CHRISTCHURCH IMPLEMENTS WORLD CLASS SMART WASTEWATER NETWORK

M. Cooper (Mott MacDonald), R. Paapu (Mott MacDonald)

ABSTRACT

Christchurch was one of the earliest cities in NZ to have extensive flow and overflow monitoring throughout their wastewater network, providing both data and insight for planning and operational requirements, was well as alarms, duration and quantity for overflow event reporting.

Traditionally a coarse system of overflow confirmation was used where sand was placed on the overflow weir and washed away during an event. This method was low tech, low on detail and required manual labour. In time, this was migrated to a network of thin-plate overflow weirs and pressure sensors. However, the installation of non-return valves on the wastewater overflow pipes throughout the city rendered use of weir ratings incorrect due to weir drowning, overstating the volume of wastewater lost to the environment.

A unique approach was required for overflow quantification, and lead Mott MacDonald to utilise a primary depth and conductivity sensor in the overflow manhole, coupled with pressure, ultrasonic and velocity sensors installed in the overflow pipe. Significant reduction in stated overflow volumes have been the result of the improved system as it is truly measuring the volumes of overflow.

However, data collection is only part of the solution for active monitoring. The balance focussed on innovative approaches to exacting specifications, requiring upgrading Mott MacDonald's Moata analytics platform to support a commitment to high data availability, assured times for 'observation-to-availability-online' of data, timely alarms in all weather conditions and much more frequent reporting from gauges than is typically found throughout New Zealand. This timeliness allows control and intervention in near real-time, moving overflow monitoring past a 'post event' reporting system to one that encompasses the best qualities of traditional SCADA, the modern technologies and availability of web browser delivery and ability to overlay increasing smarter data analytics.

Future directions include short-time period rainfall forecasting, driving the prediction of flow and overflow events using machine learning trained on physical models and informed by the long-term data we have now collected.

KEYWORDS

Wastewater, smart infrastructure, monitoring, high availability, analytics

PRESENTER PROFILE

Matthew Cooper is a Technical Director - Water with Mott MacDonald. He has over 20 years' experience in the wastewater industry, specialising in pump station flow, open channel flow, overflow and rainfall measurement. He has completed hundreds of wastewater flow monitoring studies throughout New Zealand, both short term (13 weeks) through to long term (5+ years). He is currently focused on improving the measurement and understanding of inflow and infiltration; particularly post rehabilitation effectiveness.

Ruatara Paapu has lead product teams and cross team technical practises for high profile products & websites. Ruatara worked in various roles on high traffic, high performance websites with critical commercial & compliance aspects. Ruatara has broad technical experience and particularly sysadmin experience - growing high volume sites in complex environments. Ruatara is particularly experienced at: improving team technical practises, front end architecture, website performance, fault diagnosis and system architecture for robustness.

1 INTRODUCTION

In 2017 Christchurch City Council commissioned the upgrade of their long-term flow and overflow monitoring network, requiring a significant shift in accuracy, reliability and data timeliness to meet network consent conditions and the unique challenges of wastewater overflow measurement when discharging to a stormwater network with drainage issues, the result of the 2010-11 earthquakes.

Mott MacDonald have undertaken a unique approach, coupling instrumentation knowledge and leveraging the power of data analytics, presented through the Moata platform, to track data latency, define overflow events real-time and provide three tiers of event notification through the use of four-factor conditional validation that provides Christchurch City Council with confidence in the data being gathered and exceed the required performance measures.

Being a live system, continual improvements are being made after assessing the data obtained following each overflow event; improvements to data quality, observational understanding and confidence.

