K.I.S.S. MY GREYWATER: THE COST OF OVER-REGULATION

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ABSTRACT

This paper examines the interface between greywater recycling technologies and regulation and argues that, whilst regulation may be important, the type of technologies required to comply with current Australian regulations are complex and expensive compared to those which would meet less stringent regulations. As such they will only appeal to a niche market and their potential for societal benefit will not be realised. The case is made for simple regulations that enable simple technologies – but only for a controlled range of uses. The potential risks of recycling greywater are compared with the risks (or absence of benefits) of not doing so. The conclusion is that current regulations are likely to lead to worse environmental and human health outcomes as they make greywater an uneconomic resource; indeed a waste product.

Keywords: appropriate technology, cost-benefit analysis, greywater recycling, regulations, risk, water savings

1 INTRODUCTION

There is a plethora of guidelines, standards and opinions as to the risks, benefits and costs of recycling greywater. It is hard to determine any consensus across or even within professional disciplines. Different regulatory authorities and jurisdictions have understandably therefore adopted quite different rules. Indeed, opinions and thus rules change frequently even within each jurisdiction. As diametrically opposed views are aired, regulations changed and risks vs benefits openly discussed, it is likely that potential purchasers and users of greywater recycling systems will not only be confused, but discouraged. How is a consumer meant to make a decision when the experts are so divided?

Of course, if greywater recycling is not beneficial then this becomes irrelevant – there is no risk involved in legislating it out of business. But if the potential benefits are significant then it makes sense to try to achieve them. It is more typical to think of the risks involved *with* recycling greywater (which of course do exist and must be considered seriously) than the risks of *not* doing so, but to consider *only* this makes for suboptimal decision making.

Heavy-handed regulation could make greywater an uneconomic resource for the foreseeable future, whereas appropriate regulation could make greywater affordable today. This paper investigates the cost of greywater recycling with current technology, 1) under current regulations, and 2) what would be possible under a different regulatory framework.

1.1 The Need for Greywater Recycling

Around the world, the issue of climate change has caught the public imagination. Reducing energy use has become an ambition for many people, organisations and governments. In many countries (except those with current or ongoing shortages) the issues associated with water and wastewater are less articulated. However, water issues are arguably just as serious as energy, or more so. In a world with a growing population and an increasing standard of living, finite resources are being heavily exploited. In many cases those resources can be unreliable and are becoming more so, due to climate change making weather patterns more extreme. There is also a greater pressure on those resources due to pollution from human and industrial waste. As a result, water is becoming more expensive and subject to availability, quality or use restrictions, even as demands increase. The majority of Australia's population is potentially at risk from drought (Climate Action Network Australia, nd).

Whilst agriculture accounts for the most significant use of water, both in Australia and worldwide, urban use is still significant and carries the additional burden of wastewater disposal. Greywater recycling can cut potable water use by some 50% when used for toilet flushing and garden irrigation (note: 50% is a conservative figure and the real value will vary depending on the household). Even if more efficient appliances are installed (such as a new washing machine and dual-flush toilet), the balance remains similar (the saving is roughly 50% of a smaller amount) and is still considerable. Water that is recycled is also removed from the wastewater stream, significantly lessening the burden on both municipal (reticulated) systems and on-site wastewater systems and improving the performance (Sorensen 2003) and lifespan (Gunn 2003) of the latter. Unlike rainwater tanks, the sources of greywater are available throughout the year and wastewater flows are reduced.

Where water is scarce, or urban areas grow, it is possible to collect the water from further away, treat poorer sources (including wastewater) more intensely, and even to extract potable water from the ocean. All of these sources share two things in common: high costs and the fact that more energy is required to generate these supplies than has been the case for existing supplies. Energy, as noted, should also be considered a finite resource these days. The World Health Organisation believes climate change is responsible for 150,000 deaths annually and around 5 million ‘disability adjusted life years’ (Patz *et al.* 2005). The community cannot afford to add to this problem in its search for solutions to water supply issues.

