PRACTICAL ISSUES IN COMMISSIONING A SIMPLE STORMWATER HARVESTING SYSTEM FOR WATER QUALITY

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ABSTRACT

Ku-ring-gai Council in Sydney has been very active in promoting water harvesting and re-use schemes. The St Ives Bowling Club decided to install a storm water harvesting system to replace their reliance on town water as previous drought restrictions had caused damage to some greens. Their Development Application required water quality testing to occur over a six week period which included sampling after at least one high rainfall event. The E. coli levels had to comply with the NSW DECC Level 3 guidelines (<1000/100ml).

The commissioning period actually extended to 4 months with storm water irrigation having to be used throughout this time. This had not been envisaged by the various authorities involved. The reasons for this, the design of the sampling protocol used and the variation in the results and its implications are discussed. B2P field test kits were used and some brief comments are made with regard to their use and comparative laboratory tests carried out on these samples.

1.0 INTRODUCTION

Following the severe water restrictions of the Sydney water supply in 2006/7, the Ku-ring-gai Council, located on the north shore, decided to focus on storm water harvesting and sewer "mining" for irrigation of recreation areas The St Ives Bowling Club was encouraged to submit an application for a small storm water harvesting scheme to replace its reliance on town water for irrigation of its three greens. They had experienced their greens being burnt-off during the water restrictions. It was not only a question of the economics of the capital costs and operational savings (if any) but club survival.

A scheme was designed to collect storm water from a small urban catchment where the storm water pipes actually ran under one of the greens and a grassed "overflow" car park. A connection to the storm water channel collects any flowing storm water into a sump after debris has been filtered out. When water in the sump reaches the required level, a submersible pump lifts the water at 2L/sec into two 105,000 L concrete tanks. A conventional automated pumping station with 120 micron filters is then used to supply water to a Toro sprinkler and control system rotating around the greens.

The water quality commissioning required in the Development Application (DA) was determined by Council's environmental staff based on Level 3 Water Quality as specified in Table 6.4 of the Department of Environment and Climate Change (DECC) publication "Managing Urban Stormwater: Harvesting and Reuse" (Table 1). This specifies that the E.coli levels must be less than 1000/100ml and the pH less than 8.5. After Council also looked at the national guidelines, the staff decided to specify that samples would be taken at the commencement of commissioning, and then at weekly intervals for another 3 weeks, one of which was to include sampling after a high rainfall event. In addition to bacterial levels and pH, one sampling was also to include an analysis of total nitrogen and total phosphorus. Any field testing was also to be compared with results from a NATA laboratory for one of the sampling occasions.

Table 1: ***Managing Urban Stormwater: Harvesting and Reuse, Table 6.4***

(DECC 2006)

LEVEL	CRITERIA	APPLICATION
Level 1	**E. coli <1/100ml** **pH 6.5 – 8.5** Turbidity < 2 NTU 1 mg Cl2 res > 30min	**Reticulated non-potable residential uses** Gardens, toilets, cars
Level 2	**E. coli <10/100ml** **pH 6.5 – 8.5** Turbidity < 2 NTU 1 mg Cl2 res > 30min	**No access controls** Spray or drip, parks recreation Industrial where human exposure Ornamental water
Level 3	**E. coli <1000/100ml** **pH 6.5 – 8.5**	**Access controls** Spray or drip, parks recreation Industrial where no human exposure Ornamental water

2.0 DISCUSSION

2.1 Sampling Protocol

When Council specified a sampling event frequency, the number of samples (replicates) to be collected and the protocol in collecting samples was not specified. The State and National sampling guidelines are generally not prescriptive and the development of sampling protocol really relies on the knowledge of the specific operation which is to be tested and the technical experience of the staff involved. Although the DA specified that sampling was to occur at a number of times, did it mean one sample or several samples to be tested at each event? Could several samples be pooled requiring only one analysis to be done or should several analyses be done to get an average. Would it be better to do 3-4 analyses for each event? Would testing requirements be the same at commissioning as at later routine monthly testing? To decide on this we thought it better to do a number of samples with individual analysis during the commissioning until we had a better feel for what might happen in the storage tanks and what sort of run-off quality might be expected.

