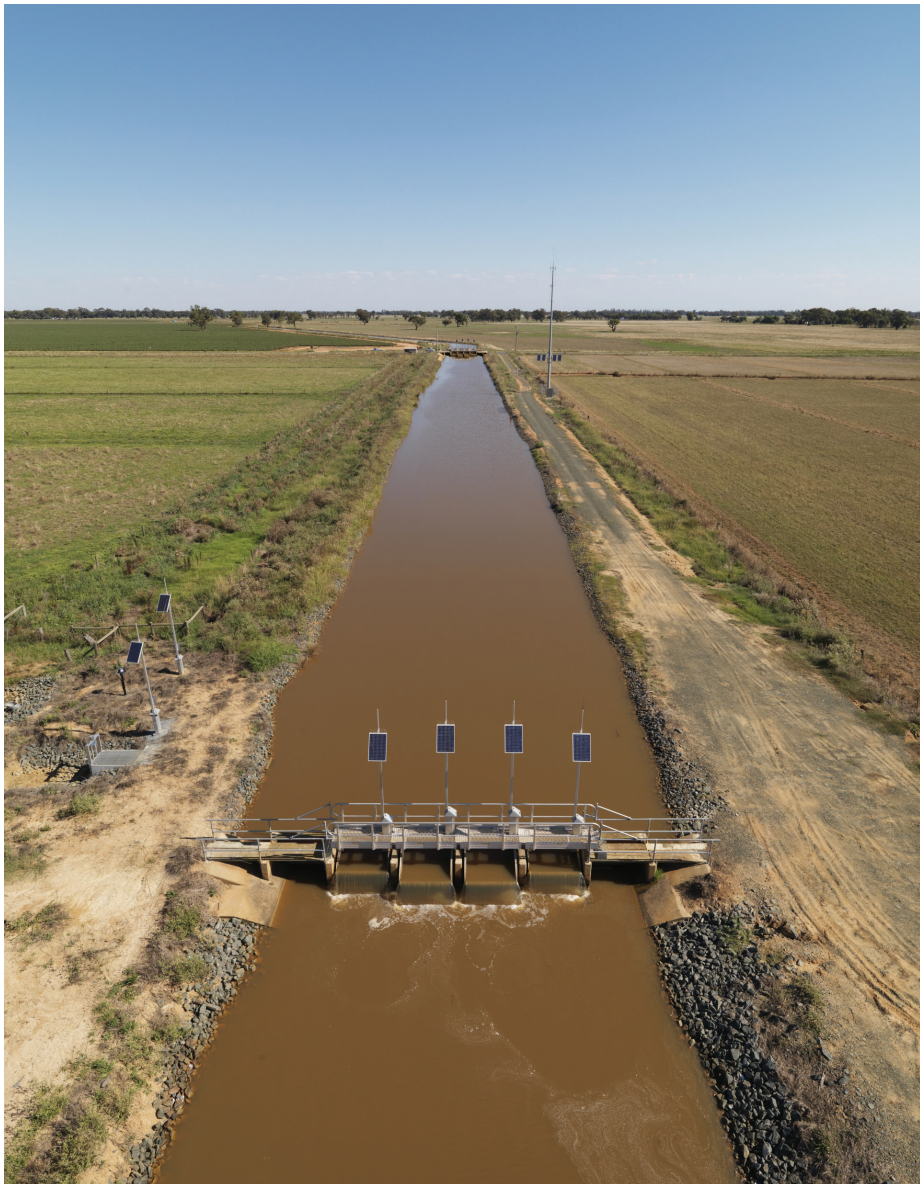
All farmers receive the same quality of service: high, consistent flows on request, regardless of whether they are towards the beginning or end of the channel system.

### Less leakage

It is easier to detect seepage occurring in the network with precise real-time data on water levels. Costs can thereby be reduced with targeted remediation. And leakage that can occur through the crown of the channel when operating the network above design-level is also reduced.

### Higher productivity

High, consistent flows to farms mean shorter surface irrigations, less nutrient leaching through infiltration and less plant shutdown from waterlogging. It's also easier to determine surface irrigation run times and so avoid excess water runoff. The net result is higher crop productivity using less water.