Greywater recycling could be used instead of (or at least defer the need for) energy intensive infrastructure developments; if it was safe and cost effective. This paper address these issues and shows that over-zealous regulation can lead to a reduction in cost effectiveness. Whilst there are problems with being unregulated, or having non-specific regulations as is the case in New Zealand (Brown 2007), a bigger problem is with over-regulation to the point that it is not worthwhile recycling greywater as the costs outweigh the benefits.

2 REGULATIONS

2.1 Risks of Setting the Regulatory Bar Too High

The UN Economic and Social Council stated in 1958 that “no higher quality of water, unless there is a surplus of it, should be used for a purpose that can tolerate a lower grade”. Since then, vast quantities of water have nonetheless been treated to potable quality standards for uses such as irrigation and toilet flushing. This is becoming increasingly unsustainable as water is in greater demand due to an increasing population and standards for receiving environments are being revised upwards. Most new sources of water have significant environmental disbenefits, with the destruction of habitats and/or high levels of energy use. New water sources bring with them increased wastewater volume which also needs to be dealt with.

Simply put, if the bar is too high then significant greywater recycling will not happen (due to the high cost) except where there is a specific local need that can be met, such as an expensive garden that cannot be irrigated with potable water (Brennan & Patterson 2004), or an on-site wastewater system that needs relief from excessive hydraulic load (Sorensen 2003). The large-scale environmental and societal benefits will not be realised.

2.2 Risks of Setting the Regulatory Bar Too Low

The risks of under-regulating (and under-enforcing) include the threat of waterborne disease (Ottosson 2003) and localised environmental damage due to chemicals in the water damaging soils and plants (Lanfax Labs n.d.) and even waterways, if the greywater was able to run off. Potentially the result of disease could be death or disability, so public health is usually considered to be the main driver for legislation. Ingesting greywater could be a serious health risk, due to the chemical as well as microbiological contaminants.

There is also a risk of cross-connection if not addressed by regulation and enforcement, whereby potable water supplies are contaminated with greywater. With all of these considerations, the risks increase as more people are connected to the system, whether as a source of greywater or a recipient of the recycled water. Thus regulation that is appropriate for a local system would not necessarily be appropriate for a widely distributed system.

2.3 Recommendations: Setting the Bar Just Right

Note: these recommendations are not intended to be valid in all situations (or indeed the *only* valid option) however they are likely to lead to economical, low-risk systems. These recommendations apply to **single occupancy dwellings** only. Multiple tenancy buildings have increased risk and may require more stringent regulations. Depending on the intended use of the recycled greywater, different levels of treatment will be required. At one extreme, if the water were intended for potable use, it must meet the potable water standards. There is debate as to what the other extreme (lowest risk use) might be. From a public health perspective it could be subsurface garden irrigation, whilst from an environmental health perspective it could be toilet flushing. These are both significant and useful ways to use the greywater, so it is recommended that **irrigation** (as defined below) and **toilet flushing** be permitted.

2.3.1 Water Sources

The source of the greywater can influence the level of treatment required. Ottosson (2004) shows that greywater presents 99.9% less risk from disease transmission than wastewater, even when greywater is defined as including kitchen sources and bathroom sinks. Kitchen and bathroom sink water are more likely to contain pathogens, so excluding these can reduce the risk further. Dishwasher waste has a higher chemical and organic content. It is recommended that greywater be sourced only from the washing machine, bath and shower – representing about 70% of all household wastewater.

2.3.2 Irrigation

For best practice it is recommended that subsurface irrigation with greywater be allowed (with subsurface being defined as under a layer of bark, soil or plants). If the distribution pipes are hidden from view and it is not apparent that the system has been in operation (there are no visible wet patches) then it is likely to be OK. Deeper pipes might be indicated for areas that receive foot traffic, whereas areas that are not traversed might be suitable for surface drip irrigation. It would add to the risk to permit spray irrigation and this reduces irrigation efficiency, so it is not recommended. Ponding and/or run-off should be avoided and greywater well-distributed. Good distribution should make ponding unlikely. The primary concern with greywater irrigation is with excess sodicity causing soil pores to become blocked. However, adequate organic material, or mitigation with gypsum can avoid or reverse problems (Lanfax Labs n.d.).

