BETTER MANAGEMENT OF WASTEWATER NETWORK BY REMOTELY CONTROLLING PRESSURE SEWER SYSTEM PUMPS

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ABSTRACT

Christchurch City Council is trialling the use of iota's OneBox control panel to remotely monitor and control individual pressure sewer system pumps, particularly in greenfield areas. This accommodates growth without further compromising a wastewater network which is already at capacity. The control panel smoothes out the diurnal flow profile from the catchment. Stormwater inflow can be identified by analysing monitoring data after every storm, and prompt follow up with property owners means that inflow from the catchment can be eliminated. In combination, this means that the peak flows expected from the catchment are only slightly higher than average dry weather flow, compared to five times average dry weather flow for a gravity system.

The Council is trialling the use of iota OneBox control panels on 29 pressure sewer system pumps in the Highsted subdivision in Upper Styx, Christchurch. If successful, this will be rolled out for the remaining 1,400 properties in the Upper Styx area and 5,000 properties in South East Halswell. Because the design flows are substantially lower than for a gravity network, Council can use spare capacity in the existing network to convey flows from the Upper Styx area, rather than needing to construct a new pump station and pressure main, saving at least $2.3 million in capital expenditure.

KEYWORDS

Pressure sewer network, low pressure pumps, flow management, flow monitoring, remote control

1 INTRODUCTION

There is significant growth in Christchurch, with new greenfield areas of development in the north and southeast of the city. Christchurch's wastewater network has capacity constraints in some areas, with overflows from manholes and to streams and rivers during storm events, due to stormwater inflow and groundwater infiltration. The wastewater network was badly damaged by earthquakes in 2010 and 2011, resulting in a much leakier network, and average daily flows to the Christchurch wastewater treatment plant increased by 40% depending on groundwater levels.

Peak flows during a storm have also increased, although this is more difficult to quantify as there are many overflows from the network. The wastewater network model for Christchurch shows that for a large storm (24 hour duration, 3 year Average Recurrence Interval), 36,370 m^3 of untreated wastewater discharges via constructed overflows to the stormwater system and the Avon and Heathcote Rivers. In addition, 41,800 m^3 of untreated wastewater discharges from 125 manholes across the city. This creates risks to both public health and the environment.

Christchurch City Council has a consent to discharge untreated wastewater from 22 constructed overflow points in the Avon and Heathcote Rivers, and the Avon/Heathcote Estuary. Due to the substantial increase in flows following the earthquakes, an interim discharge consent compliance strategy agreement is in place until March 2017, after which the Council either has to comply with its overflow consent or apply for a new consent.

Due to financial constraints, the Stronger Christchurch Infrastructure Rebuild Team (SCIRT) is not repairing all earthquake damage to the wastewater network. There is also a significant amount of damage to private wastewater laterals which is expected to remain unrepaired. This means that when SCIRT ends in 2016, the wastewater network is expected to be much leakier than it was pre-earthquake, with high levels of stormwater

inflow and groundwater infiltration. It therefore seems unlikely that compliance with the overflow consent will be able to be achieved.

The Canterbury Regional Policy Statement and the Land Use Recovery Plan have both directed Council to accommodate growth in greenfield areas, as well as intensification within urban areas. An extra 23,700 houses are to be built in the Christchurch urban area.

If not well managed, increasing wastewater flows from this extensive development will make it even more difficult for the Council to achieve compliance with the overflow consent.

2 REMOTE MONITORING AND CONTROL

iota Services Pty Ltd (commercial arm of South East Water in Melbourne) has commercialised its OneBox control panel, which allows for the remote control and monitoring of pressure pumps.

South East Water initially developed the OneBox to improve the operational control of their pressure sewer network as well as utilise the onsite storage of the pressure sewer tank to optimise the sewer network and treatment captial costs. The remote monitoring and alarm feature improve the overall customer experience – the customers are not having to respond to a flashing light and audiable alarm.

OneBox is compatible with all pressure pump makes and the use of industry standard protocols are employed in the communications between OneBox and the SCADA system. The three main modes for controlling pressure pumps which provide benefits to down stream infrastrucutre are:

Storm mode – This allows flow from a pressure catchment to be held back during a storm to free up capacity for the gravity network, reducing the risk of overflows. The tanks are emptied before a storm arrives and then prevented from pumping (unless a high level is reached) until the storm passes or until a set period has passed (say 10 hours).