2 DISCUSSION

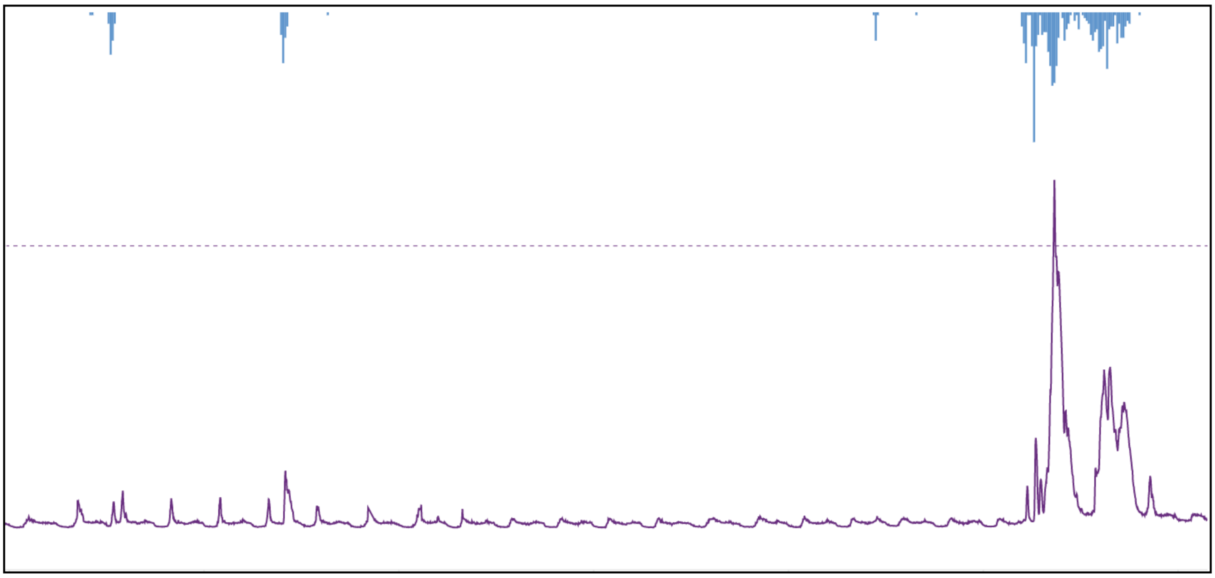
2.1 HISTORICAL APPROACH

To assist with the management of their wastewater network, Christchurch City Council undertook the establishment of a long-term flow and overflow monitoring network in the early 2000's. For the overflow monitoring component, this meant a significant move forward from the labour-intensive, low data return approach of placing sand at/on the overflow point and checking after each event, to installing thin plate V notch weirs across the overflow pipe, measuring depth in the manhole and installing early cellular telemetry.

Photo 1: Sewer manhole with overflow weir installed

This methodology offered a great deal of additional advantages, including alerts at the start and end of an overflow, quantification of the overflow volume, and a continuous depth dataset in the overflow manhole, enabling operators to ensure the site was operational and to use the data for early detection of maintenance issues through the progressive increases in depth over a 'normal' hydrograph (refer figure 1 below).

Figure 1: Additional information gathered by depth measurement in the manhole



However, stormwater drainage issues, exacerbated by the earthquakes in later 2010 and throughout 2011 (Hughes et al, 2015) meant that the core assumption for accurate measurement of 'free flow conditions over a thin plate weir' was challenged through increased river depths and a programme of rubberised non-return valve (NRV) installations throughout the city, undertaken in an effort to minimise any additional (river) flow entering the wastewater network.

The effect of these changes resulted in drowned weir conditions when overflowing, and hence the inability to accurately measure volumes, a requirement of network consent conditions.

2.2 UPGRADED NETWORK

In 2017 the monitoring network was overhauled, including both the long-term flow and overflow monitoring sites. The long-term flow monitoring network was expanded from thirteen (13) to seventeen (17) sites that assist with operational decision making such as flow diversion from one trunk network to another during periods of high flow, calibration of dry and wet weather hydraulic models, I/I investigations and a range of other network analyses.

However, the recognised issues of drowned weirs and high river levels was where innovation was specifically required; solutions that addressed the need for accurate measurement in all flow conditions, from unimpeded discharge (albeit through a rubberised NRV) through to 'no flow' (as it was being held back by the head of the river downstream).