2.3.3 Toilet flushing

There have been concerns that this could introduce aerosolised pathogens into the house, but the risk is minimal. Firstly, pathogens would only be present if they were already in the house, where there would be many more likely pathways of transmission. For example greywater has five thousandths of one percent of the faecal matter of toilet water (Oasis Design 2005, p19). In fact, by using a system with a residual disinfectant, this method of transmission (from the faeces) can be reduced significantly (Bloomfield & Scott 1997). Therefore it would be *safer* to use chlorinated greywater than freshwater, for example. Even without a residual the risk would be small. Therefore it is recommended that toilet flushing be permitted.

2.3.4 Storage

Many guidelines state that treatment is required if greywater is stored for longer than 24 hours. Although there may be odour issues due to bacteria using up the oxygen and the greywater turning septic, it is likely that this process will reduce pathogen numbers as non-pathogenic bacteria out-compete pathogens and settling of suspended solids may reduce the load on filters, etc. However, there may be an increased problem from biofilms leading to increased maintenance requirements or failure due to clogging of irrigation lines. It is therefore recommended that greywater not be stored untreated for longer than 24 hours.

2.3.5 Treatment process

Guidelines should be written with a desired water quality in mind, rather than prescribing processes. For instance, although it may be tempting to insist on a chlorine residual, this may not be necessary (depending on the full treatment process). Indeed, the cost of accurately measuring the chlorine residual is prohibitive since standard redox probes are unreliable due to the presence of surfactants. Finally, it may not be necessary to have a separate treatment and storage tank, as is stipulated in many guidelines. It is recommended that treatment processes are not prescribed.

2.3.6 Water quality

It is recommended that the standards should be equivalent to the local standards for bathing water (e.g. fewer than a few thousand colony forming units per 100 ml; Jefferson *et al.* 1999). If it is acceptable from a microbiological perspective to swim in it, then it should be acceptable to use for irrigation and toilet flushing, especially considering the restricted populations involved in domestic greywater recycling and consequent low level of risk. There appears to be no justification for simply applying the 20:30 (BOD:SS) rule for discharge of wastewater. Where the water is recycled for toilet flushing it is irrelevant as the water continues on to further treatment, but even where the water is discharged to land it should not be used – unless the discharge could enter untreated into surface waters (for which situation the 20:30 rule was designed). Unlike for on-site wastewater treatment, the rule does not provide a reasonable approximation of the effectiveness of the treatment (McIllwaine, 2003). A biodegradable organic load in the recycled water (which is measured by the BOD and suspended solids tests) will not be harmful to the soil. Therefore it is recommended that no BOD or suspended solids standards be applied.

2.3.7 General suggestions

Maintenance should be the responsibility of the homeowner. Pipes should labelled ‘greywater – do not drink’ and possibly coloured differently. Backflow to potable water should be impossible (use dedicated pipes and air gaps if fresh water is also connected). Taps should have childproof keys. Wherever possible costly bureaucratic consent processes should be minimised – publish guidelines for permitted activities and require consents for non-standard or riskier practices. Update them as required. Refer to the Victorian regulatory review document for more guidance on risk and appropriate regulation (Nolan, 2005) (also Oasis Design, 2005 and McIllwaine, 2003).

3 THE COSTS OF GREYWATER RECYCLING

No matter what regulations are chosen, it is technically feasible to treat greywater to any standard. However, there is a point where it is no longer economical to do so. One simple method to determine this is to compare the savings, minus the costs of purchasing, installing and operating the system, with the costs of purchasing water from the water supplier. If the greywater recycling system works out to save more money over a certain period of time than it costs to have it, then it can safely be assumed that it is an economical activity.

In reality, the price of water often does not recover the costs of service provision (PriceWaterhouseCoopers 2000), with the shortfall being recouped by general taxation. Future infrastructure projects will usually have higher costs than those associated with existing water and sewage provisions. If greywater recycling works out to be cheaper over a period of time compared to an estimate of the real *cost* of service provision then – to the extent that the estimate is correct – it can be said to be economical (even if the *prices* currently charged do not reflect the costs). A rational society would invest in it rather than new supply infrastructure, all else being equal.