Peak shifting mode – This smoothes the diurnal flow profile by delaying the pumping from some properties for a few hours. This means that a relatively constant average flow is pumped, and pipe sizes can be reduced.

Flushing mode – This allows the required velocity for scouring to be achieved each day, by pumping in unison. This reduces the need for flushing the lines with tankers in developing catchments and in pipelines with only a few connections. This also avoids the need for twin pressure mains in developing catchments, such as those proposed in the master plan for the South East Halswell greenfield area (Jacobs, 2014), to allow for a staged increase in flow as the catchment develops.

In addition, any group of pumps can be prevented from pumping for a set period, so that maintenance or new pipe connections can be made.

Iota has installed 4,000 pressure sewer connections with just over 2,000 using the remote control and monitoring system (OneBox), including 100 OneBox units installed for neighbouring water authorities. They are installing a further 80 new pressure sewer and OneBox connections each month as part of their backlog programme.

The cellular network is used for transferring the data from the pumps to Iota's ClearSCADA system. This is secure and is separate from South East Water's SCADA system. The Council and the maintenance contractor can then access the data and manage the pumps using a web based portal. In future, the data can be integrated into the Council's SCADA system.

Operational data collected from the system including pump run times and pump performance can be used to improve infrastructure planning into the future as well as optimise maintenance programs.

3 CASE STUDIES

3.1 GREENFIELD AREA - HIGHSTED AND UPPER STYX

Many of the greenfield development areas in Christchurch suffer from poor ground conditions and high groundwater levels, making construction of a gravity wastewater system difficult, with an increased risk of groundwater infiltration problems in the long term.

The Upper Styx area covers 156 ha on the northwestern edge of Christchurch. The area is currently largely rural lifestyle blocks, but will be developed as a residential area with approximately 1,675 houses. Approximately 21 ha will be developed as a gravity catchment, and a retirement village will also discharge to the gravity network. The remainder of the catchment will be developed as a pressure sewer catchment, and equates to approximately 1,472 houses.

The original plan for the Upper Styx was a gravity wastewater network draining to a central pump station, with an expected peak flow of 47 L/s. As well as a new pump station at an estimated cost of $1 million, a new 1.7 km long, 250 mm diameter pressure main would be required to convey flow to the trunk main, with an estimated cost of $1.3 million.

The Council was approached by the developers of the Highsted subdivision in the Upper Styx area, as they were having significant difficulty laying the first length of gravity wastewater pipe due to poor ground conditions and high groundwater table (the same 90 m length was laid three times and settled differentially with a loss of grade each time). The Council agreed that the developer could install a pressure sewer system instead. Given that the whole Upper Styx area was likely to encounter similar ground conditions, it was decided that this should be developed as a pressure sewer system catchment.

If this was developed as a normal pressure sewer network, using the E-One method of estimating peak flow based on the probability of a number of pumps operating at any one time, the peak flow was expected to be 25 L/s. Pressure mains to convey flow to the Northcote Collector would still be required, albeit with a smaller pipe diameter, and this reduced the capital cost to $920,000.

Given the potentially large number of pressure pumps, and capacity constraints in the downstream trunk mains, there was an opportunity to use a smart control system to better manage the increased flows into the network from these developments by making use of the on-site storage tanks (sized for 24 hour storage).

A pressure sewer network with iota OneBox control panels in peak shifting mode reduces the peak flow to 12 L/s. The flow has been reduced to such an extent that spare capacity the existing gravity network can be used to convey flows to the Northcote Collector on Main North Road, rather than constructing a new pressure main to service the Upper Styx pressure sewer area.

3.2 GREENFIELD AREA - SOUTH EAST HALSWELL

A master plan for the greenfield area South East Halswell (Jacobs, 2014) recommended that the entire catchment (approximately 5,000 lots) should be developed as a pressure sewer catchment, as this was lower cost both in terms of capital expenditure and whole of life costs. As the catchment is expected to develop over many years, low flows are expected in the early years of development, which can cause issues with long retention times and solids settling in the pipelines.

To avoid these issues, twin pressure mains were recommended. The nominal sizes of these would be one third and two thirds of the design pipe cross-sectional area. The smaller pipe would be used first, then as flows increased the larger pipe would be used instead, and finally both pipes would be used. However, the capital cost for twin pipes is 25% higher than for a single pipe sized for the ultimate flow, and the management of twin pipes adds an extra layer of operational complexity.

