Wastewater Management: An IoT Approach

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Abstract— **Critical wastewater events such as sewer main blockages or overflows are often not detected until after the fact. These events can be costly, from both an environmental impact and monetary standpoint. By configuring and deploying a complete Low Power Wide Area Network (LPWAN), Shoalhaven Water (SW) now has the opportunity to create "Internet of Things" (IoT) capable devices that offer freedom from the reliance on mobile network providers, whilst avoiding congestion on the existing Supervisory Control and Data Acquisition (SCADA) telemetry backbone. This network infrastructure allows for devices capable of real-time monitoring to alert of any system failures, providing an effective tool to proactively capture the current state of the sewer network between the much larger sewer pumping stations (SPSs). This paper presents a novel solution to improve the current wastewater network management procedures employed by SW. Furthermore, a preliminary end device has been developed to solve associated problems with the current method of testing SPS pump performance, in terms of achieved flow rate, for quality control and quality assurance.**

Keywords—Wastewater, Internet of Things, LPWAN, LoRaWAN, Communications Survey

I. Introduction

The wastewater distribution system is a network which is rarely thought about, and even less frequently observed. Across Shoalhaven Water's 4,660 square kilometres of network coverage, over 18 million litres of wastewater is collected daily, and then distributed through the 1,100 kilometres of gravity and pressure sewer mains for treatment. Effluent from homes travels via gravity pipe networks and collects for treatment. To service this system, Shoalhaven Water utilises a SPS network of over 230 individual SPSs, transferring wastewater to one of thirteen sewer treatment plants (STPs). In between each SPS, wastewater is transferred through a combination of both rising mains and gravity mains, onto the next SPS and then lastly to the STP for treatment.

Currently, management of most sewer networks is more reactive than proactive, with response to blockages and potential sewer overflows in gravity systems only undertaken after these events have occurred. Every wastewater overflow event must be reported to the Environmental Protection Authority (EPA), with contamination of sensitive areas leading to potentially large monetary penalties. Now, overflow events at a SPS are recorded and alarmed through Shoalhaven Water's SCADA system. However, complications between each SPS, in the rising and gravity mains and their associated manholes are only brought to attention after these events have been reported, quite often by the public in either their private dwellings or nearby land. Some system intelligence can be implemented on the current SCADA system end to alert Shoalhaven Water engineers and managers of out of the ordinary flows between SPSs, however this still does not take into account the unknown condition and potential problems of the, in some cases, tens of kilometres worth of mains in between.

To proactively inspect the entire sewer network would cost between \$6.6 and \$16.5 million, without taking into account accessibility difficulties and the logistics of all sections of the network on private land. These price estimates are compounded by the length of time it would take to inspect. The conditions of the initial sections of pipe to be inspected would significantly deteriorate with time until the final sections of main were complete. Historical methods of directly measuring flow are conducted using flow meters which are highly invasive, requiring pipes to be excavated, cut and flow meters placed in series with the existing sewer network. This method carries significant costs and inconveniences for both water utilities and residents. Furthermore, flow meters are only effective in the pressurised rising mains, where liquid is pumped out the of SPS.

There is currently no feasible solution to comprehensively monitor the flow of wastewater within the gravity main networks. A new process of wastewater system management is needed. In addition to this, Shoalhaven Water has identified problems with the current method of testing SPS pump performance, in terms of achieved flow rate, for quality control and quality assurance.

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II. Methodology

A prototype of an integrated, wireless, 80 GHz short-range radar sensor device with 3G connectivity was first developed to report, in real time, the wastewater levels within the gravity sewer system. Building upon recent advances in low power communications, a LPWAN has been configured and deployed to capture this portable flow monitoring solution remotely. Covering a large portion of the Shoalhaven region with a single base station, a comprehensive radio survey was undertaken to measure both signal strength and reception characteristics. Utilising the above technology, a portable, low power and Bluetooth enabled device was paired with a mobile application developed in-house to offer an innovative pump testing method.