Greywater systems prices will affect their affordability in a comparison of this nature. One of the reasons for different price points is that is that they are designed to achieve different standards of treatment in response to different regulations. The period of time that a system continues to operate will have an impact on how economical it is. A system that lasts 20 years will be more economical (all else being equal) than a system that lasts 10 years, assuming that it saves more money than it costs to run. Different types of treatment method may lend themselves to more or less durable system designs.

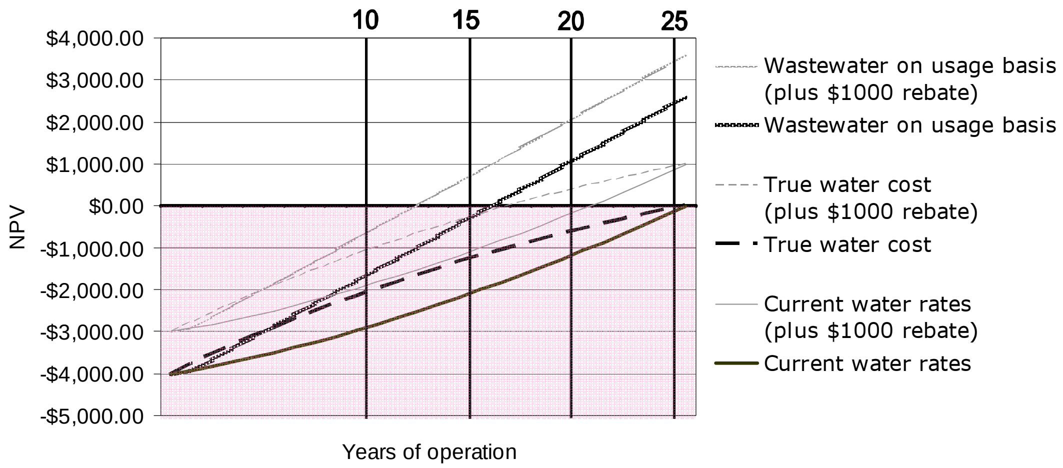
3.1 Method

This study considered the cost implications of: 1) the Class A water standard for Domestic Greywater Treatment Systems – required to recycle the water legally to the toilet in New South Wales (NSW) (NSW Health Department 2005); and 2) the suggested regulations in Section 2.3 of this paper. It did this by calculating the Net Present Value (NPV) of systems that could meet the regulations. The NPV is the value of the system over a number of years, expressed in today’s money. The calculations were based on real-life data for the town of Gosford, NSW (IPART, 2006), usage data from the Australian Bureau of Statistics (2004) and mortgage and interest rate data from the Reserve Bank of Australia (2007). The following variables were manipulated: system life, price of water (and rate of price increase), a usage charge for wastewater and availability of a rebate. Gosford was chosen because it was the closest location to Armidale for which sufficient data could be obtained.

3.2 Results

Figure 1 shows the NPV values for a system that could meet the regulations in Section 2.3, plotted against system life. Figure 2 shows the values for the least expensive current system that could meet the Class A (NSW) water standards for recycling back to the toilet. The *x*-axis is the value of the system to the homeowner whilst the *y*-axis is the number of years that the system operates. The longer the system operates, the better the value to the owner (and the higher the NPV). For the portions of the curve under the *y*-axis (shaded pink), the NPV is less than $0, which means that the investment is not worthwhile, provided that all the assumptions are correct. Where the curves continue above the *y*-axis, the investment is worthwhile and the payback time is the point at which it crosses the axis (where the NPV is zero). Since an estimated mortgage rate was used for the discount rate, one could say that – all else being equal – a homeowner would be advised to install a greywater system rather than pay back an equivalent sum on their mortgage (or would be advised to borrow more to fund the purchase).

