Australian Government
National Water Commission

The cost-effectiveness of rainwater tanks in urban Australia

Marsden Jacob Associates

March 2007

Waterlines

A SERIES OF WORKS COMMISSIONED BY THE NATIONAL WATER COMMISSION ON KEY WATER ISSUES

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This paper is part of a series of works commissioned by the National Water Commission on key water issues. This work has been undertaken by Marsden Jacob Associates on behalf of the National Water Commission.

Disclaimer

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NATIONAL WATER COMMISSION POSITION

Rainwater tanks have a long history of use in Australia, especially in many rural areas (farms and towns) which often depend upon them for household water. More recently the use of tanks has grown in urban areas, driven by State or local government policies to encourage their use (including rebate schemes) and by home owners' personal choice.

To inform the discussion of rainwater tanks as a water supply option, the National Water Commission engaged Marsden Jacob Associates to undertake an analysis of the cost effectiveness of rainwater tanks in urban Australia. The study assesses cost effectiveness largely from the perspective of the property owner.

The National Water Initiative is the blueprint for improving Australia's water management and use. One of its aims is to create water sensitive Australian cities. Under the National Water Initiative governments have committed to encourage innovation in water supply, including the reuse of stormwater and recycling of wastewater where it is cost effective to do so.

As the Commission stated in its report to COAG in June 2006 (*Progress on the National Water Initiative: A Report to the Council of Australian Governments*, 1 June 2006), it is essential that all water supply options are on the table in order to find the most effective combination of means to secure water for our cities.

The cost effectiveness of rainwater tanks in any location should always be made clear to consumers so that they can make informed choices. The Commission considers that the model developed in this analysis to measure the cost and yield of rainwater tanks could form the basis of a standard methodology in Australia for assessing the cost effectiveness of tanks at the household level.

Governments too need to be more transparent in evaluating the cost effectiveness of their own programmes to encourage rainwater tanks, and more up-front with taxpayers and consumers about the costs and benefits of the subsidies provided.

How the costs of rainwater tanks compare with other water supply options depend on the price of mains water supplies. Urban water pricing remains central to achieving efficient levels of supply and demand for water in our cities. As required by the National Water Initiative, governments are currently examining options for improving the way they set urban water prices.

Householders obtain a range of benefits from rainwater tanks. These may include: reducing their annual water bill; mitigating the effects of water restrictions on their lifestyle, amenity and property values; improving the taste of water in areas of poor water quality; and a sense of community-mindedness.

The gap between the overall cost of tank installation and the financial savings obtained by a householder, as identified by the study, quantify to some extent the value that a household attributes to these benefits. In part, the gap indicates the additional costs households are willing to bear to maintain their ability to use water in ways that would otherwise be subject to water restrictions. On behalf of all governments, the National Water Commission is undertaking a review of urban water restrictions as part of the National Water Initiative (to be completed in the first half of 2007).

Of course, cost effectiveness to households is not the only prism through which to assess rainwater tanks as a water supply option. Rainwater tanks should also be assessed for their contribution to integrated urban water cycle management.

For example, the cost of tanks may be offset by savings in the stormwater system, and by environmental benefits for urban rivers and streams (in the form of an improved runoff regime which reduces sedimentation and bank erosion). There is also the broader community benefit of promoting better stewardship of water at the household level.

The Commission also notes that there are pitfalls in simply comparing rainwater tanks installed by individual households with large scale water supply options. Rainwater tanks remain a largely decentralised source of water, with costs and levels of service varying dramatically – as shown by this analysis – depending on location and individual household circumstances.

Australians are facing major decisions in relation to the water future for our cities – decisions not just by governments but also by individual households. Rainwater tanks will be part of that future. Decisions about their contribution, and the contribution of other water supply and demand management options need to be made with better information and greater transparency. This study is a contribution to that decision making.

The cost-effectiveness of rainwater tanks in urban Australia

A report prepared by Marsden Jacob Associates for the National Water Commission

22 February 2007

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Executive Summary and Conclusions

1. Australia is currently facing some of the most severe drought conditions on record. The extreme reduction in water storage levels across the country has focussed attention on alternative water supply solutions, including the use of stormwater, water recycling, desalination and other options designed to reduce the draw on our dams and catchments. Rainwater tanks are a component of many water supply strategies and are a familiar and well established means of providing high quality water and reducing reliance on the public water supply system.

2. Around 17% of Australian households currently have a rainwater tank installed and some State Governments now require the installation of rainwater tanks or other water conservation measures for all new housing developments. Rainwater tank rebates and regulations typically have strong popular and political support across Australia.

3. By contrast, studies by water authorities have not presented rainwater tanks in such a positive light, concluding that tanks are generally less cost efficient and energy efficient than many other water supply solutions. These conclusions have been strongly disputed by some researchers, including Dr Peter Coombes from the University of Newcastle.