## The challenge

To reliably deliver water on-demand, with high flows to all farmers equally is the ultimate goal of open channel irrigation.

But without accurate and real-time measurement of flow throughout the channel network or the ability to make frequent changes to manually operated regulating gates, this is a real challenge.

In addition, unknown leakage and seepage, unexpected weather events and human misjudgement make channel regulation more of an art than a science. This is especially true in long or slow-moving systems where water can take days to flow from the head of the channel to the tail or where water is shared with other uses such as hydro-electric generation.

As a result, unpredictable water levels and potential shortages of water occur, especially at the far downstream end of the distribution network where the effects are magnified.

To prevent this, a typical approach is often to supply excess water from the dam or river, but any water in excess of that used by farmers is then spilt through the tail escape or expensive reservoirs are built to recirculate the water.

In a world of increasingly scarce resources, the consequences can be serious. They range from unnecessary energy costs of overpumping; to declining crop production from insufficient water availability at peaks; to over-extraction affecting the sustainability of future production and the environment.

## The Network Control Solution could help if you:

- have problems controlling levels and flows in your network
- want to only release water from storage that closely matches actual irrigator usage
- need to reduce extraction pumping costs
- need to improve the consistency and reliability of supply to farms
- want to reduce relining costs with targeted remediation
- want to improve field operator productivity and safety.

## A TCC® solution

The Network Control Solution is one of the products making up a modular family of precision hardware and software called TCC (Total Channel Control®).

TCC is an advanced technology set designed to improve the management and productivity of water in open channel distribution. Unlike traditional infrastructure, TCC products can interact and work together to help managers improve:

- the availability of water
- service and equity to users
- management and control
- health and safety for channel operators.

# Network Control Solution

## The solution

Rubicon's solution has proven to be simple to install and quick to get up and running. It involves installing:

- a new generation of regulator gates called FlumeGates
- FlumeGates or SlipMeters® at large service points
- a data-radio network to enable gate-to-gate communication
- channel network control software called NeuroFlo® to coordinate the actions of the FlumeGates
- a remote monitoring and management telemetry system called SCADAConnect® and
- network visualisation and analysis software.

All of the regulating gates along the length and breadth of a channel system are coordinated so that water levels remain stable while just the amount of water needed is supplied from the dam or river. The channel system behaves with nearly the same responsiveness and efficiency as a pipe but without the high cost of piping.

### FlumeGates®

FlumeGates are installed at regulating structures in series along the channel. The FlumeGate's overshot design (meaning water flows over like a weir) and precision motor control provides fine control of the flow through the gate. Its integrated sensors provide accurate measurement of levels and flow in real time. SlipMeters provide real-time flow measurement and automated control at offtakes or service points.

### Data radio

The FlumeGate's integrated data radio communication system enables each FlumeGate to send information to its adjacent FlumeGate.

The gate-to-gate communication means much faster response because long-distance transmissions to the control centre are unnecessary. It also provides redundancy because the network solution operates even in the event of a temporary failure in communications back to the control centre.

### NeuroFlo®

When a FlumeGate receives flow and level information from its neighbour or from an offtake, the NeuroFlo software determines the response. NeuroFlo determines by how much the FlumeGate should open or close, by how much it should increase or decrease flow to supply water flowing out and to keep water levels at the desired level.

The response needs to be carefully determined to change flow as quickly as possible, but not too quickly that it would cause overflow or drain a channel. The optimal response calculated by NeuroFlo also ensures that the change in flow has the effect of dampening the transient, wave-like impacts that occur elsewhere in the channel network as a result of a flow change. Without NeuroFlo such impacts can cause instability throughout the channel system.

### SCADAConnect® & Network Visualisation

The SCADAConnect software constantly monitors channel operation to alert human operators to any potential abnormal behaviour. Detailed visualisation, navigation and dynamic analysis of channel flows and levels in real time and clever alarms ensure that human operators have all the information they need.

Like security guards, operators only intervene to avoid, diagnose and resolve problems. And with the tools built into SCADAConnect, they can do so efficiently and rapidly.

