[1]Everything But The Kitchen Sink: Mywaterwisehome.com – A Case Study In Water Sensitive Urban Design

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Abstract

This paper reports on a water sensitive urban design (WSUD) initiative at a private residence in Ipswich, Australia. The project makes use of custom, emergent and established technologies in its approach to management of the owners' lifestyle preferences and problematic site conditions. It is also an innovative project from the perspective of current governance conditions, making use of previously untried regulatory mechanisms. The project comprises two integrated components: rainwater harvesting (RH) and onsite waste treatment, potentially offsetting household reliance on the mains water supply by as much as 90%, and offering further beneficial externalities. Rainwater is harvested from a 135m^2 roof catchment through a conveyance system that includes leaf diverters and screens, though no first flush diverter, to a 15kL PE storage tank. A high performance pump feeds the rainwater successively through a filter and a water meter to a Bianco Rainsaver which enables switching between the rainwater supply and mains water back-up. From the Rainsaver, water is supplied throughout the house via a PE-X water service to every outlet except the kitchen sink. The kitchen sink (plumbed separately) permanently draws from the mains water supply, a necessity with Ipswich City Council regulations. Flow restrictors and AAA (or higher) rated fixtures and fittings are used throughout the home and a 30-tube 315L Endless Solar hot water service is used. All waste water (black and grey water) is processed onsite in an OzziKleen RP10A advanced secondary treatment plant that features custom modifications for this project (due to site conditions, but not affecting system performance). Permission to install the OzziKleen RP10A system was obtained under s4 of the Queensland Plumbing and Wastewater Code 2006, with this project as a test case. The paper presents the author/owner's experiences with researching, installation and use of the various technological components. It then addresses problems and resolution of relevant compliance and regulation issues, with conclusions drawn from these experiences. It concludes with plans to operate the site as a non-commercial community education project.

Background

In 2005 my wife and I relocated a 135m^2 (1450 sq ft) Queenslander style timber home built in the 1930s to Bundamba, a suburb of Ipswich, about 40km (25 miles) from the Queensland capital, Brisbane. South East Queensland, midway on the east coast of Australia, continues to suffer from a long 'green' drought. A green drought is a period in which it may rain, but rainfall does not replenish water storages (Cordiner, 2006).

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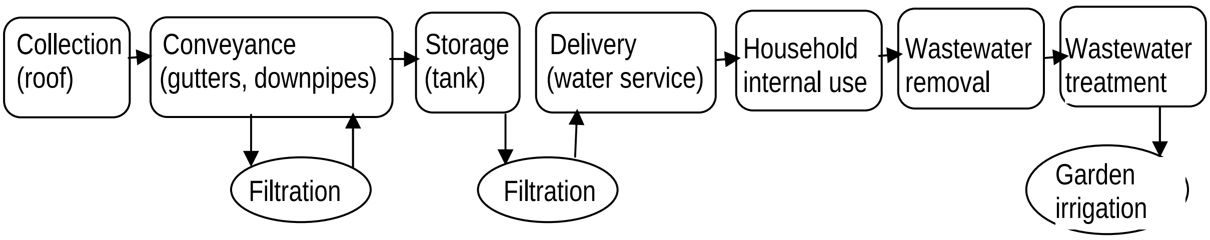
This paper reports on my own experiences as the owner builder of the project, in which I have educated myself throughout the process by research and selection of RH system components. Such experience has, in part, become tacit concerning RH technologies. However I am told I have ‘pushed the envelope’ on WSUD (at least for south-east Queensland) and so feel motivated to share this experience.
The one million homes of our urban population in South East Queensland are supplied principally by dams, some operating as low as 20% of capacity. Residents are currently on ‘Level 4’ water restrictions, meaning that gardens may only be watered using the mains supply with buckets, and only on alternate days, or ‘Level 5’, which prohibits all watering using the mains supply. It is mooted by the State Government that the water restrictions will soon become even more stringent.

To circumvent the water restrictions for household use (typically to keep gardens alive) and also in ‘doing their part’ to conserve water, many households have installed rainwater tanks. Mean annual rainfall volume in South East Queensland is 1000L/m^2 (24.5Gal/sq.foot) of roof catchment (Australian Bureau of Meterology, 2003). This is sufficient to supply roughly half the average household demand for water (110,000L/p/A (29,000 Gal/p/A)) (Australian Water Association, 2005: 29), which is roughly the volume used by households outside the home (Australian Water Association, 2002: 116).