The next question was what was the purpose of the testing? Clearly, it was to ensure that the filter system was working effectively and that the night-time irrigation quality met the Level 3 standard. Now one thing we know is that bacteria (unlike chemicals) are not evenly distributed in storage tanks or pipes, they tend to clump, form biofilms and more specifically attach to very tiny soil / colloidal particles. We had no knowledge of the flow dynamics in the tanks once the irrigation pump started pulling out the water. Would the particles settle on the floor and walls or close to the inlets or outlets? As we had no real idea as to what might happen in the tanks when they were at different levels of capacity, and as the flow patterns might change over time as the particulate matter was disturbed, we decided that we would run the pumps for at least 15 minutes before we collected the first sample and then collect a sample every 15 minutes using three individual samples for the water quality analysis. For consistency, we started at 7.30 am each time.

The same issue arose as to the sample collection location. Should we collect from different sprinkler heads to satisfy our purpose for testing?

This might again introduce more variation into the results making it necessary to sample more to get a true mean. The most practical thing to do was to install a sampling tap immediately after the filter system and before the main irrigation delivery main.

2.2 Sample Method and Handling

The normal method of bacterial sample collection for a laboratory analysis is to fill a 500ml sterile PET jar, put it on ice and send it off to the laboratory by courier. Using the B2P Watercheck jars, this was not necessary for bacterial testing as we could collect directly into the 100ml Watercheck jar and walk to the office, press the cap to release the growth media and indicator dye, place them in the MicroMagic incubator / analyser /data logger and then leave them to run for 10-12 hours or just come back the next morning to read off the results (they turn off automatically after 14 hours).

Figure 1: ***The B2P bacterial testing system with the sampling/test kits and MicroMagic***

The pH was measured using an EZDO 7011 Pen Tester. The calibration and pH testing took longer than the B2P Watercheck sample collection and test start!

For the one-off Sydney Water Laboratory NATA comparison of bacterial testing and total N and P, the conventional sample collection procedure was followed. However, we already had our on-site results, before the laboratory commenced their tests the next afternoon. The laboratory test conducted was a standard Membrane Filtration test. Although several labs now use Colilert routinely for water testing, the international scientific literature and our own comparative testing shows that Colilert may not identify the presence of several species of key E. coli. In some international published studies this has been up to 34% missed including E. coli 0157; we have found 10-20% differences. This is why a comparison is better with MF.

2.3 Initial On-site Investigation

After the installation of the sampling tap, we then commenced our first sampling investigation having been told that the tanks were about 30% full. At this stage, we were advised that it was not possible to run the irrigation system because of the licensing arrangement with Sydney Water as they had not yet disconnected the mains water. They were not able to run both systems into the irrigation lines alternatively. Mains water had to be turned off when the storm water system was commissioned.

The water that was in the pumping line was quite cloudy and when the pH was checked it was above 11. Further questions to the pump installer and the Bowling Club members revealed that the tanks had been filled with mains water initially in order to stabilise them and that any limited run-off was insufficient to dilute this water and the lime from the concrete walls and base.

We then had to monitor the rainfall events and the pH until the tanks had filled and the pH had declined. Understandably, there was an increase in pH when the tanks filled and the roofs became wet for the first time.

We had to arrange for the mains water to be switched over to the storm water system so that we could effectively pump out the tanks to let them refill with harvested storm water as part of the commissioning process. As a precaution, we did do some E. coli testing on the high pH water (when down to 8.9) to ensure that there was not a major health hazard in pumping out the water. Firstly, at such a high pH it was unlikely that the bacteria would be able to survive. Secondly, as the pH declined and growth became possible the B2P Watercheck system was ideal to test the true E. coli levels which ranged from 24-61 E.coli/100ml . The B2P media contains a buffer which reduced the pH levels from 9 or over down to about 6.9 to 7.4 with this water. Delays in transport to the laboratory and the high pH would not have allowed for the identification of these levels The green keepers were quite delighted to have to deal with a high pH water as it is always a problem to maintain a near neutral soil pH when applying fertiliser regularly to the greens. The rainfall irregularity and the need to have some big storms to re-fill the tanks and reduce the pH further delayed the water quality testing. The weekly rainfall and pH is shown in Figure 1.

