

Sustainable Water Cycle Design For Urban Areas

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ABSTRACT

This paper will present the argument that the environmental, social and economic benefits of decentralised systems are such that it should present a serious alternative to centralised systems in existing and future planned urban developments. It will be shown that the combination of technical, social and regulatory factors that influenced the popularity of centralised systems has altered, and that decentralised systems should now be considered as well.

The environmental, social and economic advantages and disadvantages of several sustainable watercycle case studies will be looked at, and compared to centralised systems. The studies examined will go from large scale down to designs suitable for typical residential houses on standard urban blocks.

KEYWORDS

Sustainable watercycle benefits

INTRODUCTION

The environmental and financial impact of water and sewerage infrastructure on the cost of development and the environmental impact of developments, are beginning to be questioned at all levels of government and the wider community. This paper will look at how the costs and environmental impact of water and sewerage can be reduced by looking at the water cycle of a house from the perspective of Ecologically Sustainable Development.

The techniques and approaches discussed in this paper, while focused on a detached residential dwelling, are readily applicable to duplexes, townhouse, subdivisions, suburbs through to cities. The importance is not so much in making significant water savings in a house, but rather, in making cost savings on the design of larger residential estates, subdivisions and so on.

There is a very simple reason that we have such large savings with decentralised systems. With centralised water and sewerage, most of the resources to collect, treat and deliver the water or wastewater come from fossil fuels. Around 80 to 90% of the cost of centralised sewerage is for transportation, with only 10 to 20% being for the actual treatment (Goodland and Rockefeller 1996). With decentralised, that is on-site, water and sewerage, there are minimal transportation costs and the main power for treatment comes from natural sources, such as the sun. Rainwater tanks fill without any pumping, and on-site sewerage systems can be designed to treat the sewage with few or even no moving parts. As well, there is no need to pump the water or wastewater many kilometres.

Let us consider a small example – a household raintank. It is quite straightforward to show that even small rainwater tanks can reduce mains water use by 50%, and reduce annual maximum daily peak water demand from a reticulated system by 24%. They are also cost effective. Please note that the studies resulting in these savings were only using the raintanks for hot water, toilet and outdoor use. They can also be used to reduce the size of on-site detention for stormwater. Consider the implications for entire developments when such savings can be made so simply.

Centralised or decentralised

We shall now examine centralised and decentralised, or on-site, systems a bit further.

Large cities in the 19th century were places with inadequate sanitation, namely open sewers, leading to significant health implications. At the end of the 19th century there was rigorous debate among many western nations, including Australia, as to the best method for dealing with human waste. It was hard fought and the arguments between water-carriage systems and what was called 'dry conservancy' systems were diverse and ranged from the dangers of 'miasmas', which was basically smell, to the dangers of sewer gas explosions. This was further compounded by a lack of knowledge on the subject of sanitation and meant that there were no criteria to base comparisons on. In the end, water-borne sewerage systems were chosen as they were regarded by most as modern and progressive, and not because of any great technological superiority (Beder 1990).

The result of this decision is that most people regard sewerage systems as the only safe option for the treatment of human waste, when in fact they "are the product of history, a history that started ... when little was known about the fundamental physics and chemistry of the subject and when practically no applicable microbiology had been discovered... These practices are not especially clever, nor logical, nor completely effective - - and it is not necessarily what would be done today" (Feachem et al 1983). In fact, after risk and uncertainty are considered, the advantages of centralised sewerage are frequently outweighed by the disadvantages (Laak 1986).

So, simply stated, the preference for centralised sewerage systems is a historical artefact. As well, properly designed decentralised systems provide at least as good as, and in many instances better, treatment. To explain, centralised sewage treatment plants in NSW must have a NSW EPA licence to discharge to a watercourse. This licence allows them to pollute the watercourse, albeit occasionally. Properly designed on-site systems never pollute.

With regard to rainwater used for drinking water, "The prime motivation for a centralised water supply was drought security and the need for a readily available source of water for fire fighting. Public health concerns resulted primarily from inadequate sewerage disposal systems and, to a lesser extent, poor construction of underground rainwater storages." (Coombes et al 2001). However, the main reason often given is health concerns, although there are no published studies or data to show there is any risk. Indeed, "about 3 million Australians currently use rainwater from tanks for drinking with no reported epidemics or adverse health effects." (Coombes et al 2001).

So, the arguments for a centralised water and sewerage system as the only real option, are in fact based on minimal scientific evidence. Decentralised alternatives are not only viable, but are also cheaper and more sustainable. For instance, a recent New Zealand Cost-Benefit Analysis for on-site systems in urban areas (Waitakere City Council 1999)

found that the 50-year net present cost for on-site water and wastewater solutions was \$7,498 and \$42,056 for conventional off-site reticulation.

Water cycle

Let us now look at some of the savings that can be made in a typical residential house by looking at how water is usually used. At present, any rainfall on the roof or the property is piped away from the house. At the same time, other water is piped to the house from far away for uses such as drinking, showering, cooking, cleaning and toilet flushing. The wastewater that is produced is then also sent far away through pipes. What are some alternatives?

