RIGOROUSLY REDUCING SEWAGE FLOWS - CASE STUDY OF WATER CONSERVATION IN MOUNT VICTORIA

Tony Cartwright, Sydney Water
Stuart White, Institute for Sustainable Futures
Anna Carew, Institute for Sustainable Futures

ABSTRACT

This project aims to assess the degree to which water conservation can reduce the extent of proposed amplifications to the Mount Victoria sewerage system.

Mount Victoria is a village of around 500 homes located in the Blue Mountains about 120 kilometres west of Sydney. Sydney Water has developed the Mount Victoria Program, which will offer customers the opportunity to refit their homes with water efficient appliances.

This paper describes how the program was developed using least-cost planning principles. It also discusses a range of topics associated with the program including strategies to encourage maximum customer participation, the method used to select water efficient devices and how actual flow reductions will be quantified.

Information from this study will assist other agencies in developing a total water management approach in the design of their water and sewerage facilities. In particular it will provide real data on the reduction in flows that can be achieved from water conservation.

KEYWORDS

Water conservation, least-cost planning, water efficient fittings and appliances, customer participation, water management, environment.

1 INTRODUCTION

Mount Victoria is a village in the Blue Mountains situated 120 kilometres west of Sydney. There are approximately 500 homes in the village, most of which are supplied with potable water; however, only about half of them are connected to the sewer. The sewerage system and the village water supply are owned and maintained by Sydney Water.

Sydney Water examined wastewater options for the Upper Blue Mountains in 1998. In late 1998 and early 1999 a draft EIS for the augmentation of the Mount Victoria, Blackheath and Medlow Bath sewerage systems was publicly exhibited. The preferred option included amplification of the sewerage systems to provide hydraulic capacity for expected future growth and to further improve the sewage treatment processes. In 1998 Sydney Water commissioned the Institute for Sustainable Futures (ISF) to undertake a least-cost planning (LCP) study of the preferred option identified in the EIS.

LCP, or integrated resource planning, provides an economic framework that allows a water agency to examine the full range of demand and supply side options to provide its customers with the water-related services that they require, rather than with water itself. LCP recognises that customers do not necessarily want more water, they want the services that water provides, such as sanitation and clean hands, dishes and clothes. Demand management options can be analysed with supply options, including augmenting the water supply system, efficient reuse schemes or augmenting sewerage systems. LCP is used to evaluate costs and benefits from the whole of community point of view, taking into account all water elements. It allows the selection of a

preferred option that is not only the most economical for the community, but also one which can comply with other factors such as licensing conditions and environmental protection requirements.

