Smart Stormwater Harvesting Management with Next Generation Smart Metering

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Abstract

A large number of stormwater harvesting schemes have been built in recent years. Yet, few have reliable operating data, if any. Even fewer have online monitoring through smart metering to ensure the systems perform as expected and deliver the anticipated water savings and environmental outcomes. Web based systems can now provide near real time feedback on harvested water volumes, tank levels and irrigation practices.

The monitoring implemented across some 15 systems allows for a clear understanding of how water is used. In this latest advancement of the smart metering system, climate based benchmarks were developed to determine monthly water budgets adjusted for the rainfall in that particular period. Calculated water use is then graphically compared to actual water use allowing for a clear assessment of over or under watering. When combined with monitoring of the stormwater harvesting scheme (tank level and thus volume, harvested water and potable top up) it leads to a powerful modern water management system. It provides increased understanding of the rainfall/runoff relationships which will aid in the design of future systems. Irrigation practices in terms of irrigation depth, frequencies and scheduling are recorded and can readily be viewed. It provides the means to optimise the system both from a water conservation and a turf health perspective. It has proven to be a valuable tool for the sustainable management of stormwater harvesting, reuse and irrigation schemes.

Introduction

Stormwater harvesting has become a popular strategy to mitigate the impact of droughts, climate change and population growth on water availability in urban irrigation. Hundreds of thousands of dollars have been invested in stormwater harvesting systems, to save tens of thousands of kilolitres of potable water each year. These systems need to be maintained to ensure they provide value for money – and monitored.

Smart metering systems have facilitated this by providing near-real-time operational data. Regularly reviewing and acting upon this data helps to achieve the expected water and cost savings of stormwater harvesting systems. Next Generation Smart Metering Systems have been implemented to provide assessment of stormwater harvesting system performance via KPI charts and direct comparison of rainfall with stormwater usage.
The system has been implemented on 15 stormwater harvesting systems across New South Wales, ensuring savings of some 50,000kL/year. The advanced smart metering systems monitor parameters such as:

- storage tank water level
- stormwater processed by filtration
- stormwater use
- remaining mains water use
- top up water
- daily rainfall
- monthly water budgets updated by real-time weather

Figure 1 shows the system architecture. The water meters and storage tank level sensor transmit data to the Data Collection & Transfer Unit. The data from each meter or tank travels either wirelessly or hardwired, depending on the layout of the site. From the Data Collection & Transfer Unit, all data is transmitted via GPRS to a web server. The data can then be accessed via the internet on any computer, tablet or smart phone through a password-protected website.

Multiple types of storage tank level sensors have been used to capture tank level, such as pressure transducers and ultrasonic sensors. Pressure transducers measure water pressure from the bottom of the storage tank. Ultrasonic sensors are mounted above the water level and measure the distance between the water level and the sensor. The experience from this project has been that pressure transducers were more reliable, easier to install (where access to the bottom of the tank was possible), simpler to configure and cheaper.
Data was displayed using an interactive web site. Default graphs were set up for each smart metering point, with 15-minute interval data displayed over a week. The water meter graphs showed L/min flow rates over a week, as well as cumulative kl per day and per week bar charts. Tank volume was calculated from tank level values. Charts were presented to assess the daily performance of irrigation systems, such as comparison of water usage for irrigation vs daily rainfall. Monthly targets and actual water consumption were compared to assess system performance.

Automatic notifications were configured to alert users when the tank level was low, when there was continual base flow indicating leakage, or when there were atypical spikes in water consumption.

Results

The smart metering systems revealed the stormwater harvesting and water use profiles for each oval. For example, at Site 1 there was 654kL of irrigation in the 2010/11 fiscal year. The irrigation occurred primarily in October, December and March to April (Figure 2). The irrigation was run every second day during these periods, except in December when irrigation was run every day.
In 2010/11, there was 1,138kL of irrigation, or nearly twice as much water use as in 2009/10. December to January and March to April (Figure 2) were the times when most of the irrigation occurred, every second day. However in March to April 2011 there was daily irrigation. With this data available, the user can now analyse whether a field was well or poorly managed, develop further benchmarking data and reduce costs.

**Tank Leaks**

Several tank leaks were revealed through the smart metering system. These were identified by the asymptotically decreasing pattern of tank level. For example, at Site 2 (Figure 3) the underground storage tank the water level always levelled off at 1.15m. The culprit was a leak in the underground collection and diversion main. Smart metering the tank level allowed to clearly demonstrate this. Once repairs are made, the system allows the user to easily check that the repairs have been effective. Site 3 was another site with a tank leak (Figure 4). It shows the importance of monitoring stormwater harvesting systems, especially with underground tanks.
Site 1 showed a high irrigation usage in December 2009 (Figure 5). This was investigated. A contractor had done work on the irrigation system but forgot to turn off a valve which resulted in the tanks emptying themselves over a weekend. This resulted in wastage of more than 100kL, or over $200 in water costs. This would have gone unnoticed for some time had there not been alarms on the system. Also, through the behaviour of the tanks at Site 1 the user could identify that the isolation valve between the two tanks had been tampered with (someone had attempted to shut the valve). This is another instance that would have gone unnoticed for quite some time without the monitoring.
Figure 5: Site 1 Valving Error

Lack of Irrigation

At the Site 2 site in 2010 the monitoring system showed that there was no water being used even during times when irrigation should have taken place. After contacting the sports field manager it was confirmed that the field was scheduled for irrigation three nights per week. The irrigation control system also indicated that irrigation had occurred. However, no water had actually been applied. A detailed investigation into the matter revealed that a faulty rain sensor was overriding the system,
shutting off the pumps while the controller still indicated that irrigation was taking place. As irrigation was scheduled to occur at night as part of the user’s risk management, this issue is likely to have gone undetected for a long period of time if the monitoring system had not highlighted the discrepancy.