These components operate together, passing level and flow information along the length of the channel ensuring a coordinated response right up to the dam or pumping station. Any increase in water extraction anywhere in the system (including leaks and evaporation) can be supplied by all the FlumeGates opening the right amount. Any reduction in extraction (including local rainfall and irrigation rejections) results in FlumeGates closing along the channel, effectively storing the water for later use.

## NeuroFlo® controller design

The cornerstone of the solution is NeuroFlo which determines the optimal response of each and every FlumeGate.

NeuroFlo determines the optimal response based on exact knowledge of the hydraulic behaviour in each section of channel and the operating strategy chosen by the channel managers (see box *Operating strategy*).

### Hydraulic behavior

During the implementation project, Rubicon configures a mathematical model for every section of channel.

The models are calibrated using measurements of the real system in the field: water is released in controlled steps and its behaviour is precisely measured in a process called System Identification. In this way the unique characteristics of each section of channel can be taken into account without the guesswork usually associated with modelling. Variations in geometry or alignment, the impact of aquatic growth or obstructions and the state of the lining become known to NeuroFlo.

Rubicon then uses the calibrated model to design a controller, which is the part of NeuroFlo that is able to predict the behaviour of water in that section of channel in any combination of flow and water height (the combinations are called control states).

Finally, once designed, the NeuroFlo controller is validated through computer simulations.

### Optimal response

The result is that NeuroFlo is perfectly tuned to control each FlumeGate to respond optimally to changes in water use in the channel system.

## Operating strategy

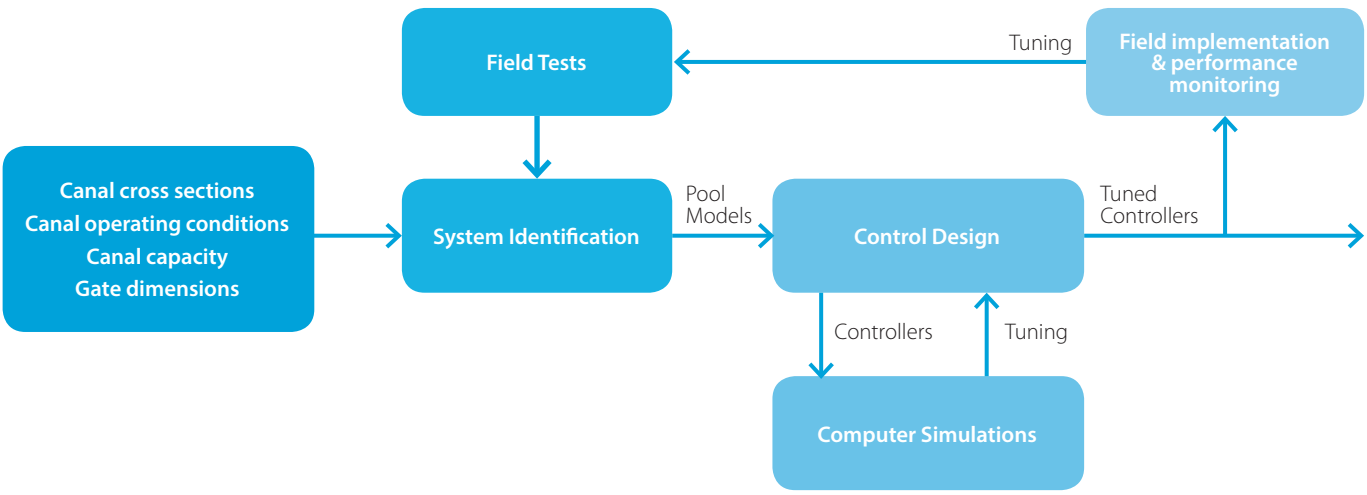
The operating or regulation strategy is the overall plan for controlling the delivery of water in a channel network or system. An irrigation manager chooses a strategy to balance factors like responsiveness to change in demand, need for volume storage, basin topology and construction costs.

The general types of operating strategies are:

- Upstream or Supply control
- Downstream or Demand control
- Hybrid or Mixed control – a combination of the above.

Rubicon's Network Control Solution can work with any of these operating strategies.