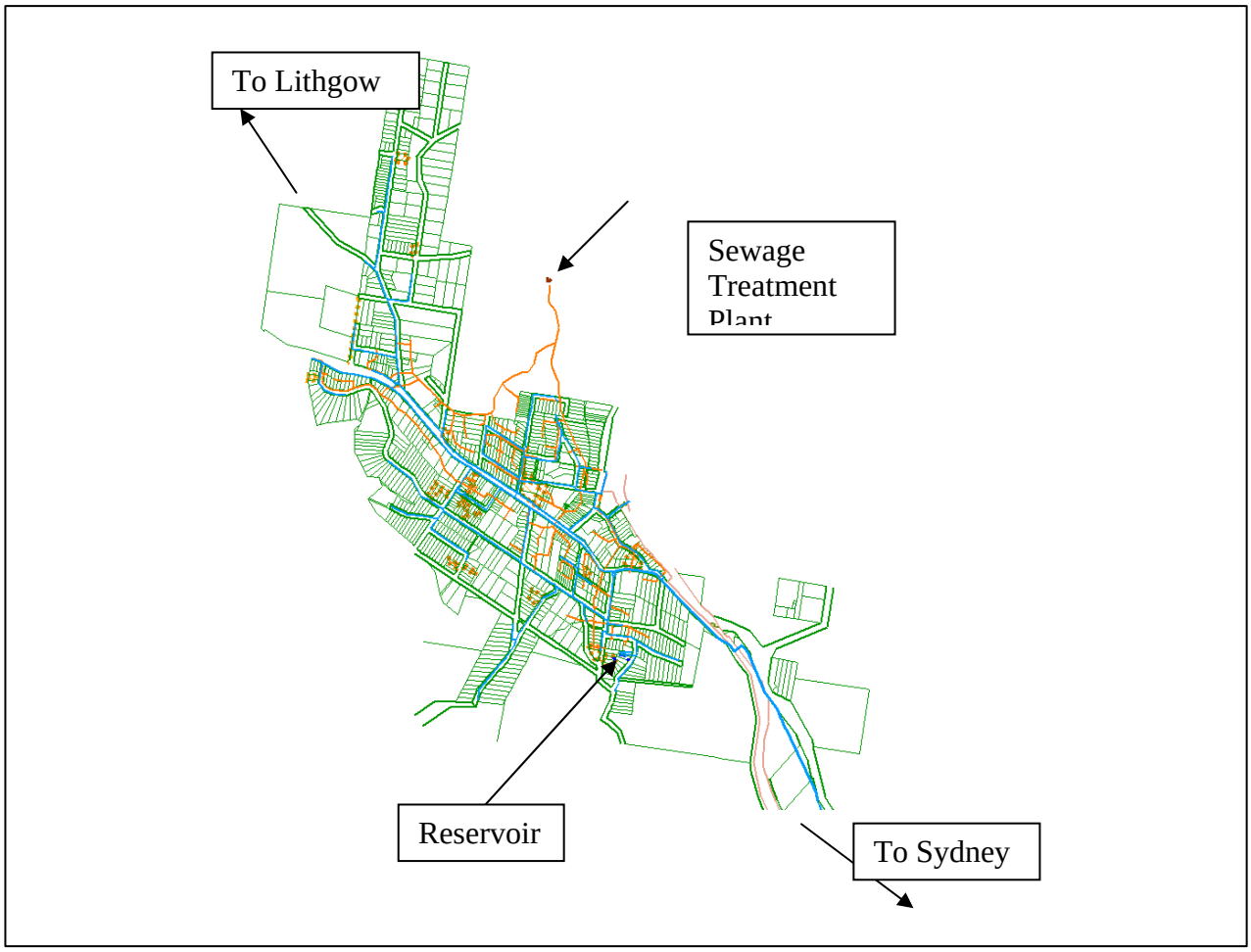
Costs and benefits of a range of demand management options for the sewerage system for the Upper Blue Mountains were examined. The case study indicated that by carrying out a comprehensive demand management program, involving the installation of water efficient fittings in most residential and commercial properties, both the volume and phosphorus load of sewage flows could be cost effectively reduced. The program is also expected to reduce in-house water usage.

Mount Victoria (see Figure 1) was selected to validate the results of the overall study because it is a suitable size and has its own potable water reservoir and sewage treatment plant (STP). The Mount Victoria program is scheduled to begin in September 1999.

Sydney Water anticipates that the results will show a reduction of about 15% for in-house average water demand in the village, a decrease of about 15% in the average dry weather sewage flow to the STP and a drop of between 25% and 50% in the phosphorus load.

There have been similar projects undertaken elsewhere in Australia, for example, the large program in Kalgoorlie-Boulder in Western Australia to reduce water demands. However, Mount Victoria is the first instance in Australia where a major urban water agency has used LCP to develop a program of demand management initiatives specifically to reduce the extent of proposed amplifications to a sewerage system.

Figure 1., Plan of Mount Victoria (Scale 100mm : 3000m approx)



2 DEVELOPMENT OF THE MOUNT VICTORIA PROGRAM

A four-step process was used in developing the program, including:

- Re-evaluation of projected sewage flows and adjusted costs;
- Development of demand management options and costs;
- Analysis of the effect of the demand side management options on sewerage systems; and
- Identification of an optimised mix of demand management measures.

Estimation of sewerage system amplification costs were based on standard design parameters. As water amplification costs were not available, the cost-benefits as a result of reduced water usage were mainly restricted to the sewerage system.