Incorporating both RH and onsite sewage treatment has allowed the WSUD of this household to offset reliance on the mains water supply by as much as 90%. Every aspect of the house required extensive renovations or replacement, so that this project was almost equivalent to building a new home in terms of incurred expense. Explication of the WSUD is structured according to its flow from catchment to usage to disposal.

FIGURE 1: Basic Flowchart of Water System



Catchment and Conveyance

The entire surface of the 135 m^2 Colorbond roof feeds into the conveyance system through four 90mm PVC downpipes, each of which is fitted with a Leaf Eater (see right) housing two screens that eject leaf matter and other detritus, while allowing water to pass through to the rainwater tank storage. A decision was made not to include the first-flush diverters that are a proliferating component in RH systems due to research conducted by one of my PhD supervisors, Mr Ted Gardner, Principal Scientist of Queensland Government Department of Natural Resources Mines and Water. Although originally an advocate of first flush systems, based on research overseas, Ted’s subsequent research in Australia (eg Gardner, Baisden and Millar, 2004) suggested that the water quality was not significantly improved by removing the first flush and, on balance, lost too much water for the benefit. This led to a hypothesis that other factors of geographical location (city, traffic, dust, rural, trees etc.) may be important factors for the contamination on the roof, and the need/effect of first flush. This is currently the subject of PhD research by one of my colleagues in the Cooperative Research Centre for Water Quality and Treatment, Rob Huston.

Storage

From the conveyance system, harvested rainwater then drops over a visible air gap to the screened inlet of a 15,000L (4,000 Gal) polyethylene storage tank. Two significant problems with storage eventuated. First, I attempted to 'economise' on storage capacity. I reduced the planned storage capacity of 40,000L (10,500 Gal) because of cost issues on my student budget. The current tank is too small and has occasionally overflowed during seasonal rains despite constant use. However, it is easily fixed, and a second tank (20,000L for a total 35,000L) will be connected later this year.

This flags an efficacy issue with household RH installations across the wider community. My PhD pilot survey research showed a modal tank size of only 5000L. With decreasing lot size in new housing developments, the ABS 4602.0 (2005: 52) shows that tank size is the only inhibitor *increasingly* cited by households as a reason for not installing a tank. In my conclusions I note that this limited efficacy is better than failure to install an RH system.

The second problem concerned the quality of trade labour. Amongst other problem leaks, the plumber whom I contracted to establish the rainwater service failed to fit the rubber o-rings at the valve outlet to the tank. Consequently, as the tank filled I observed a constant leak. To remedy this, the tank had to be drained, sacrificing 10,000L of harvested water. I have further observed in my pilot reconnaissance of domestic RH system installations in the community that the quality of trade labour leaves something to be desired, but more on this later.

Delivery System

Water is pumped from the tank using a Lowara Teknospeed 4HM9-D Automatic Variable Speed Constant Pressure System which has a maximum head of 40.3m and maximum flow of 120L/minute. The decision about the pump was important because my wife and I did not want a substantial difference in the 'operational feel' of using rainwater versus mains pressure (including low flow or pressure). This pump operates at variable speed, automatically sensing when flow is increased throughout the house (eg turning on additional taps). The pump feeds rainwater successively through a 25 micron disc filter and a water meter (to measure actual rainwater usage) to a Bianco Rainsaver. The Rainsaver is basically a solenoid that enables automatic switching between the rainwater supply and mains water back-up at a level designated by a float, or in the event of a blackout/power outage. Additionally, manual switching between rain and mains water is available at any time.

Teknospeed 4HM9-D pump   Bianco Rainsaver

From the Rainsaver, water is supplied throughout the house via a PE-X water service to every outlet except the kitchen sink. Because of the slightly acidic pH of rainwater (5.5 to 6), PE-X piping was selected for the water service over the traditional ½" and ¾" copper piping, consistent with the CRCWQT (2005 Draft) Good Practice Manual for the Design and Installation of Roofwater Harvesting Systems in Urban Areas of Australia.

Yorkflex, the PE-X system used, was selected at the unanimous recommendation of three plumbers who collaborated on the project (for its quality and ease of assembly). Yorkflex is not UV resistant and should be covered if exposed to the sun. On this project, limited sections of copper tubing were used instead and easily integrated with the PE-X tubing using Yorkflex fittings. The PE-X water service was additionally sheathed in a clear sleeve that indicates it carries rainwater.

The kitchen sink was plumbed separately and permanently draws from the mains water supply, a necessity with Ipswich City Council regulations since untreated rainwater (even when filtered) does not fully comply with the standards laid out in the Australian Drinking Water Guidelines (2004).