## NeuroFlo® controller design and tuning



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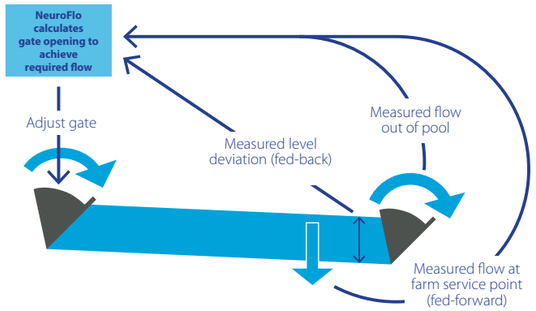
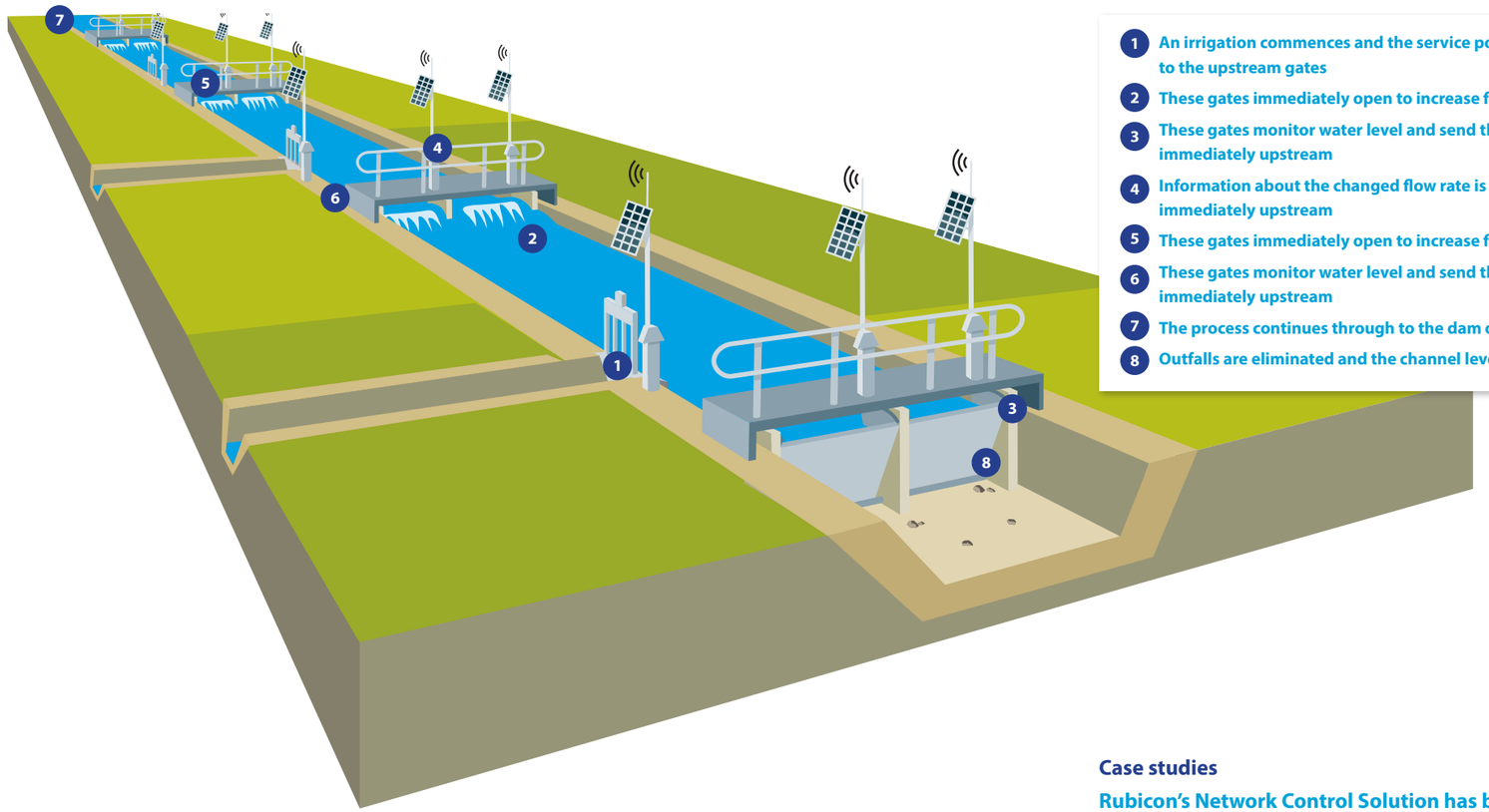
## How does the NeuroFlo® demand operating strategy work?