2.1 SEWAGE FLOWS AND COSTS

Water demand and sewage flow projections have conventionally been calculated using standard litres per capita per day (lcd), (e.g. 270 lcd or 210 lcd for sewerage system design), and projected population growth. This approach fails to take into account the impact of change in demand due to a number of water saving appliances or fittings that are making inroads into the residential and non-residential market.

One example is the 6/3 litre dual flush toilet that is now the only model available in the Australian retail market. Calculations have estimated that the natural attrition of inefficient toilets (e.g. 11 litre single flush and 9/4.5 litre dual flush) and their subsequent replacement with efficient models is expected to reduce water consumption for toilet flushing from 38 lcd to 25 lcd by 2026.

The conventional design method, when applied to Mount Victoria, resulted in a capacity requirement of 0.45 ML/d for the STP. The capacity was 're-evaluated' as 0.39 ML/d in 2026 if demand reductions (due to appliance and fitting changeover and any existing or committed demand reduction measures) were taken into account. Reduced STP capacity requirements have been projected to reduce the cost of amplifying the Mount Victoria STP from $3.32m to $3.20m.

2.2 DEVELOPMENT OF DEMAND SIDE MANAGEMENT OPTIONS

A range of ten demand side management options was developed with their associated capital costs. The options encompass a wide range of potentially viable methods, and include low, medium and high cost options. Table 1 provides a description of the options.

Table 1., Demand side management options.

Option No	Option Description
1	Development Control Plan requirements for water efficient showerheads and taps in new dwellings.
2	As for 1 plus refitting water efficient showerheads and taps in backlog properties at point of connection (2008 – 2010).
3	As for 1 plus refitting water efficient showerheads and taps in all dwellings in 1999.
4	As for 2 plus refitting 6L/3L dual flush toilets on backlog properties at point of connection (2008 – 2010).
5	As for 1 plus refitting water efficient showerheads, taps and 6L/3L dual flush toilets in all dwellings, from1999 to 2001.
6	Rebate of $200 at point-of-sale for front loading washing machines if replacing a top loader and community education campaign to reduce the use of phosphate based detergents.
7	Greywater reuse system recycling shower/basin/bath water to toilet and garden.
8	Non-residential audits and refitting showerheads, taps and 6L/3L dual flush toilets and other efficiency measures as required.
9	Dual reticulation in backlog areas.
10	Combination of options 5, 6 and 8.

2.3 ANALYSIS OF DEMAND SIDE MANAGEMENT OPTIONS

An economic analysis using the LCP framework compared costs of developing each option with benefits obtained by the option. Table 2 shows some results of the cost-benefit analysis for the options listed in Table 1.

Table 2., Cost benefit analysis for options.

Option No	Reduction in Blackheath STP capacity in 2026 (ML/d)	Reduction in Mt Victoria STP capacity in 2026 (ML/d)	Average Water savings in 2011 (ML/a)	PV Sydney Water program costs ($m)	PV Sydney Water benefits ($m)	PV customer costs ($m)	NPV (Total Resource Cost)
1	0.06	0.01	16	0.04	0.37	0.00	0.33
2	0.08	0.02	23	0.07	0.40	0.00	0.33
3	0.07	0.02	34	0.27	0.78	0.00	0.51
4	0.09	0.02	29	0.27	0.43	0.00	0.16
5	0.12	0.03	120	1.30	1.25	0.00	-0.05
6	0.08	0.02	24	0.31	0.44	0.00	0.13
7	0.58	0.12	208	9.17	1.46	8.15	-15.86
8	0.09	0.02	46	0.22	0.65	0.00	0.42
9	0.00	0.00	26	0.77	0.02	0.15	-0.90
10	0.28	0.07	189	1.83	2.04	0.00	0.21

The analysis established that quantifiable benefits would outweigh the costs of program implementation for options 1,2,3,4,6,8 and 10, while options 7 (greywater systems) and 9 (dual reticulation) were economically unjustifiable. Financial benefits included in the economic analysis were:

- Avoided capital costs from STP augmentation (e.g. for option 10, the 0.07 ML/d reduction in the capacity of the Mount Victoria STP below the 're-evaluated projection' reduced the cost of the proposed STP from $3.20m to $3.04m);
- Avoided sewage pump out costs for unsewered properties;
- Reduction in customer detergent costs with front loading washing machines;
- Reduction in customer energy bills;
- Avoided pumping costs (sewage pumping station);
- Avoided load based licence charges (post 2000);
- Avoided STP operating costs;
- Avoided water supply pumping and treatment costs; and
- Avoided chemical and operating costs associated with treating phosphorus at the STP.