Water collection

The first obvious alternative is to keep that water which falls on the roof for use inside the house. This is achieved by having a raintank, of an appropriate size for what you want, that will collect rainwater. This is such a simple step and yet it is one that we have already seen can have large savings in water use and cost. A raintank can be sized for laundry use, toilet flushing and even drinking water. In fact, with the right sized rainwater tank there is no need for a piped water supply at all, and many Health Authorities don't seem to have any problem with this. However, even if the step of providing drinking water is not taken up, the savings are still substantial.

As an example of the attention currently being given to rainwater tanks, a rainwater forum was hosted by Sydney Water in September 2001. The outcomes of the forum are being used in the review of Sydney Water's 20-year plan for water, wastewater and stormwater management in the Sydney region, WaterPlan 21 (Sydney Water 2001).

Stormwater collection and treatment options are also increasingly being reconsidered in light of ESD, and there is a significant movement towards Water Sensitive Urban Design (WSUD) as the best way to deal with stormwater issues. The key principle of WSUD is that stormwater should be managed as a resource rather than as a problem. As with water and sewerage systems, the traditional approach to stormwater involves pipes and drains and very little else, certainly little in the way of treatment. The importance of WSUD to the sustainable house is that WSUD explicitly considers rainwater tanks to be a significant way to reduce stormwater flows at the source. There are studies that show rainwater tanks can have storage volumes available for stormwater retention "prior to 92% to 99% of annual maximum storm events: (Coombes et al 2001). The impact of such retention on the need for stormwater drainage is significant as they "reduce the volumes of stormwater discharged to catchments" (Coombes et al 2001), and reduce the scale of on-site detention systems and stormwater drainage required, and hence cost.

Water demand

Let us now look inside the house and consider where savings can be made. The first step here is obviously to use water-efficient devices. A flush toilet in a house can use up to 50,000 litres a year. Using a 6 litre/3 litre dual flush toilet can reduce that by 67%. Shower heads also can use up to 50,000 litres a year, and AAA-rated shower heads can save up to 25,000 litres a year for an average household (White 1998). For a development of 25 houses, there could be water savings of 1,100,000 litres a year.

To give an understanding of the size of benefits that can result from effective demand management, a study (White 1998) examined the benefits of reduced water demand for several towns. As an example, it found that for one town with a population of 10,000, water

savings could allow augmentation works to be deferred for 9 years. This would give present worth savings of the order of \$4,200,000.

Another type of water-reduction device is a waterless composting toilet. In its modern form, the waterless composting toilet originated in Scandinavia. Along with no water being needed, there are no smells produced, maintenance is minimal and the end-product useful. Waterless composting toilets must meet strict performance guidelines prior to gaining approval from Health Authorities. Once a waterless compost toilet has approval, then they can be installed in any domestic, or other, situation. Another example is the Hybrid Toilet System, a non flushing drop toilet which feeds directly into an improved septic tank.

Water reuse

We now come to another interesting area, reuse of water. The simplest form of reuse is to collect laundry water for reuse in the garden. A typical top-loading washing machine uses 150 litres a wash, and if this is used on average 2 times a week, then there are 300 litres a week kept out of the sewer, or 15,600 litres a year.

Another form of reuse is to collect the greywater from the house, which is basically all the water used in the house except that from the toilet, and use in the garden. One could also collect the greywater and treat it to the approved standard and then reuse it for flushing toilets and even laundry washing.

These, and other, reuse options are permissible in sewered areas in NSW and Victoria provided certain approval guidelines are followed.

So, in summation, it should be possible to have a house in a sewered area where:

- water supply is either augmented by a raintank or solely based on a raintank;
- water-saving devices are used throughout the house;

Further, if permissible in that State:

- greywater produced by the house is treated and reused in the garden, or reused further in the house.

Approval

Traditionally, decentralised systems have been used in non-sewered areas, and now increasingly in sewered areas. As an example, Environmental Management is aware the Australian states of NSW and Victoria allow greywater reuse provided certain approval guidelines are followed, and Queensland authorities are currently investigating the feasibility of such an approach. However other states, as well as New Zealand, are believed not to permit this type of reuse in sewered areas. The rationale often given is that when a centralised service has been provided that it is superior to decentralised, however this paper has clearly shown this not to be the case.

It is worth noting that changes in regulations and approval are often driven by demand. The fact that the two largest States in Australia have implemented policies allowing controlled greywater reuse in sewered areas, and that Queensland is seriously considering the option, can therefore be seen as indicative of a rising community and industry demand for sustainable approaches to urban watercycles.

As an example of this change in approach to the urban watercycle, Sydney Water as part of their Waterplan 21, is committed to shifting water management to a 'total water cycle' approach that promotes ecological sustainability by:

- reducing the demand for water from existing water storages
- reducing treated waste water releases to the ocean and rivers
- managing treated waste water as a resource instead of a waste. (Sydney Water 2001)

These are substantial and significant changes in direction for a water utility.

