REMOTE TELEMETRY UNITS FOR CONTINUOUS WATER QUALITY MONITORING: AN EXAMPLE FROM SILVERSTREAM LANDFILL

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ABSTRACT

Continuous monitoring of key water quality indicators is becoming a more common requirement of resource consent conditions. Recent electronic advancements have enabled the use of compact, low maintenance, autonomous remote telemetry systems. These are capable of continuously monitoring near ‘real time’ environmental data. Effective telemetry systems can significantly reduce travel and labour costs otherwise required to ensure compliance at remote locations.

On behalf of the Hutt City Council (HCC), Geotechnics Ltd has installed two permanent remote telemetry units (RTUs) to meet compliance monitoring requirements at the Silverstream Landfill. The units continuously record measurements of pH and conductivity at both the inlet and outlet of a storm water settlement pond situated down slope from the landfill.

The data obtained from the two RTUs is stored in the onboard memory until is it uploaded via a GSM network. The data can then be viewed via Short Message Service (SMS or text message), Multimedia Messaging Service (MMS), or Internet communication services such as email and the World Wide Web. The system is also configured to send alarms, in the form of an e-mail and/or a text message, to warn when predetermined trigger levels are breached (i.e. high or low pH or high conductivity).

This paper outlines the solutions we developed to overcome the challenges of designing a reliable remote monitoring system for a location with minimal sunlight and poor data transmission coverage.

INTRODUCTION

Remote Telemetry Units (RTUs) are now more economically feasible due to the availability of cheaper internet and cellular network suppliers. Recent advancements in communication devices have made RTUs more viable due to increased signal transmission distances and larger onboard data storage capacities. Given this, RTUs can be used remotely to significantly reduce travel and labour costs previously required to ensure complete monitoring compliance at remote locations. The telemetry of results also provides the opportunity to react quickly to any potential problems. Some industries where RTUs are currently being used successfully include: agricultural sites, water quality monitoring, wildlife surveys, motor racing and production lines, to name a few.

The Greater Wellington Regional Council (GWRC) has issued Resource Consent for discharges of stormwater and groundwater from the sedimentation pond located within the Tip Stream for the new Stage 2 landfill development at Silverstream. The consent conditions require that water entering and flowing from the sedimentation pond is monitored continuously (15-minute readings) for pH and conductivity (Discharge Permit WGN040184[23251]). Trigger levels are to be calculated based on 3 months of continuous monitoring prior to refuse being deposited in the new landfill. The consent also requires that the monitoring system has an alarm to indicate when trigger levels are exceeded. The alarm triggers contingency actions such as collecting surface water samples for laboratory testing.

To meet GWRC's consent requirements, two locations were selected to continuously monitor pH and conductivity levels. One site was selected at the inlet and one at the outlet of the recently constructed storm water settlement pond. Each installation consists of two environmental sensors (ph and conductivity), two parameter specific transmitters and a data logger-transmitter. Following data collection, the information can either be uploaded remotely at anytime using a modem or is sent out via GPRS as an e-mail and/or text message to warn of any compliance levels that may have been exceeded.

This paper describes the processes and subsequent issues encountered to develop a custom built RTU installation at a difficult site. Several potentially problematic factors had to be considered prior to installation of the RTUs, including their position relative to flood water levels, cell phone and data reception quality and site security. A further issue that became apparent after installation of the RTUs was the lack of solar energy at Silverstream in the winter months.

METHODOLOGY

At the Silverstream Landfill accurate and consistent monitoring of pH and conductivity is required. These parameters need to be monitored for the expected lifetime of the installations, which is 10-15 years. For this reason careful selection criteria needed to be met. Factors such as durability, reliability and accuracy were all considered to ensure that data loggers, parameter sensors and data transmitters would meet the needs at each site.

Central to each RTU is an EDAC 320 cellular based remote monitoring control and logging system. The EDAC 320 connects to the Global System for Mobile communications (GSM) cellular network and uses this connection to deliver data. The EDAC 320 transmits data through GSM using General Packet Radio Service (GPRS) to deliver information in the form of SMS message and/or e-mail.

The EDAC 320 has the ability to monitor up to eight parameter inputs, these can consist of either digital 4-20mA analog or 0-5V analog inputs. This system also has four integrated relay outputs, which can be used to control various types of equipment. These outputs can be switched either remotely via SMS or email or automatically depending on the state of an input. For example, in a cool store where an increase in temperature is detected, the EDAC will activate the air conditioning system automatically. For the Silverstream Landfill compliance monitoring of only two inputs (4-20mA pH and conductivity sensors) is required, however there is scope to add a further six parameters if required.

An IC Controls glass electrode pH sensor (Model 642) was selected for both locations due to is ruggedness and versatility. This sensor uses the potentiometric method to indicate the pH of a sample. It works on a two reference electrode basis; a reference on the inside of a glass membrane and a reference that is in contact with the external tested solution. A millivolt potential difference between the two references is carried by the potassium and sodium constituents within the glass membrane and provides the pH signal (User manual, IC Controls pH Sensor um-600SR3).