However, www.rainharvesting.com.au/rainwater_research.asp reports eminent Australian water researcher, Associate Professor Peter Coombes' findings that: "Extensive analysis of literature and research revealed that health concerns about rainwater tanks was significantly overstated. You are more likely to contract illness from drinking mains water compared to rainwater." Coombes, Argue and Kuczera (2000), for example, demonstrated a marked reduction in bacterial counts over time suggesting that the rainwater tanks have a self-disinfection action.

Flow restrictors were provided through a (voluntary) State Government Waterwise Home water audit and are used on all the outlets except to the Jacuzzi. AAA (or higher) rated fixtures and fittings are used throughout the home (washing machine, dishwasher draws, 9L/minute showerheads, 3/6L dual flush toilet).

Hot Water Service

A 30-tube 315L Endless Solar hot water service was selected after ongoing consultation with a range of solar suppliers and manufacturers. In addition to the innovative

tube system (see right) that allows more effective exposure (>92%) to the sun than a flat panel (45% - 60%), the Endless Solar system recirculates the overheating water more effectively than other brands (something they call ‘thermosyphon’). Furthermore, in the course of my research I was advised by a local and well-respected manufacturer of hot water services that some flat panel solar units can discharge as much as 300L of water per day in summer (though I have not been able to corroborate this in consequent communications with that manufacturer). The water temperature obtained by the Endless Solar unit has been measured as high as 90˚C (194˚F) and at this project site has melted the insulation around the copper piping used at the outlet from the Endless Solar. There have been no adverse effects from the heat on the PE-X tubing.

Onsite Sewerage Treatment

The second major stage of the water sensitive design concerns treatment of all waste water. The new home site of 1.7Ha (4 acres) has a wonderful river frontage, but is in a 1 in 100 risk flood zone which has prevented installation of reticulated sewerage in an otherwise established suburb. The riparian positioning and flood risk placed the project in a category where Advanced Secondary Treatment (AST) of all household effluent was essential. The Queensland Plumbing and Wastewater Code (2006: 38) defines that effluent of advanced secondary quality shall meet the following compliance characteristics:

> (a) 90% of the samples taken over the test period shall have a Biochemical Oxygen Demand less than or equal to 10 g/m^3 with no sample greater than 20 g/m^3.
>
> (b) 90% of the samples taken over the test period shall have total suspended solids less 10 g/m^3 with no sample greater than 20 g/m^3.
>
> (c) Where disinfection is provided, 90% of the samples taken over the test period shall have a thermotolerant coliform count (determined by either the most probable number or membrane filter technique) not exceeding 10 organisms per 100 mL with no sample exceeding 200 organisms per 100 mL.
>
> (d) Where chlorination is the disinfection process, the total chlorine concentration shall be greater than or equal to 0.5 g/m^3 and less than 2.0 g/m^3 in four out of five samples taken.
>
> (e) 90% of the samples, with 95% confidence limits taken over the test period shall have a total nitrogen concentration less than or equal to 10 mg/L.
>
> (f) 90% of the samples, with 95% confidence limits taken over the test period shall have a total phosphorus concentration less than or equal to 5 mg/L.

As it currently stood, the criteria for AST were only met officially by one product on the market, Bushman’s Waterboy HSTP 10. For candour and without wishing to denigrate the manufacturer, I had two concerns with this product which reflect my own experience, but not necessarily that of others. First, the cost was simply unacceptable for my budget (>A$20,000). Second, from speaking with owners, I was aware of technical, maintenance and Council compliance reporting problems with existing installations.

Researching my potential options, I spoke with or emailed every domestic waste water treatment plant manufacturer I could find in Australia. I was consistently impressed with the feedback I obtained on the OzziKleen RP10A system which was the ‘next closest’ in effluent quality. I visited several sites around Australia that were using OzziKleen RP10A and visited the manufacturer twice as well as maintaining telephone and email contact. I learned from others (and confirmed these reports with the manufacturer) that the test data from the OzziKleen were an aggregate of test results taken from the initial system design prototype, and as an average of all such results, did not represent the actual final system performance parameters. The manufacturer and other individuals with whom I consulted were consistent in their belief that the OzziKleen RP10A, in practice, delivered AS effluent quality.

Permission to install the OzziKleen RP10A system was obtained under s4 of the Queensland Plumbing and Wastewater Code 2006, which allows the installation of treatment plants under test case conditions (see Figure 2). The OzziKleen RP10A features custom modifications for this project (due to aforementioned site conditions, but not affecting system performance). The test installation must satisfy regular, frequent and independent assessments of effluent standard over a six month period. This testing regime is still current, but proceeding well.