Mott MacDonald addressed these challenges with the removal of the thin plate weirs and installation of depth/velocity sensors located in the overflow pipes and coupled with a downward ultrasonic located over the main channel.

Figure 2: Upgraded overflow site configuration

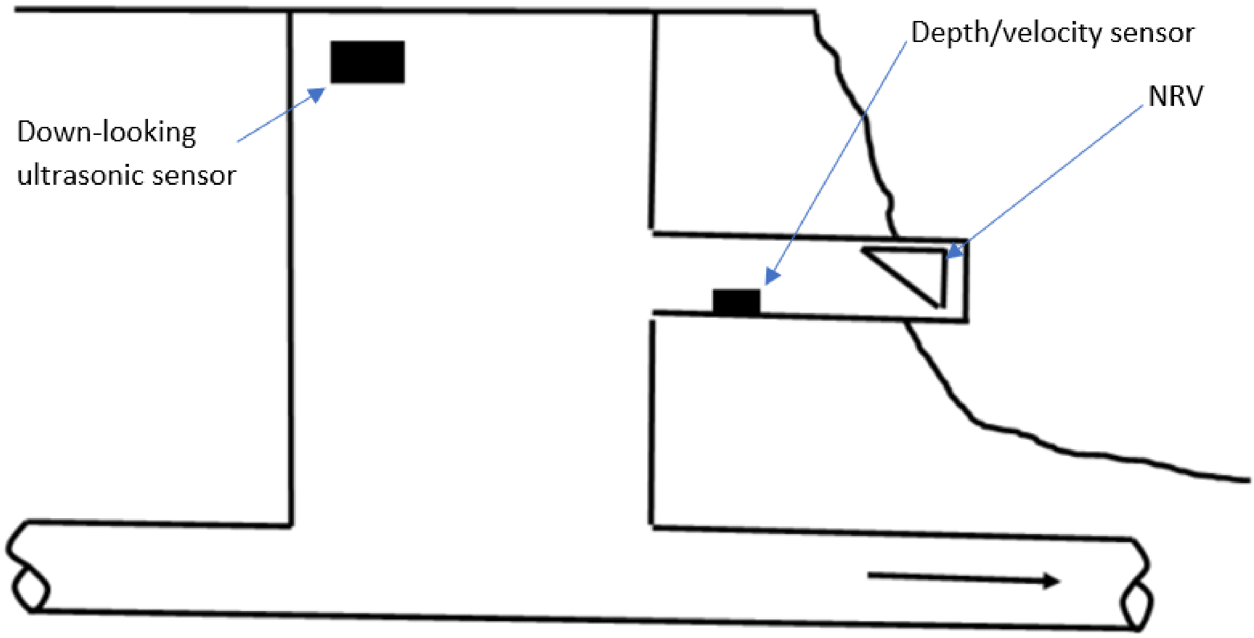
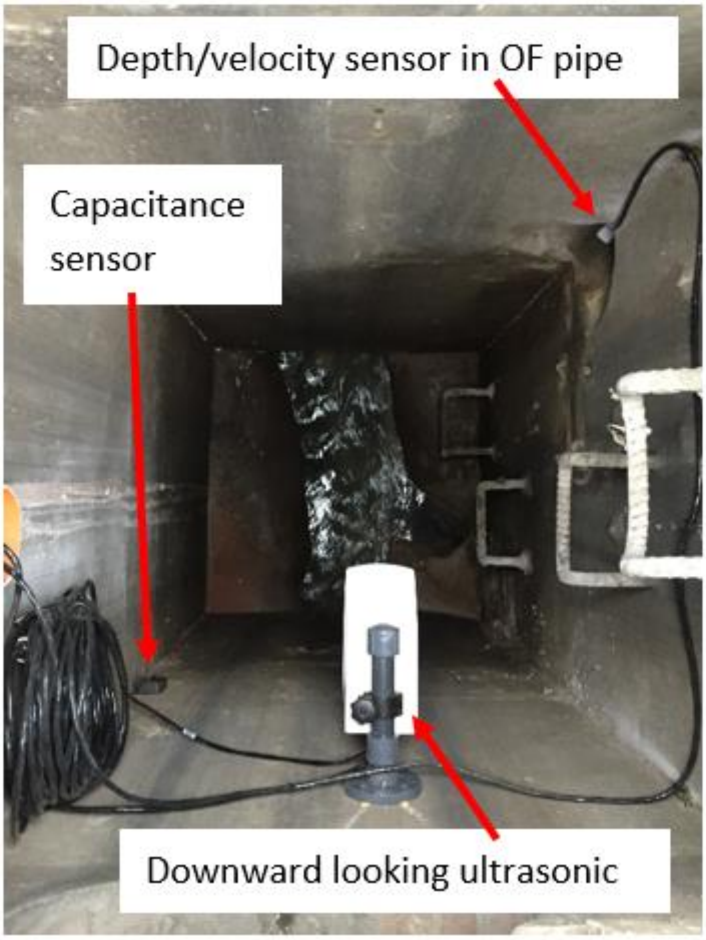