III. Results

Presenting one of the first comprehensive communications surveys in Australia of this nature, this paper has found that a LPWAN, utilising the LoRaWAN protocol and deployed appropriately within a geographic area, can attain maximum transmission distances of 20 km within an urban environment and up to 35 km line of sight (Fig. 1). A heat map of this survey has been produced for the Shoalhaven region (Fig. 2). Additionally, a prototype end device utilising these LPWAN protocols has been installed within SW's wastewater network to effectively monitor SPS levels and flows (Fig. 3).
Furthermore, a portable radar device was developed and tested (Fig. 4); offering a long range, low cost and low power alternative solution to the current manual drawdown test (Fig. 5) with a derived accuracy within error of costly to install magnetic flowmeters.

IV. Conclusion

With the emerging IoT revolution, this paper has proven LoRaWAN to be an effective long range, low power and low cost wireless sensor network protocol for utilities, and cities as a whole to deploy, as well as offering a specific industry-focused application in the form of SPS level and flow monitoring.

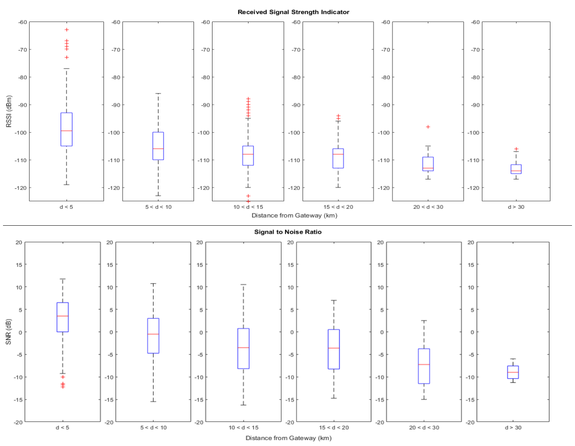

***Figure 1:** Signal characteristics of communications survey*

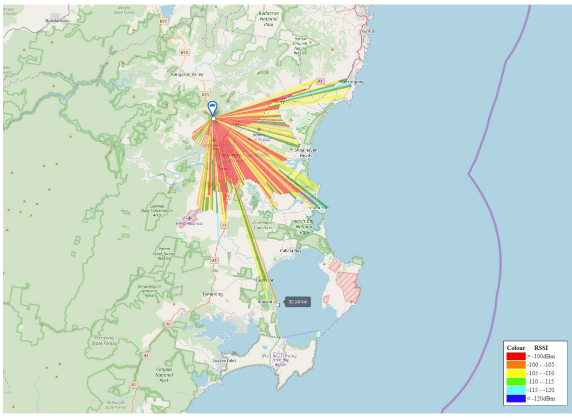

Figure 2: *Shoalhaven region communications survey*

Figure 3: *LoRaWAN end device level and flow monitoring*

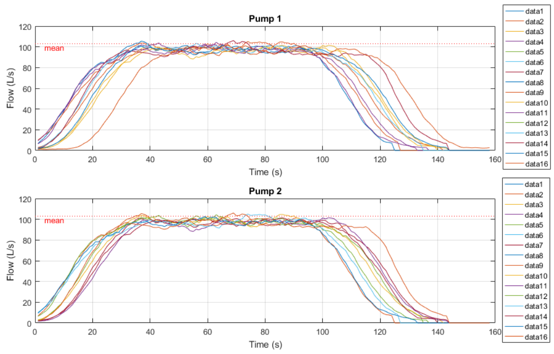

Figure 4: *Bomaderry SPS 9 drawdown test derived flows*

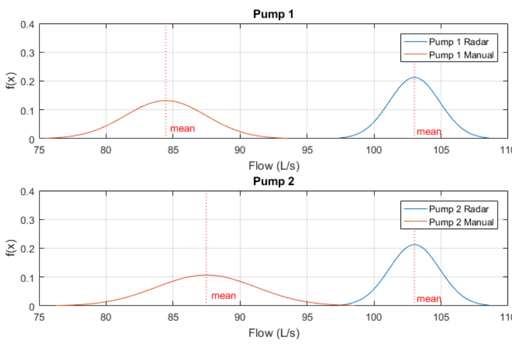

Figure 5: *Normalised SPS 9 drawdown test results comparison – Manual method vs Radar device*