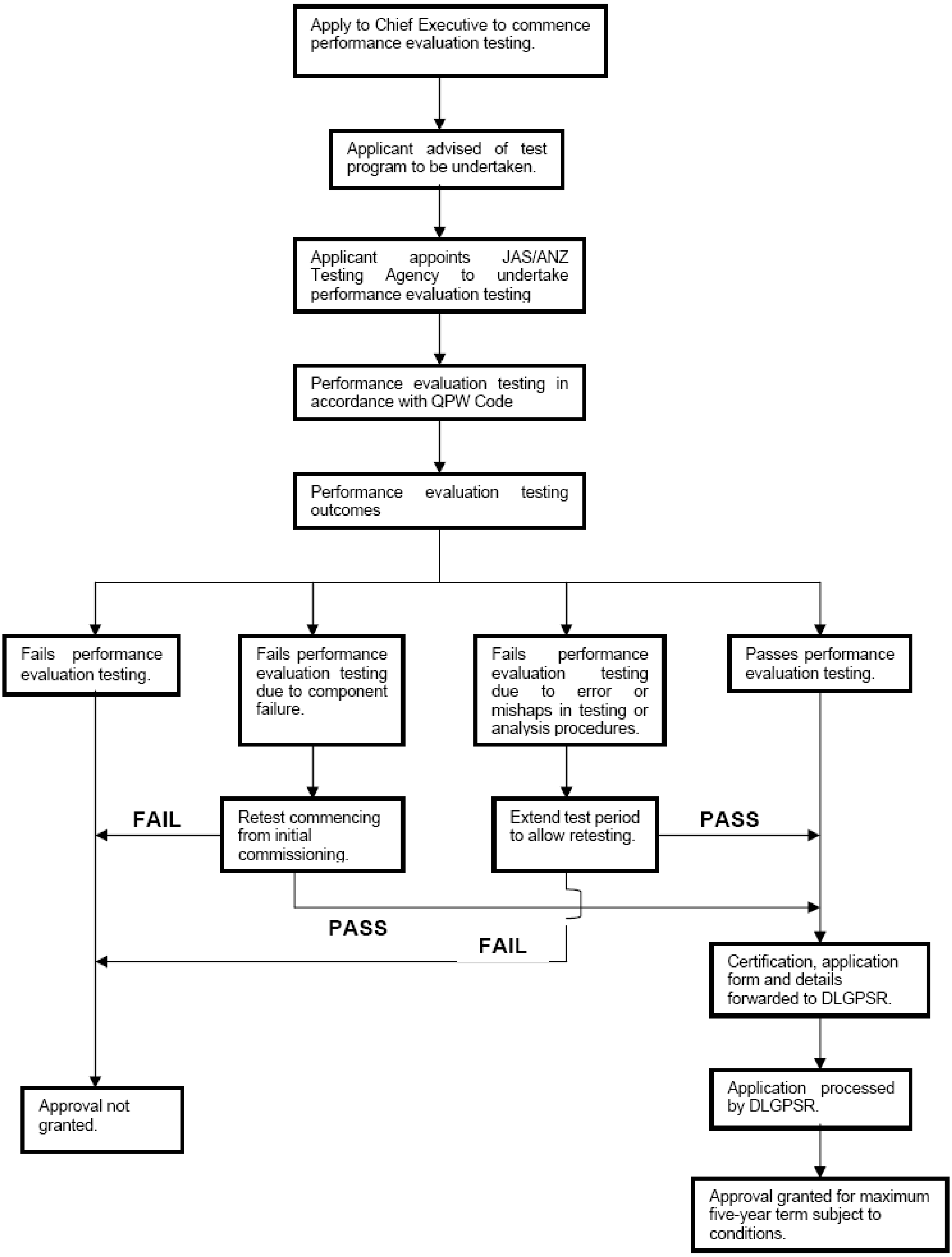


FIGURE 2: Approval Procedure for Test Case Installation, Queensland Plumbing and Wastewater Code 2006

Issues with Regulation and Compliance

As an owner builder, I took a path less travelled in my amateur quest to provide a WSUD for my own household and so incurred the difficulties that arise with irregularity in bureaucratised systems. The s4 approval, for example, had not previously been attempted in Queensland (although the legislation is admittedly recent). I found that the 'organisational knowledge' of the organisations I had to deal with (suppliers, Building Codes, Council etc) was often limited to the interest and enthusiasm of individual staff. Institutional ignorance including lack of procedural awareness was concatenated with misinformation and poor communication, burgeoning the permission process out over more than six months.