Photo 2: Upgraded overflow monitoring, manhole configuration



As the downward looking ultrasonic sensors came equipped with capacitance sensors, these were installed at overflow level also, offering four-factor overflow validation.

2.3 COST

The establishment of the HVQ style of overflow measurement is significantly greater than that of the historical methodologies, however, in the case of Christchurch City Council, it is necessary for compliance with network consent conditions.

It must be acknowledged that not every overflow site will warrant this level of monitoring complexity or cost, but the understanding gathered at critical, high pollution-impact locations may significantly benefit from the lowering of measurement uncertainty offered by gathering a detailed dataset in the manner utilised throughout this project.

2.4 DATA PROCESSING AND ANALYTICS

Data collection is only the initial part of the wider solution for active overflow monitoring. The balance focussed on innovative approaches to exacting specifications, requiring upgrading Mott MacDonald's Moata analytics platform to support assured data availability and gauge performance.

Together, Christchurch City Council and Mott MacDonald identified three areas for particular focus - high data availability, least possible delay from observation to reporting (data latency) and the reliability of alarms.

Committing to high data availability, Mott MacDonald duplicated the cellular telemetry to provide redundancy, and developed point-specific reporting metrics that timed incoming telemetry data from field observation to when it is available on our data platform for viewing, alarming and other calculations.

This latency is a key SLA metric, with 98% of data being available within 40 minutes of observation and alarms being dispatched within 30 minutes of the overflow state being observed, providing system confidence and setting Moata apart from traditional SCADA systems which likely would not have the capability to track latency in this manner.

Alarm dispatch timeliness is another key KPI parameter as the Council's maintenance contractor is required to visually confirm overflows for public heath notification and water sampling, so must be able to get to the site while the overflow is still occurring.

To minimise false alarms, four-factor conditional statements are utilised, being threshold exceedance on the primary depth sensor, high capacitance, depth in the overflow pipe and velocity in the overflow pipe. In addition, we use the depth and velocity data from the overflow pipe to categorise overflows real-time into 'discharging' or 'not discharging'.

The first notification is an 'Early warning' – triggered at a nominal threshold below the overflow level. This does not always follow with an overflow as it is dependent on the nature of the storm, maintenance or blockage event. Operational staff can log into Moata to see the context of the notification.