Preliminary design for the trunk mains to service this area is currently underway, and construction is expected to be complete in 2017.

3.3 MONITORING DUPLEX PRESSURE PUMPS IN SCIRT REBUILD PROGRAMME

SCIRT is constructing pressure sewer networks in areas with very poor ground conditions, to improve resilience in the event of future earthquakes. The pressure pumps are normally located within the property, but some property owners saw this as an imposition and objected to this under section 181 of Local Government Act 2002. As a result of this, SCIRT is locating some pressure tanks in the street. There are also some multi-unit dwellings that discharge to a common pressure tank, and SCIRT is locating these in the street for ease of access for maintenance purposes. The ability to remotely monitor faults in these tanks is required, as an audible or visual alarm which requires a property owner to report a fault is not appropriate in this setting.

Only a basic text message alarm was available through the pressure pump supplier, and this would have required the establishment of a base station receiver/alarm handler. SCIRT chose to install iota OneBox control panels for these pumps, as this was a lower cost solution overall, and gave a much improved monitoring and alarm functionality. Network operators can see the details of the fault, and can see the level in the tank, and so assess the urgency of the response. These units are about to be installed, and the performance of these units will be reported on in the conference presentation.

3.4 INTENSIFICATION IN AREAS OF WASTEWATER CAPACITY CONSTRAINT

Council has recently developed an acceptable solution to allow additional wastewater connections in areas of constrained wastewater capacity (defined as where the wastewater network model shows a downstream manhole is overflowing in the 3 year ARI design storm). For anything other than a single additional house of up to three bedrooms, Council will allow a connection to the wastewater system only if on-site storage is provided, and no wastewater is discharged from the property during a storm event. This will be achieved by the property owner installing a low pressure pump in a tank which can store wastewater expected to be generated from the site over a 24 hour period, with an Iota OneBox control panel that allows the Council to remotely monitor and control the pump. In a storm, Council will prevent the pump from operating, so that there is no additional flow from the property when the wastewater network is already at capacity.

3.5 IMPROVEMENTS EXPECTED

The improvements expected from iota's OneBox are:

Regulatory Compliance - iota's OneBox will allow the Council to reduce the risk of network overflows from the increased wastewater from developments, by preventing pumping during a storm and instead making use of on-site storage, and so improve compliance with the overflow consent.

Operational Control – OneBox will allow the Council to monitor and manage pumps individually and in groups. For example, pumps can be turned off to allow maintenance on a pipe, or turned on in unison to achieve a daily flushing cycle. Alarms can be integrated with the maintenance contractor roster, so that alarms are sent directly to the staff member on duty, by email, text message or pager. The staff member can then view the pump station concerned via a web portal, and see more detail about the issue and how much storage is remaining in the tank, and assess the urgency of the alarm. The contractor is able to respond to the alarm before the customer is even aware there is a problem.

Asset Management – OneBox will allow us to monitor pump performance, including an automated report after every storm that will identify which pumps pumped more frequently than normal, and so easily identify illegal stormwater connections on a property by property basis. The customer can then be contacted and asked to remove the illegal connection, and so avoiding incremental increases in inflow over time. The peak shifting mode smoothes the diurnal peaks and allows pipe sizes to be reduced, and may defer or reduce the size of infrastructure (pipes, pumps, storage facilities) downstream, thus making the most efficient use of our assets.

4 CONCLUSIONS

The key benefits for the Council in using pressure sewer networks with iota OneBox control panels are:

- Reduced risk of overflows in the downstream network as a result of these developments

- Maximising the use of the existing gravity network, in some cases avoiding the need for new pump stations and pressure mains, with significant capital cost savings
- Reduced pipe sizes, resulting in decreased capital costs
- No need for twin pressure mains to allow for gradually increasing flows in developing catchments, saving approximately 25% in capital costs
- Automated reporting to identify properties with illegal stormwater connections after every storm, meaning that inflow can be addressed immediately with the property owner
- Specific alarms to the maintenance contractor, and the ability for them to use a web portal to view individual pressure pumps if desired (e.g. to see how much storage is in the tank and therefore the urgency of the alarm)
- Better customer experience, as the maintenance contractor can receive and respond to the alarm before the customer is aware of the problem.

REFERENCES

Jacobs SKM (2014). South East Halswell Wastewater Strategy Development, report prepared for Christchurch City Council.