Conductivity is measured using an IC controls model conductivity analyser (415). This was selected because of its durability and its compatibility with the data transmitter (IC Controls model 450). This model contains a microprocessor that compensates for environmental variables such as the change in temperature and fouling. To allow for these variables and other variables the 450 conductivity transmitter has an auto range capability which allows for a tenfold increase or decrease in range by the microprocessor. This can achieve accuracy at a far greater range than was previously possible. For example, a $1.0/cm^{-1}$ constant recommended for 0-1,000 μS/cm range can read accurately up to 0-10,000 μS/cm or down to a 0-100 μS/cm scale. The microprocessor also allows for the fouling of the sensor and other changing water conditions by determining the cell constant at the point of calibration and compensates accordingly. Changing cell constants are no longer a factor adversely affecting repeatability (Technical Notes, IC Controls Conductivity Theory and Measurement; Issue 4-1).

All of the equipment needed to be housed securely, as other similar installations, such as the Wainuiomata Landfill weather station, which had shown signs of vandalism and deterioration. A 3mm gauge steel cabinet was fabricated and zinc coated for corrosion protection (Fig 1). This, in turn houses a polycarbonate waterproof enclosure. This level of protection was deemed necessary for the projected 10-15 year life span of the equipment.

Figure 1-Weatherproof enclosure and weir at Site 2, Tip Stream, below Silverstream Landfill settlement pond.

Following the mounting and connection of the system, initial calibrations were required. This involves cleaning the sensor probes and immersing them in a calibration standard.A series of quick operations on the analyser controls set the new parameters on the microprocessor. This will be followed up with regular monthly cleaning and calibration visits to ensure accurate data is collected on an ongoing basis. Both of the sensors systems retain in their memory a record of calibration dates, values, and cell constants that can be downloaded to monitor consistency of results and sensor cell condition.

DISCUSSION

The Site 1 and Site 2 RTUs were installed in the winter of 2008, historically the period of the year with the least amount of sunlight hours. Site 1 is located at the inlet to the settlement pond. Due to steep topography and dense vegetation there was insufficient solar energy for the system to be self-sufficient. However, a mains powered leachate flow meter had been installed approximately 25m away and mains power was diverted to Site 1. A transformer was installed to provide the reduced 24 volts required by the equipment.

Site 2, located further down the valley and receiving higher sunlight hours, operated successfully up until the 18^{th} of August 2008. It had become apparent that the panels were no longer receiving enough sunlight hours to maintain charge in the batteries. Initially two 5W solar panels were installed; these panels did not provide the power needed to maintain charge in the two 12V batteries with reduced sunlight. Subsequently, four larger panels (Fig 2), capable of generating 10W each, were installed to provide the extra power needed. It was also established that the seasonal shift of the suns axis to a more over-head trajectory resulted in the sunlight being blocked by nearby pine trees. These trees have since been pruned and the system is operating successfully at present.

Both sites have power regulators installed to control power flows between the power source and the sensory equipment. This acts by protecting the batteries from over or under-charging and controls the amount of current drawn; this protects the equipment and batteries from damage. A five metre high steel mast was erected at Site 2 to provide an improved line of sight for the solar panels and the antenna. The wiring for the solar panels and the antenna was fed down the inside of the steel mast and trenched underground to protect the wires from any damage.

Figure 2-The 5m high steel mast at Site 2 with Solar panels and unidirectional 'Yagi' antenna mounted.

Each site is located within a steeply sided, heavily vegetated valley, making it difficult to obtain GSM signal for data transmissions. Site 2 was the nearest in proximity to a cell phone tower, however it proved to be the more problematic of the two sites, with uploads dropping out in poor weather. Initially both installations were fitted with low gain (3dB) omni-directional ‘wand’ antennas. These were removed and replaced with unidirectional (9.5dB) ‘Yagi” antennas. Although much more expensive and limited to receiving signal from one direction, this antenna worked well. Site 1, although further up the valley, was able to receive and send information successfully using the low gain ‘wand’ antenna.

Site 2 has now been reading and collecting data since 16th April 2008 The system is configured to take a reading every 15 minutes, 24 hours a day. In this time it has automatically collected approximately eighteen thousand readings. To ensure the installations are working properly and the information being logged is accurate and consistent; results will be compared with weekly laboratory-tested samples over a three month assessment period. Although Site 1 has been physically installed, the weir in which the sensor probes are to be mounted is yet to be constructed. To date no data has been collected at this location.

CONCLUSIONS

When deciding on a RTU system for environmental monitoring purposes it is essential that a completely integrated evaluation is undertaken prior to any construction. All equipment must be compatible and the expected maximum ranges of each parameter being recorded must be identified. Careful consideration must be given to physical location in relation to network transmission strength, flood water levels and available sunlight hours. Both monitoring sites at Silverstream Landfill, being surrounded by steep topography and dense vegetation, had issues with sufficient sunlight and GSM network coverage. These difficulties were overcome by diverting nearby mains power at Site 1 and by installing larger solar panels and a unidirectional antenna at Site 2. The collection of a background level data set will commence on 15th October 2008 over a three month period at both sites. At the end of this time the data will be assessed to establish 'alarm' trigger levels for pH and conductivity. Once trigger levels for the stream below Silverstream Landfill have been established the official monitoring for resource consent conditions will begin.

REFERENCES

Conductivity Theory & Measurement, Technical Notes, issue 4-1, (online) accessed August 2008 available from <http://www.iccontrols.com/files/4-1.pdf>

pH Theory and Measurement, Technical Notes, issue 6-1, (online) accessed August 2008 available from <http://www.iccontrols.com/files/6-1.pdf>

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