2.4 PREFERRED DEMAND MANAGEMENT OPTION

It was recommended that Option 10 (see Table 1) was the most appropriate option. The LCP approach had obtained an option that enabled the largest reductions in water demands and sewage flows while providing economic benefits that outweighed the costs. The initiatives recommended in Option 10 will be trialled in Mount Victoria and will be referred to as the Mount Victoria Program.

3 METHODOLOGY FOR IMPLEMENTING THE MOUNT VICTORIA PROGRAM

Before the Mount Victoria Program could be put into practice, there had to be a basis for contracts to undertake various works to institute the program. Consequently three major plans were devised to cover communications; refitting and rebates; and monitoring.

3.1 COMMUNICATIONS PLAN

Sydney Water developed the Communications Plan, which was designed to encourage residents to willingly participate in the program. A brochure introducing the program has been posted to all residents. It will be followed by another brochure containing more details. On a Saturday morning this September there will be a display and sausage sizzle in the village, and local politicians and the media will attend. Then there will be follow-up displays, posters and newsletters.

3.2 REFITTING AND REBATE PLAN

Australian Water Technologies was engaged to develop a Refitting and Rebate Plan for Sydney Water. The plan had to refine Option 10 by providing details of the actual water efficient fittings and appliances to be offered free of charge during the program; and also define the conditions required for an effective program.

It proved a challenge to select which fittings and appliances to offer residents, as it was necessary to consider performance, cost, acceptability, ease of maintenance and availability. Some of the products, fittings and appliances chosen and their conditions of use are described below:

- AAA-rated 6/3 litre dual flush toilet suites. Products were chosen ranging from $200 to $400. A like-for-like policy was established, (i.e. to obtain an all ceramic toilet suite, a household must already have an all ceramic suite). Only one refit per household would be allowed and other toilets would be fitted with a cistern weight device.
- AAA-rated showerheads that deliver 9 L/minute or less. Products were chosen ranging from $10 (for a rose) to $70 (for a hand held shower set). A second refit of a showerhead per household would be allowed.
- Tap flow regulators. These devices were limited to the kitchen (8 litres/minute nominal rating) and bathroom and ensuite (both 6 litres/minute nominal rating). Costs range from about $5 to $15 for each device. These devices are to be of the nominal flow limited type, (ie a pressure increase does not allow flow to increase beyond the nominal flow).
- Phosphorus-free washing powders. The nutrient reduction campaign in Option 10 will involve distributing a selection of different powders. About three packs per household will be offered at a cost of about $10 per household.

The $200 rebate offer for residents purchasing a AAA-rated washing machine is to run for about three months. A 5% to 10% uptake rate on this offer is expected.

It is also intended to undertake refitting in non-residential development, but it will need to be assessed on an individual case-by-case basis.

3.3 MONITORING PLAN

Australian Water Technologies developed a Monitoring Plan to allow Sydney Water to assess the program's success at achieving reduced sewer flows. It is intended to independently correlate changes in water demand with reductions in sewage flows, hence both water demand and sewage flows will be monitored.

The plan includes monitoring of:

- The water supply delivery in the village on a daily basis. A multi-variable regression model of the daily influence of climate on usage will be calibrated for the period before the program is introduced. This will provide a baseline model to measure the program, which will then be projected over the period of implementation. Changes in the base load and climate driven external use will be analysed and from this data the likely impact on demands can be inferred.
- The water consumed in the township from individual water meter readings on a quarterly basis. This will be used to correlate with the daily water readings.
- The influent flows to the STP on a daily basis. A daily regression model of sewer flows relating rainfall inflow and groundwater infiltration will be developed. This model will enable changes in the dry weather sewer flow to be detected.
- The quality of the influent flows to the STP and phosphorus, suspended solids (SS), BOD and COD will be analysed. STP influent quality will be monitored for approximately six weeks before refitting to establish the baseline. The influent quality will also be monitored for six weeks when the washing powder is distributed and for a further six weeks about four to six months later.
- Phosphorus in the influent flows to the STP on an hourly basis for twenty four hours. This will only occur once during each of the baseline, washing powder distribution and final monitoring periods to determine a diurnal profile for phosphorus.