An example of the change in approach to decentralised systems in sewerred areas, is the NSW Department of Health document titled 'Greywater Reuse in Sewered Single Domestic Premises' (NSW DOH 2000). This document outlines the ways greywater, both treated and untreated, can be reused on a sewerred lot and therefore obtain local council approval.

There is an Australian/New Zealand Standard for decentralised sewerage (AS/NZS1547-2000) as well as a suite of other Standards dealing with on-site sewerage equipment (AS/NZS1546:1, AS/NZS1546:2 and AS/NZS1546:3).

The only approval required for raintanks is generally from local authorities such as councils and shires. It is worth noting that many councils in NSW have declared raintanks to be 'exempt development' provided that requirements on size, height and siting are satisfied (Coombes et al 2001).

Approvals for stormwater systems, depending on the scale, can be with councils, the Minister or an accredited certifier for a construction certificate.

Management

There is another perceived disadvantage of decentralised systems when compared with centralised, that they are harder to ensure that the owners operate and maintain them properly. While this has been a difficulty, it is becoming less so.

As an example of this change, the NSW Department of Local Government has brought in a system of an annual licence inspection, which is quite standard in the USA. The result is that councils are now implementing licence inspections more and more and the standard of maintenance by householders is improving. The powers of council to enforce proper maintenance have also been increased, and it can now ensure there is proper maintenance more readily.

Issues of management therefore, while a concern, can be dealt with. For instance in the US, management programs run by communities are an increasingly popular option. The scope of these management programs "can range from complete public responsibility for (and in some cases, even ownership of) individual systems, to simple regulatory programs or public education initiatives." (NSFC 1996). This is in contrast to centralised systems where skilled operators are always required, while on-site wastewater systems can be designed to be so simple that lay people can look after them most of the time.

There is also the issue of maintenance. Simple faults at a centralised sewerage system can often lead to a breakdown in the treatment process and release poorly treated effluent into the environment. However, if a decentralised systems fails, it is usually gradually, and

the amount of pollution will be small. The risk to people and to the environment will be much less than if there is a failure or overloading of a centralised sewerage system.

Another management approach currently being discussed in Australia is centralised management of decentralised wastewater systems, an approach implemented in the US. This involves individual wastewater systems linked by remote monitoring to a centralised computer system where problems are reported to a service operator for inspection or repair (West 2001).

What can be done

To introduce decentralised systems to a new development, the first task would be to ensure there was enough area for treating the wastewater and applying it to the land. If there is sufficient land available, the cost of on-site sewerage can be quite small. As the area of land becomes less however, the wastewater has to be treated to a better quality, so that sub-surface systems don't clog up. A qualified watercycle designer could help with this.

What if there isn't quite enough land? There can be several strategies to cope with this.

- Treat the sewage to a high standard. Equipment for this can include improved septic tanks, sand or textile filters, reed beds, aerated wastewater treatment systems, ponds, flowforms, mounds and evapotranspiration-assisted trenches and beds.
- Use waterless toilets to remove toilet wastes from the watercycle and therefore make it easier to treat the remaining greywater.
- Recycle some of the wastewater.
- Treat some of the sewage on site and treated the rest in a nearby public space, such as a park, underground, such that there is no smell. This is called a 'Common Effluent Distribution System'.

A qualified watercycle designer can cost out these options, as well as options for water supply and stormwater use, to help the planner decide on the most cost-effective size for a block of land.

Examples

Decentralised systems have been used, successfully, for many years in unsewered areas in Australia. What perhaps few people know is there have been individual decentralised systems in sewerred areas since 1995, starting with the approval in Victoria of an on-site system at Hepburn Springs in Victoria.

There are also examples in Sydney of installations with rainwater tanks, composting toilets and greywater reuse systems, including reuse in a laundry. These range from domestic situations to community groups.

Other examples show the scale at which decentralised options are possible, and how the move towards decentralised systems is worldwide and applicable to any situation.

For example, a three-storey office building in Vancouver Canada serves up to 300 people. Through a combination of rainwater collection, composting toilets and greywater treatment

in a planter bed for irrigation, they have reduced their water use to 500 litres a day, when a comparable conventional building would have used up to 7,000 litres. (Del Porto 1999)

There is also the town of Tanum in Sweden (population 12,000) where, to combat beach pollution and damage to fisheries, all new homes would receive ready permission only for composting toilet, and existing flush toilets should be replaced. The end result was that only two to three out of the 40 to 50 new houses built each year have flush toilets.

Or, the town of Paradise California, population 28,000, which rejected a proposal for centralised sewage for a commercial area in favour of establishing an Onsite Wastewater Management Zone which has a full-service monitoring program that issues permits, evaluates systems and so on (NSFC 1996).

CONCLUSION

Decentralised systems for water, wastewater and stormwater are not only more environmentally friendly than centralised options, they are also cheaper. Approvals for such systems are obtainable, and we believe there is an opportunity to incorporate decentralised systems into their developments, the benefits will be environmental and financial, and can only contribute to the betterment of society as a whole.

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