In other areas, over-regulation was a problem, particularly with regard to backflow prevention. There is unhealthy paranoia in policy making about rainwater entering the mains supply. I was required to fit no fewer than three BPDs (Backflow prevention devices) for the privilege of using rainwater (at the pump, the switching device and at the mains connection) at $90 each. Questioning the redundancy of these devices drew a blank stare from Council.

Issues with Industry Standards

Similar problems of reluctance, ignorance and dubious competence emerged with the four plumbing contractors who collaborated on this project. I was frankly, quite surprised at how many plumbers I had to approach to complete the house, since they would not attempt a project "outside their experience". The plumbers I eventually contracted were unaware (but admittedly candid) of statutory requirements in the installation of RH systems, for example one insisting that no backflow prevention device was needed, while another that only an $800 BP system would pass Council inspections.

Green plumbing is an innovative initiative developed (and trademarked) by the Master Plumbers and Mechanical Services Association of Australia. Yet apart from Victoria, where the organisation is based, penetration into the plumbing profession is low. For example, of 16667 plumbers listed in a Yellow Pages search, only 40 were distinguished as 'Green Plumbers'. It has been observed by others (cf Saunders, 2001) that current apprenticeship training for the construction industry is based on outmoded curricula. I encountered no information on WSUD in the twelve months of a (four year) plumbing apprenticeship I completed prior to commencing my PhD.

Community Demonstration Project

From the beginning I planned to open my home as a community demonstration project, allowing site inspections from interested individuals and groups, so that they could see the whole WSUD system in operation for themselves, and provide for them the opportunity to ask questions where the answers were disinterested from commercial gain. To be honest, the frequency of complications and excessive delays involved in realising outcomes from my communications with public and private sector organisations nearly scuttled this intention. One of the most significant roles of the owner builder is to 'get others to do *their* jobs', although I only had difficulties with the plumbing. The determination to persevere in the face of what Douglas Adams in his Hitchhikers Guide to the Galaxy series calls SEP fields (Someone Else's Problem) was essential to completing the project. I felt conscientiously reluctant to expose anyone to similar frustrations.
However, as the final pieces of the puzzle have fallen into place, I am more prepared to share my experiences, so that others may profit from them. By the time this paper is presented I expect that mywaterwisehome.com will resemble more closely this original intention to share knowledge among my community.

Acknowledgments

This project was more ambitious in its scope than the vast majority of domestic rainwater harvesting installations. Due to the relatively complex nature of the project, 'off-the-shelf' solutions were not readily available. One difficulty I felt throughout the process was of obtaining a higher order standard of product without blowing my bank account. The total cost incurred in the installation of this WSUD exceeds A$15,000, though it represents a retail value closer to A$25,000. I am genuinely thankful to each supplier I collaborated with for their generosity in accommodating my wide eyed interest with a student budget. I would particularly like to acknowledge the advice and assistance I received from Lyle Kajewski at Ipswich City Council, Rod Ennor, Managing Director of irrigationwarehouse.com.au, Mal Close, Director of SunCoast Waste Water Management, Gary Cooper of Reliance Worldwide, Tim Walsh, Director of Endless Solar and Paul Crane, Manager of Tradelink Plumbing Supplies at Ipswich.

Conclusions

I would like to emphasise here that my selection of particular components should in no way be taken as a solution to a 'one right answer' problem. The needs and preferences of households will vary from installation to installation and from individual to individual.

I appreciate that the complexity of the WSUD used here may be a disincentive to other households. I am a PhD student studying household motivation for the adoption of RH systems. In the course of my research I have been exposed to ideas and technologies I may not otherwise have used. It remains my intention that my learning from this project and my PhD activity mutually inform each other.

While I have discovered shortcomings in the efficacy of RH installations elsewhere (insufficient tank capacity, failure to exploit the full catchment area available and so on), the simple unadorned use of a rainwater tank for garden watering, if that is what actually motivates household adoption, should not be considered inferior by technophilic purists.

Do try this at home! If you are considering a 'waterwise' project of this ilk, I am very happy to respond to email requests for more information (through mywaterwisehome.com), or if I can't help you personally, to seek an answer for you.

Finally, I note that moving away from the 8% penetration of household RH adoption in south east Queensland (ABS 4602.0, 2005), John Black in the Financial Review (5 August 2006) argues that if the Queensland Government invested $3500 in a RH system for each of the one million homes of south east Queensland, they would reduce demand on dams by 150,000 megalitres at an equivalent cost of 42 litres per dollar to the 91,000 megalitres forecast from the two new proposed dams.

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