- When a farmer begins to irrigate, the service point immediately sends information about the flow to the gates upstream
- The upstream gates respond by changing the flow rate to send additional volume into this section of the channel
- The gates downstream of the farm monitor any variation in desired water level and send this information to the upstream gates to make minor adjustments to the changed flow rate to ensure the water level maintains its proper level
- At the same time, the upstream gates send information about the high flow rate they are passing to the next upstream gates
- Those next upstream gates open to increase flow rate into this section of the channel
- The gates at the downstream end of this section of the channel also monitor the levels and send the information to the upstream gates to make minor adjustments to their flow to ensure the water level in this section stays at its proper level
- The process continues along the length of the channel so that just the right flow is passed to maintain proper water level and no spillage occurs
- Outfalls at the end of the channel are eliminated
- Conversely, when a farmer stops irrigating, the information is sent from the service point to the gates upstream of the farm which reduces flow and downstream gates monitor the water level and send this information to the upstream gates to make minor adjustments to the flow. Then this too repeats itself in every section of the channel along the length of the channel as before, using the storage capacity available in the channel to capture any water that has been released into the channel.

## Network Control uses feedback and feed-forward control loop technology




1. An irrigation commences and the service point sends the flow information to the upstream gates
2. These gates immediately open to increase flow
3. These gates monitor water level and send this information to gates immediately upstream
4. Information about the changed flow rate is sent to the gates immediately upstream
5. These gates immediately open to increase flow
6. These gates monitor water level and send this information immediately upstream
7. The process continues through to the dam or river
8. Outfalls are eliminated and the channel levels are stabilised

Scan or visit http://youtu.be/I3RUFh1-87k to see an animation of Network Control

## Case studies

**Rubicon's Network Control Solution has been proven in many parts of the world. Case studies are available for the following customers:**

- Oakdale Irrigation District in California has completely eliminated outfalls on their 10 km Claribel channel making an extra two gigalitres of water available annually
- Shepparton Irrigation District in Australia has improved distribution efficiency from 75% to 90% for their 700 km of channels, making an additional 39 gigalitres of water available, resulting in more sustainable farming and improving the environment
- Fen River Irrigation District in Shanxi Province in China is reducing water losses at 25% of the cost of traditional approaches.

# Network Control Solution

FlumeGates are combination overshot flow measurement and control gates used in line to regulate the channel system. FlumeGates provide accurate flow measurement, precise motor control, power supply and radio telecommunications, fully integrated into a single device.

Rubicon's engineers will design and install a communication system that will enable the inter-communication between FlumeGates along the length of the channel and the remote monitoring of all field equipment from the control centre.

NeuroFlo is the software that determines the response of each FlumeGate and coordinates the propagation of flow information up (or down) the channel.

SCADAConnect is Rubicon's SCADA software designed specifically for irrigation. It provides the ability to monitor and manage all field devices, with comprehensive alarm management and the ability to do sophisticated trend analysis.

The Network Visualisation software function pack provides a visual, schematic representation of the irrigation network making it easy to navigate the network and provides a dynamic summary analysis of the operating behaviour.

SlipMeters are combination undershot flow measurement and control gates designed for use at farm entry points or tertiary channel offtakes. Using SlipMeters can help further optimise the channel control strategy, making it faster to respond.

## About Rubicon Water

Rubicon Water delivers advanced technology that optimises gravity-fed irrigation, providing unprecedented levels of operational efficiency and control, increasing water availability and improving farmers' lives.

Founded in 1995, Rubicon has more than 25,000 gates installed in TCC systems in 10 countries.

SB-NC-12/17-AU

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