FIGURE 1. Various NPV curves for a greywater system that meets Section 2.3 regulations



The *current water rates* curve (which assumes the current rate of price increases) never crosses the *y*-axis, which means that if the homeowner owned the system for 25 years, they would not get a return on their investment (although they would only be out of pocket by $27). This may be an unrealistically long time to expect the system to last (although the calculations assume a maintenance contribution of $100 each year). If the system only lasted 15 years they would be about $2000 out of pocket (expressed in today’s value). The *current water rates plus $1000 rebate* curve, indicated with the dotted line, shows that the payback period is decreased by about 5 years – so the system would only need to operate for a little over 20 years to be worthwhile.

When one assumes a *true water cost* of $2.50/kL from the present day – but with future increases linked to the predicted rate of inflation only – then the curve starts off more steeply, so the payback time is shorter. However, after 25 years the NPV is the same as for the *current water rates*. When the *$1000 rebate* is included, the payback time is about 16.5 years.

Currently wastewater is charged as a fixed annual fee. The final NPV curves on the graph were calculated as though the wastewater was charged on a *usage basis*. Thus half of the annual fee – which was increased each year by the rate of inflation – was assumed to be saved. This is because the water saving was 50% and variable wastewater charges are usually pegged to water use as more water used equals more wastewater produced. When these savings were included in the computations, the payback time was around 15.5 years (and less than 12 years with the *$1000 rebate*).

FIGURE 2. NPV curves for a greywater system that meets Class A (NSW) standards

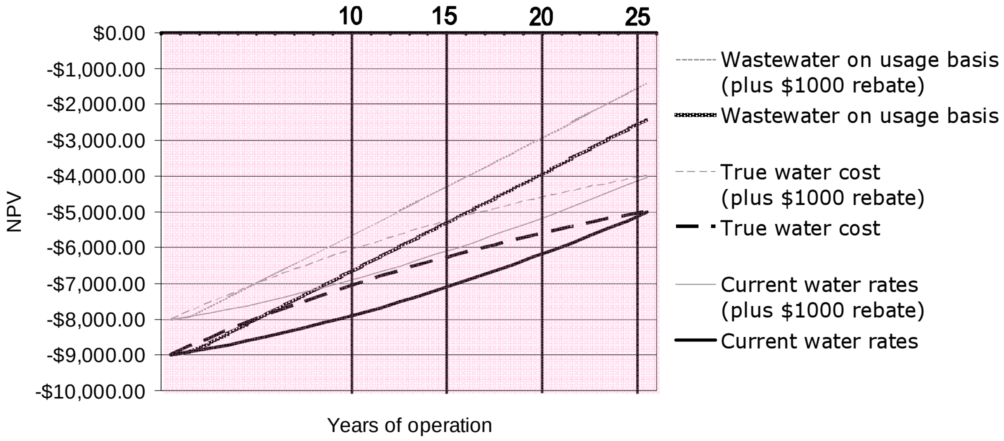
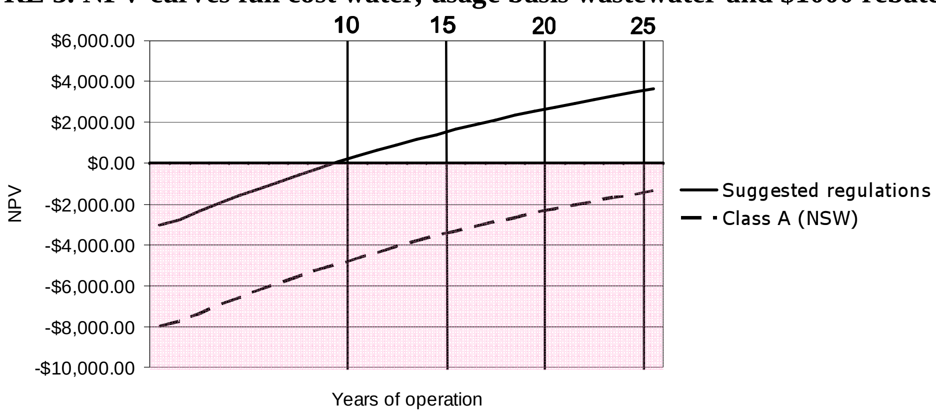


Figure 2 shows that under no circumstances does the Class A (NSW) greywater system have a payback period under 25 years. Indeed, with wastewater charged on a *usage basis* plus $1000 rebate, the owner would still be out of pocket by about $1400 (even if the system was operated for 25 years).