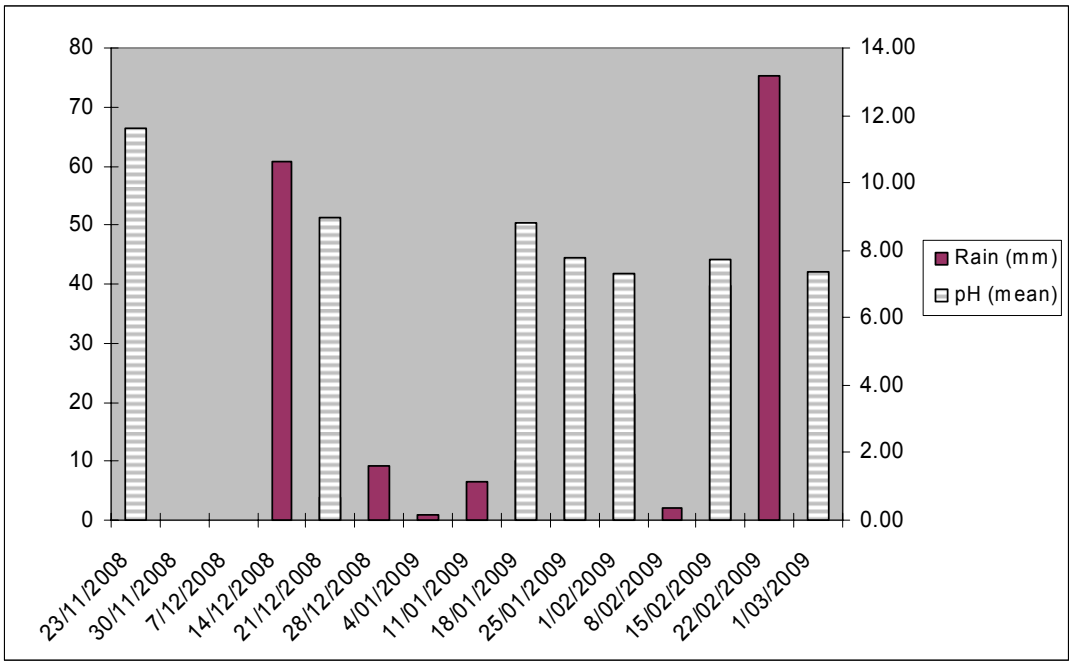

Figure 2: ***Rainfall events and pH during tank emptying and re-fill***

2.4 Commissioning Results

These are provided in Table 2. The first opportunity we had to sample with the pH having now dropped to below 8.5 as required, was on the 28 January 2009 after a very high rainfall event. However, at this time the green keepers were reluctant to irrigate the greens as they did not want to waterlog them. As an alternative we agreed that they could use a heavy duty hose to run the pumped water from the sampling tap back into the storm water sump and we sampled at the end of the hose at the sump. The results exceeded the Level 3 limit (Table 1) and we sent the B2P Micro Magic files to our overseas R&D lab to confirm immediately.

The spectrophotometer wavelength patterns were unusual suggesting the presence of some other material / biological activity in the test water but the results were confirmed with some minor modification. Just to check, we re-ran the same MicroMagic machines with Sydney tap water to confirm that it was not a problem with the machines or the media. Had we disturbed a biofilm in the hose (which usually lay out cooking in the sun) from the high pressure pumping?? We repeated the tests as soon as irrigation of the greens could be commenced using our standard protocol. The results now complied, with E.coli results ranging from 13 to 299/100ml.. The other results showed a slight lift in levels after another rainfall event but all were well under the 1000 E. coli/100ml.