**Alarms**

To make the user aware of abnormal water consumption, abnormal stormwater harvesting system behaviour and water wastage, smart automatic notification alarms, in the form of emails and SMS’s were developed for this purpose.

Alarms included Minimum Night Flow alarms. They are set to trigger when the irrigation meter is turning over in periods where the irrigation system is not scheduled to run. Low Tank Level alarms are set off when the tank level has dropped too low and the top-up water is not filling up the tank as expected. The alarm levels are customised for each site, as well as the messages the alarms relay (Figure 6). The messages can be a prompt for the irrigation operators to investigate the header tank for leaks or check valves, or any other action.

![Irrigation Meter](image)

<table>
<thead>
<tr>
<th>Irrigation Meter</th>
<th>Input Settings</th>
<th>Calibration</th>
<th>Logging Frequency</th>
<th>Alarms</th>
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**Minimum Night Flow Alarm Conditions & Recipients:**

- **Condition:** Send alarm when irrigation meter does not measure less than 200 L per minute between the hours of 20:00 and 23:00.
- **Recipient list:** Add emails and phone numbers.
- **SMS Recipient:** (comma separated list)
- **Email Recipient:** (comma separated list)
- **Alarm Message:** Roseville Chase Oval Irrigation Meter exceeds 200L/min between 8pm and 11pm.
- **Disabled:**

**Figure 6: Alarm Configuration**

At other sites, alarms were set up to notify users of zero water usage to alert when the irrigation system is not working. This helps maximise the up-time of stormwater harvesting systems so that turf remains well-kept throughout the year.

**Detection of top-up water leaks**

At several sites, next generation smart metering has shown when the potable water top up valve does not close. Figure 6 shows the water use where the top-up valve for the header tank was stuck open causing the tank to overflow continuously for three weeks. The last two days show the water consumption after the valve was fixed. If this had remained undetected and unaddressed, it would have wasted over 14,600kL/year and $45,000/year in water costs.
Benchmarking Charts

The system also allows the inclusion of features such as benchmarking charts and rainfall charts. Monthly water budgets (Figure 7) have been established for several sites to help better manage water consumption and amenity value. These are calculated based on seasonal turf water demand, expected efficiency of the irrigation delivery system and historical monthly rainfall.

Benchmarks have been made more relevant by importing live rainfall data from the Bureau of Meteorology enabling to reflect actual rather than historical weather patterns. This is increasingly important for the future where climate change is leading to future weather very different to past weather, more extreme daily and seasonal weather events (refer to Figure 9). By having the ability to recalculate water targets daily based on real-time weather, users can manage their stormwater harvesting systems most efficiently.

Figure 7: Water Consumption due to a Potable Top-Up Leak

Figure 8: Sample of Monthly Irrigation Benchmarks
An example of the implementation of these rain-adjusted targets is displayed in Figure 10 for the months August and September. This shows the total irrigation over August and September was not distributed appropriately.

In addition to the monthly benchmarks, daily rain data is displayed side-by-side with daily irrigation totals. Both parameters are expressed in the same unit: rainfall or irrigation depth in mm/day.
11) It allows a direct comparison of watering needs met by natural rainfall vs. water supplied through irrigation.

![Daily Irrigation Depth vs. Daily Rain Depth](image)

**Figure 11. Daily rainfall and irrigation depth for Site 4**

Figure 11 shows the historical over-irrigation for Site 4. The August daily water demand is 2.1mm/day. In the first week of August there was four times the required irrigation.

**Virtual water meters**

Other options include virtual water meters. For example, there are ovals which have the harvested stormwater and the irrigation water flow smart metered. The potable top-up volume is displayed as a virtual smart meter by subtracting the harvested volume from the irrigation volume.

**Summary**

The project has demonstrated the value of monitoring stormwater harvesting schemes and the need to actively and continuously assess the functioning of the systems during operation.

Some systems have installed water meters into the harvested water lines. It provides a manual means of checking the water yield of a harvesting project. However, having both the water use and the storage tank level data available online significantly enhanced the level of monitoring possible. Instead of periodic 1 – 3 monthly checks taking a couple of hours per site, fifteen systems can be supervised within 30 min. In addition automatic alarms are sent out for significant deviation from normal use. The status and performance of these assets totalling some $5m is now continually monitored. Users are aware of any issue immediately, and can intervene to ensure the assets create the value to the ratepayer and the funding provider they were envisaged to. Monthly targets values provide a high-level analysis tool to compare the present and historical performance of the stormwater harvesting systems.
A number of interesting lessons were learnt related to the still relatively new technology employed and the flux of ongoing product development and compatibility between instruments and logging equipment. Installing such a monitoring system right at the start of a project, or at least making provisions for it with conduits and penetrations/insertion points for level transducers or other devices provided, would help reduce system costs. Still, it was found that the system provided value for money even as a retrofit. As a result, this type of advanced metering should be incorporated into future water harvesting projects right from the onset.