Overall, it can be seen that the fastest payback would arise from: 1) charging on a usage basis for wastewater; 2) charging the full cost of water; and 3) offering a $1000 rebate. Figure 3 shows the NPV curves for these conditions for both systems on the same graph. Even under these conditions the *Class A (NSW)* systems are not economical. However, the system that can meet the *suggested regulations* has a payback time of less than 10 years. Should the system be operated for 15 years it would be worth approximately $1650 in today's money or $2750 over 20 years.

FIGURE 3. NPV curves full cost water, usage basis wastewater and $1000 rebate



It can be seen that in order to make the *Class A (NSW)* system economical to homeowners over a 10 year period, a rebate of $5,670 would be required under the best conditions (15 years: $4,450). Under the current conditions, the rebates would have to be $7,830 for 10 years (15 years: $7,010).

4 DISCUSSION

The cheapest current technology capable of producing Class A water that is acceptable for recycling via the toilets in NSW is not economical under any of the conditions. It would require a significant rebate to make it more attractive to homeowners if savings on water bills were the only driver. Of course, environmental and water security concerns – or benefits to an existing on-site wastewater system – may override this. The system which could meet the suggested regulations (Section 2.3) is an economical investment under certain conditions. With charges set as they are currently and with the current rebate it would be marginal, however charging water at the 'true cost' (PriceWaterhouseCoopers 2000) – with inflationary increases only from that point – would lead to the investment being economical. Although an immediate move to 'true cost' pricing is unlikely, the comparison with the 'true cost' can be used to show that greywater recycling is – under the right regulatory system – more economical than alternative infrastructure investments. (Even though it does not take account of the cost of wastewater services provision, which may have to increase if water supplies were simply augmented, to cope with the additional flows).

When the cost of wastewater services is apportioned according to water usage, rather than as a fixed charge, it becomes clear that greywater recycling can indeed be an attractive investment. It is quite conceivable that wastewater charges could move to a usage basis; indeed it seems anomalous to charge for water on a usage basis but to charge a flat fee for wastewater. This would have the benefit of encouraging water conservation measures, including greywater recycling. The effect of accounting for the savings that could be made on wastewater charges to the overall economy of a greywater system is significant, with it clearly becoming financially attractive to homeowners, even if no rebate was offered. However, a rebate has other benefits, such as signaling official support for greywater recycling and lowering the up-front capital costs for homeowners that may not be able to borrow further against their mortgage.

If government, or water utilities, want to promote greywater recycling, one option is to offer a full loan for the purchase of a system, paid back through the water bill. As can be seen, the return would exceed the costs of paying back the loan (under the suggested regulations) enabling greywater systems to be installed at no cost to the homeowner and indeed to save them money on every bill. The loan would be fully repaid at a commercial rate of interest. In summary, the results show that if wastewater was charged on a usage basis, the system which could meet the suggested regulations (Section 2.3) would be worthwhile installing in Gosford. The Class A (NSW) system would not be.

5 CONCLUSION

The high costs of greywater recycling could be reduced today if alternative regulations were adopted. The present author believes that the current high standards are not justified for the uses for which the product is designed, namely toilet flushing and subsurface irrigation in an individual household. The higher standard adds no functionality and does not increase water savings, but does add to the initial and (probably) ongoing costs and embodied energy of the system. It does not significantly decrease the risk as the risk is very small to begin with. Indeed, it may even lead to poorer environmental and public health because the benefits of greywater recycling may not be realized, whereas the negative effects of traditional water and wastewater service provision may; remembering that future provision will likely be more expensive and more environmentally damaging than previously.

Therefore, it is recommended that the regulations suggested in Section 2.3 of this paper be adopted and that wastewater should be charged on a usage basis.

References

Australian Bureau of Statistics 2004,Water Use – Australian economy consumes 50 Sydney harbours. Retrieved on 8 August 2007 from: http://www.abs.gov.au/ausstats/abs@.nsf/e5cb0b45f4547cc4ca25697500217f47/cc9d340e1feef80bca256e9900810f09!OpenDocument

Bloomfield, SF & Scott, E 1997, Cross-contamination and infection in the domestic environment and the role of chemical disinfectants. *Journal of Applied Microbiology 83* (1), 1–9.