Table 2: ***Water Quality Commissioning Results – St Ives Bowling Club DA***

Date & Time	**Sampling Event**	**pH**	**Total Coliforms / 100ml**	***E. coli /100ml***	**Notes**
28/01/2009	**High Rainfall**				2 hour 32m rainfall refilled tanks after hot weather+++volume used.
9.46		7.55	1500	1100	*Sample collected by running hose back into sump. Sampling error ?*
10.01		7.79	907	907	<1000 E.coli/100Ml, pH<8.5
10.07		7.92	907	907	<1000 E.coli/100Ml, pH<8.5
Average		*7.75*	*1105*	*971*	
30/01/2009	**Resample**				Sampling from Tap after Filter
8.04		7.16	13400	13	<1000 E.coli/100Ml, pH<8.5
8.24		7.36	2347	299	<1000 E.coli/100Ml, pH<8.5
8.43		7.35	2750	299	<1000 E.coli/100Ml, pH<8.5
Average		*7.29*	*6166*	*204*	
11/02/2009	**Mid Sampling**				Sampling from Tap after Filter
8.05		7.68	1169	99	<1000 E.coli/100Ml, pH<8.5
8.21		7.76	2930	704	<1000 E.coli/100Ml, pH<8.5
8.35		7.68	5552	620	<1000 E.coli/100Ml, pH<8.5
Average		*7.71*	*3217*	*474*	
23/02/2009	**Last Sampling**				Sampling from Tap after Filter
8.25		7.38	38	0	<1000 E.coli/100Ml, pH<8.5
8.35		7.38	9	9	<1000 E.coli/100Ml, pH<8.5
8.45		7.38	1	1	<1000 E.coli/100Ml, pH<8.5
Average		*7.38*	*16*	*3*	

2.5 Comparative NATA Laboratory Results

Sydney Water conducted a Membrane Filtration E. coli test on each of a 500 ml sample that had been refrigerated below 4 degrees. Three B2P Watercheck tests were taken from the same samples and started at the same time. The B2P tests were

running in the Micro Magics before the lab material had been sterilised and the plates prepared.
The lab staff knew the range of results already obtained in the field and did a dilution of 1/10. The tests commenced at about 1.30 pm which is the usual time for this testing to start. B2P results were available when the staff came in the next morning. At 3.30 the next day, the laboratory had to repeat their tests for confirmation with a dilution of 1/100 as there was a white background material growing on the plates which masked the E. coli results and they could not count them. This may have been pseudomonas sp. (but was not identified) and may have accounted for the unusual wavelength patterns we had previously identified. The results two days later were virtually identical to the B2P figures (15 and 7 E. coli/100ml vs. 6, 11 vs. 13). Total P was in the expected range (0.136 mg/L) and N was slightly higher than the normal storm water range (3.64 mg/L) but suited the green keepers!

3.0 CONCLUSION

Obviously the practical issues of the water quality commissioning were quite different to the expected time frame by both the DA and the Bowling Club members. Neither anticipated the issues arising from using concrete tanks, the lack of rainfall and then the variable rainfall pattern. Sydney Water requirements that a system could not be run in dual mode (i.e. mains water and /or harvested storm water) until after commissioning was completed did give rise to some anxiety. The system required that the initial water which was both mains/storm water and high in pH needed to be pumped out before commissioning of the storm water could begin.

The other message that was very clear was not to vary from the protocol that has been decided. Because we were testing on site and in a short time, the high E. coli levels found when sampling with the hose back to the sump could be re-sampled virtually within 14 hours because we were using B2P field sampling rapid methods.

The variation likely in the results tells us that it is quite critical to take a minimum of three replicate samples at each time of sampling in the commissioning phase. Because of the levels found (DECC mid Level 3 to Level 2) it might be possible to reduce this to one sample only at regularly monthly testing if using the B2P method. In this case the results are so fast and easy to collect that resampling with on-site instrumentation can be quickly and easily repeated if an abnormal spike is found.

The B2P method is very fast and reliable and the time for testing to result is at least one to two days faster than sending samples to a laboratory, even if some laboratories claim that a test result can be provided in 20 -24 hours ….. it depends!

4.0 ACKNOWLEDGEMENTS

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