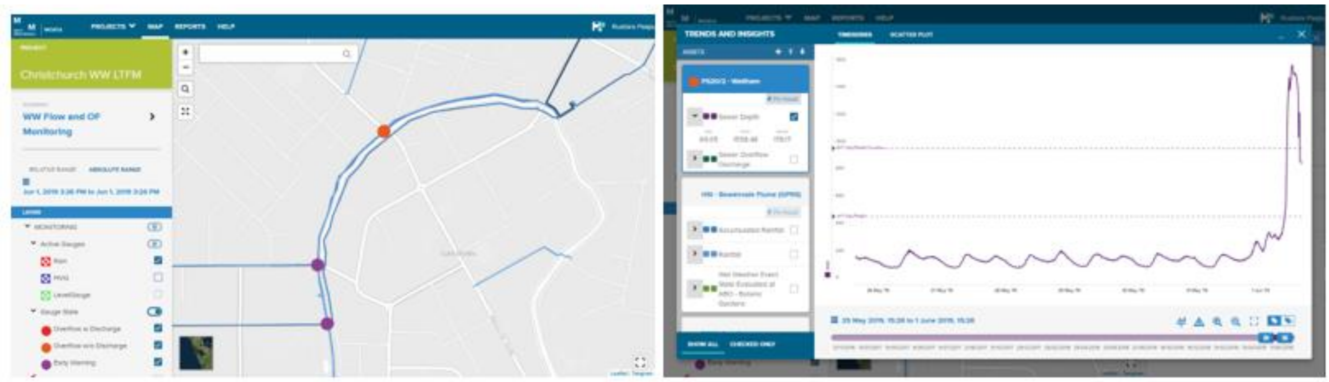
'Overflow without discharge' and 'Overflow with discharge' are the two principal alarm states, dependant on the NRV and level of the receiving river. Additional time-delay logic is also added to mitigate 'switch-bounce' occurrence.

Event end notification dispatched 24 hours after an overflow recedes below threshold.

By utilising rainfall data provided by a 3rd party, overflow events are categorised real-time into wet weather or dry weather events.

The current alarm states are displayed on a map in Moata allowing simple identification of the state of sites and access to the data and analytics for each site.

Figure 3: Moata data analytics



2.5 FURTHER DIRECTIONS

Moata is a live system and we continue to optimise, improving the processing time and reducing waiting time to get even shorter latency from observation to reporting, adding other data streams to provide observational understanding and confidence such as river level from 3rd party organisations and using this to compare to the outlet level to validate assumptions about the state of the NRV. This will help confirm non-discharging overflows as well as identify likely faulty NRV's.

The provision of a predicting 'time to overflow' when the early warning threshold is breached is in operation, however the logic limitations have proven this to have limited usefulness. Future development of this will likely leverage machine learning, continuously trained on both historical system performance, the real time rainfall and rain forecasts.

2.6 RECOGNISED IMPROVEMENTS

Through the use of HVQ gauges in the overflow pipe and ultrasonic depth sensors above the main manhole channel, Mott MacDonald and Christchurch City Council have been able to establish confidence in the overflow data collected over the past 14 months.

Reported overflow volumes are now typically less than what they had been with the previous monitoring methodologies employed, as they represent the actual flow conditions during high level/wet weather events.

Leaking NRV's have also been identified as an unexpected benefit of the monitoring programme, enabling repair and lowering the volume entering the wastewater reticulation.

3 CONCLUSIONS

This project presented unique challenges for flow and overflow measurement, borne out of the constraints of the stormwater drainage system in Christchurch and the demanding network consent conditions for overflow alarming and reporting. By drawing on instrument operational knowledge and a close relationship with the data scientists behind Moata, Mott MacDonald were able to provide a system that both meets and is operationally exceeding the Council's requirements.

Through leveraging the data analytics offered by Moata, customised and value-laden functionality was established, providing confidence in the system and realistic data reporting during and post overflow event.

ACKNOWLEDGEMENTS

We acknowledge Christchurch City Council for permitting us to share this presentation, and for the staff who, together with Mott MacDonald, seek to continually improve the alarming logic and system operation with every overflow event that is captured.

REFERENCES

Hughes, M.W, et al. (March/April 2015) '*The sinking city: Earthquakes increase flood hazard in Christchurch, New Zealand'*. *GSA Today*, Volume 25 Issue 3. Retrieved from https://www.geosociety.org/gsatoday/archive/25/3/article/i1052-5173-25-3-4.htm on 8 July 2019.

Mott MacDonald. (2 March 2018) '*CN4600002138 Wastewater Flow and Overflow Monitoring and Alarming Installation Report'*, Mott MacDonald.