Brennan, MJ and Patterson, RA 2004, Economic Analysis of Greywater Recycling. In *Proceedings of 1st International Conference on Onsite Wastewater Treatment and Recycling*. Murdoch University, Perth 11-13 February 2004. Retrieved 10 July 2007, from http://lanfaxlabs.com.au/papers/P57-Brennan&Patterson%20Perth04.PDF

Brown, C 2007, Greywater Recycling: Risks, benefits, costs and policy. Paper submitted for presentation at 49th Annual New Zealand Waters and Wastes Association conference in Rotorua, New Zealand, 19-21 September.

Climate Action Network Australia nd, Changes in Rainfall and Water Systems. Retrieved 10 August 2007 from: http://www.cana.net.au/water/cities/index.html

Gunn, I 2003, Review: ECO Waste Water Recycling System – Household water saving and wastewater reduction potential.

IPART 2006, NSW Water Fact Sheet 1: Prices for Water Supply, Wastewater and Stormwater Services for Gosford City Council and Wyong Shire Council. Retrieved 1 July 2007 from: http://www.ipart.nsw.gov.au/water/documents/Waterfactsheet2.pdf

Jefferson, B, Laine, A, Parsons, S, Stephenson, T & Judd, S 1999, Technologies for Domestic Wastewater Recycling. Urban Water 1, 285-292.

Lanfax Labs n.d., Laundry Products Research: Reuse of greywater on gardens. Retrieved on 6 August 2007 from the Lanfax Labs website: http://www.lanfaxlabs.com.au/gardens.htm

McIllwane, S 2003, Graywater Reuse in Jordan. Center for the Study of the Built Environment. Retrieved on 25 August 2007 from the CSBE website: http://www.csbe.org/graywater/report2/legislating_for_graywater.htm

NSW Health Department 2005, Domestic Greywater Treatment Systems Accreditation Guidelines. Retrieved 10 August 2007 from: http://www.health.nsw.gov.au/public-health/ehb/general/wastewater/greywater.pdf

Nolan, J 2005, Alternative Urban Water Supplies – Regulatory Review: Technical Summary Report. Hyder Consulting Pty Ltd. Retrieved on 1 August 2007 from: http://epanote2.epa.vic.gov.au/EPA/Publications.nsf/2f1c2625731746aa4a256ce90001cbb5/3e94ad194175b06dca257114001f8e1a/$FILE/ATTWEVL2/Summary%20Technical%20Report.pdf

Oasis Design 2005, Greywater Policy Packet. Retrieved on 5 August 2007 from: http://www.oasisdesign.net/downloads/GWPolicyPacket.pdf

Ottosson, J 2003, Hygene Aspects of Greywater and Greywater Reuse. Licenciate thesis. Stockholm: Royal Institute of Technology, Department of Land and Water Resources Engineering.

Ottosson, J 2004, Comparative Analysis of Pathogen Occurrence in Wastewater – Management strategies for barrier function and microbial control. PhD thesis: Dept. Land and Water Resources Engineering, KTH, Stockholm.

Patz, JA, Campbell-Lendrum, D, Holloway, T & Foley, JA 2005, Impact of Regional Climate Change on Human Health. *Nature*. 438, 7066, 310-317.

PriceWaterhouseCoopers 2000, Economic Aspects of Water Recycling in Queensland. Retrieved on 5 August 2007, from: http://www.epa.qld.gov.au/publications/p00416aa.pdf/Economic_aspects_of_water_recycling_in_Queensland_/_prepared_on_behalf_of_Queensland_Water_Recycling_Strategy_by_PriceWaterhouseCoopers.pdf

Reserve Bank of Australia 2007, Website: http://www.rba.govt.au/

Sorensen, DJ 2003, Reducing the Wastewater – Managing the Problem. Presented to On-site '03: Future Directions for On-site Systems: Best Management Practice. Armidale, New South Wales.