4. The National Water Commission has commissioned Marsden Jacob Associates to evaluate the cost-effectiveness of domestic rainwater tanks in urban Australia, assisted by discussion with industry, researchers and State Government agencies.

OBJECTIVES OF RAINWATER TANK INSTALLATION

5. Rainwater tanks provide several distinct benefits and potentially serve a number of objectives for individual households and the community. For instance, individuals might install a rainwater tank for reasons including:
   - to reduce their annual water bill;
   - to mitigate the costs and impacts of water restrictions on their lifestyle, amenity and property values;
   - to improve the taste of their water in areas of poor water quality;
   - to help avoid the environmental impact of constructing new water sources; and
   - community-mindedness (i.e. easing the burden on the public water supply).

6. The purpose of this study is to review only the first of these objectives, i.e. the cost efficiency of installing rainwater tanks as a substitute for reticulated or ‘scheme’ water use. A second financial benefit for property owners, which is beyond the scope of this study, is the ability of households to mitigate the impact of water restrictions (for example, avoiding the death of non-drought resistant plants, losses in property value or reductions in the availability of home grown fruit and vegetables). The impact of restrictions will be highly specific to each household, but in many cases will be a key determinant of the decision to install a rainwater tank.

7. This study therefore represents only one important element of a property owner’s decision to install a rainwater tank. The study does not seek to assess the intangible

benefits of rainwater tanks, but we note that the extensive uptake of tanks across Australia, even in locations where installation is clearly uneconomic, demonstrates that the intangible benefits are substantial.

8. In addition to examining the impact on individual property owners, this study also reviews the cost efficiency of rainwater tanks at the community level, including savings to public water supply and stormwater infrastructure.

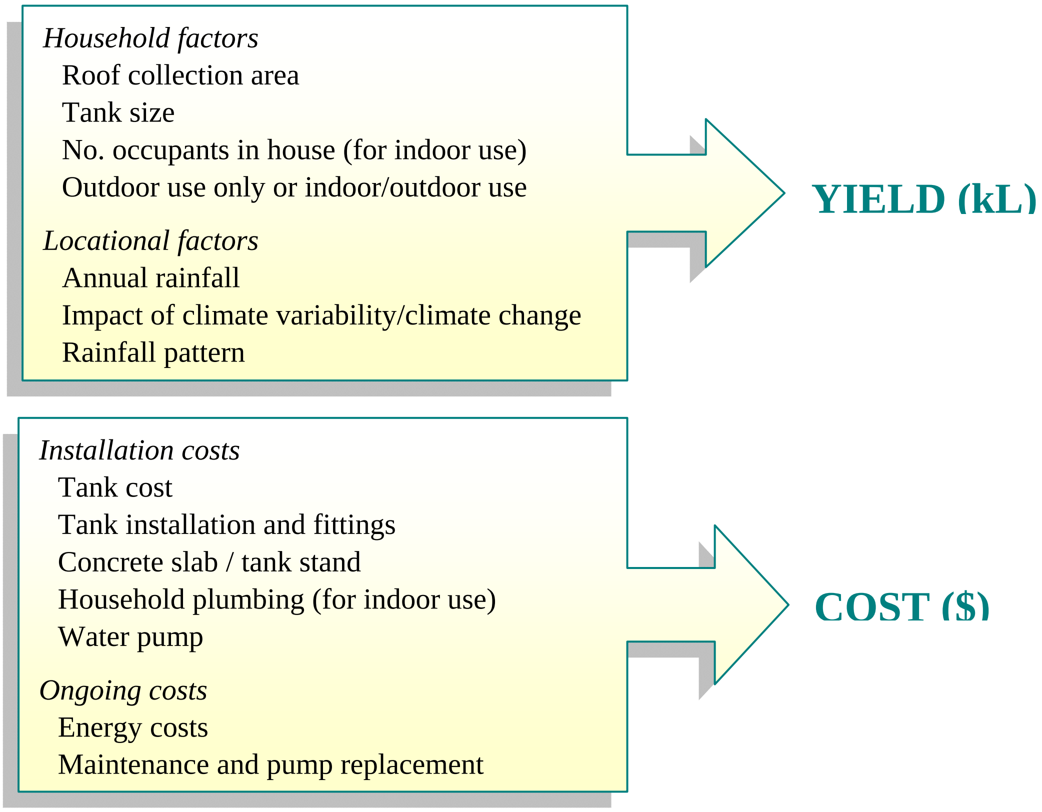
9. The study examines the benefit from the point of view of the community as a whole rather than from the point of view of water authorities or governments. This distinction is important because, while rainwater tanks free up water that utilities could sell to other customers or use to defer new water sources, the water authority will also lose revenue from each household that installs a tank. From a whole of community perspective, the revenue lost to the water authority is the corollary of savings in water bills for property owners. Therefore, throughout this study we consider only the net resource cost to the community rather than the costs and revenues to individual sectors within the community.