The daily water supply delivery and influent flows to the STP will continue to be monitored for about nine months, including a baseline period of about six weeks before refitting starts.

4 EXPECTED RESULTS AND MONITORING APPROACH

4.1 FLOWS AND DEMANDS

Table 3 presents the refitting program's estimated effect on in-house water usage for an 'average' household in Mount Victoria; information for the original total in-house water usage is derived from Sydney Water data. The estimates for in-house usage for a single house assume that the house originally did not have water efficient fittings and appliances. However, water savings from the purchase of a AAA-rated washing machine are not included (due to the low percentage uptake rate anticipated). As can be seen from Table 3, a single house that uptakes on the offer can expect an approximate 30% reduction in in-house water demand.

Table 3., Estimated total saving in in-house water usage for a single house.

	Original usage (lcd)	After refitting usage (lcd)	Saving (of total usage - %)
Toilet	41	24	10
Kitchen basin	11	7	2.5
Bathroom basin	6	4	1.5
Shower	52	27	14
Washing machine	37	37	-
Leakage	3	1	1
Other	18	18	-
Total	168	118	29 (Say 30)

The following information is needed to estimate the expected aggregated in-house water demand and sewage flow reductions for the village:

- The percentage of homes that will take part in the program; and
- The percentage of existing water efficient fittings and appliances in Mount Victoria homes.

Initial approximations result in an estimated village in-house water demand reduction of approximately 15%.

Determining the reduction in sewage flows is complicated because about half the homes supplied with water are not connected to the sewerage system. However, in percentage terms, reductions in sewage flows to the STP are expected to be reasonably similar to the reduction in in-house water demand except during and after periods of rainfall. It is expected that dry weather sewage flows will also be reduced by about 15%.

4.2 PHOSPHORUS LOAD REDUCTION

The distribution of phosphorus-free washing powders is expected to reduce the phosphorus load at the inlet of the STP by about 25% to 50%. This is based on results by Ransom (1998) in a trial in Albury, NSW, where phosphorus-free washing powders were supplied to about 230 of a total 360 homes within a catchment. Also, it is expected that the diurnal pattern will show that the previously recorded peaks in phosphorus concentration during the day should be reduced, resulting in a more even concentration of phosphorus entering the STP.

5 CONCLUSIONS

Over the next twenty or thirty years current demand side water saving initiatives, such as the progressive introduction of dual flush toilets and consequent natural attrition of single flush toilets, are estimated to continually reduce flows to the sewer.

LCP can help develop additional demand management options that can further reduce water demands and have a significant effect on the design and cost of sewerage systems and water infrastructure (from a water management perspective, the current and projected levels of water consumption are the critical factors for the timing and scale of any wastewater augmentation.) If infrastructure is designed using LCP principles, it is possible to develop an option that not only provides the largest reduction in water demand and sewage flows, but is also accompanied by economic benefits that outweigh the costs.

Sydney Water anticipates that the results of the Mount Victoria Program will show a reduction of about 15% for in-house average water demand in the village, a decrease of about 15% in the dry weather sewage flow to the STP and a drop of between 25% and 50% in the phosphorus load.

The results of the Mount Victoria Program will be assessed to establish the benefits of applying such approaches to the design of the Upper Blue Mountains sewerage system amplifications as proposed in the EIS, as well as more widely within Sydney Water's area of operations. The program will also bring environmental

benefits from reduced water usage and sewage flows, as well as an improvement in effluent quality from reduced phosphorus loads.

When monitoring of the Mt Victoria program is complete, there will be “hard” data on the reduction in water and sewage flows that can be achieved from water conservation. This real data will hopefully assist other agencies in adapting a total water management approach in the design of their water and sewerage facilities.

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7 REFERENCES

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