COST EFFICIENCY OF RAINWATER TANKS

10. The cost efficiency of a tank is directly related to the whole of life cost and the yield that can be drawn from the tank over time. Water from rainwater tanks can be used solely for outdoor garden use or can also be used internally. This choice has a material effect on a tank's yield and costs. For example, internal use (and in many cases garden use) typically requires the services of a plumber and the installation of a water pump, both of which are key drivers of cost.

11. The key factors influencing the cost and yield of rainwater tanks are shown in Figure 1.

Figure 1: Factors affecting tank cost and yield



RAINWATER TANK YIELDS

12. The yield of a rainwater tank is determined by both the volume and timing of run-off into the tank and the volume and timing of usage. The yield is therefore influenced by a number of factors, including factors specific to the individual property, including:

- rainwater collection area (roof size);
- tank size;
- the number of occupants in the house (and therefore usage);
- garden requirements; and
- whether the tank is plumbed into the house and if so, to which areas.

13. In addition, the roof run-off is also influenced by the total volume and timing of rainfall. The timing of rainfall is based on the climate conditions, which can include:

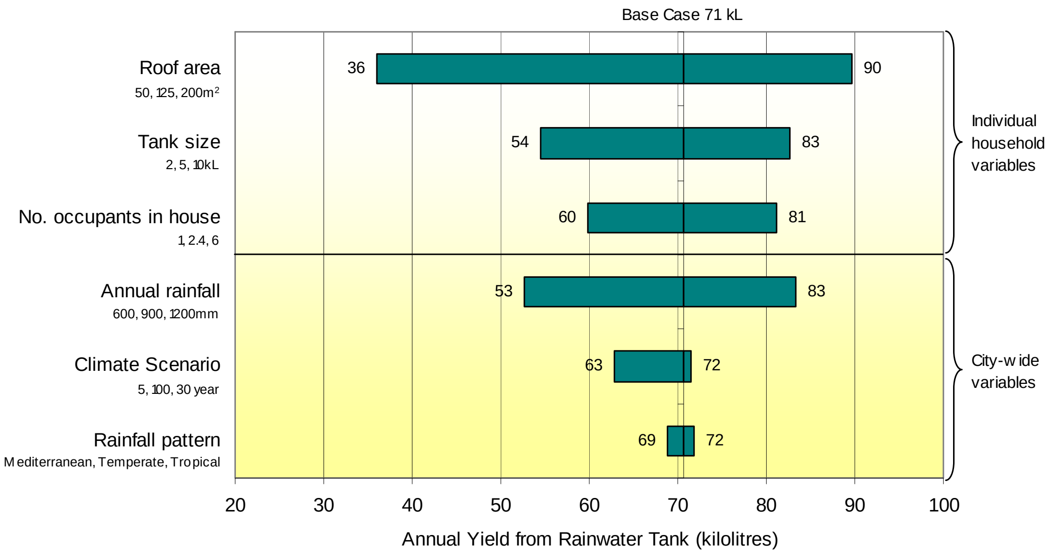
- the heavy tropical rains of Queensland and the Northern Territory;
- the relatively consistent year round rainfall of New South Wales, Victoria and Tasmania; or
- the Mediterranean climates of South West Western Australia and southern South Australia, traditionally characterised by significant rainfall during winter and relatively dry summers.

14. To determine the levels and variability of tank yield, Marsden Jacob developed a model to simulate rainwater tank water balances under different conditions, known as the

Multi-factor Analysis Rainwater Tank or MART model. The MART model determines tank yields for each city, based on rainfall at Bureau of Meteorology (BoM) sites (generally the main airport in each city). Importantly, some cities experience extensive variation in rainfall across different suburbs. Yields are therefore unlikely to be representative of the yield achievable across the entire city. This is particularly the case for Brisbane airport, where higher rainfall may be experienced due to its coastal location compared with other more inland suburbs.

15. The relative impact of the key characteristics affecting yield are shown in Figure 2.

Figure 2: Annual rainwater tank yield varied by key factors – tank plumbed for both indoor and outdoor use



Notes: Line dissecting the graph (71 kL/year) relates to the "base case", i.e. a property with 125m^2 roof connected, 5 kL tank and average 2.4 occupants, and a location with an average rainfall of 900mm (based on 100 year record) and a temperate climate. Low and high variations to yield are based on the low and high estimate described on the vertical axis.

Source: Marsden Jacob MART model

16. Marsden Jacob's analysis shows that for rainwater tanks plumbed for both **indoor and outdoor use**:

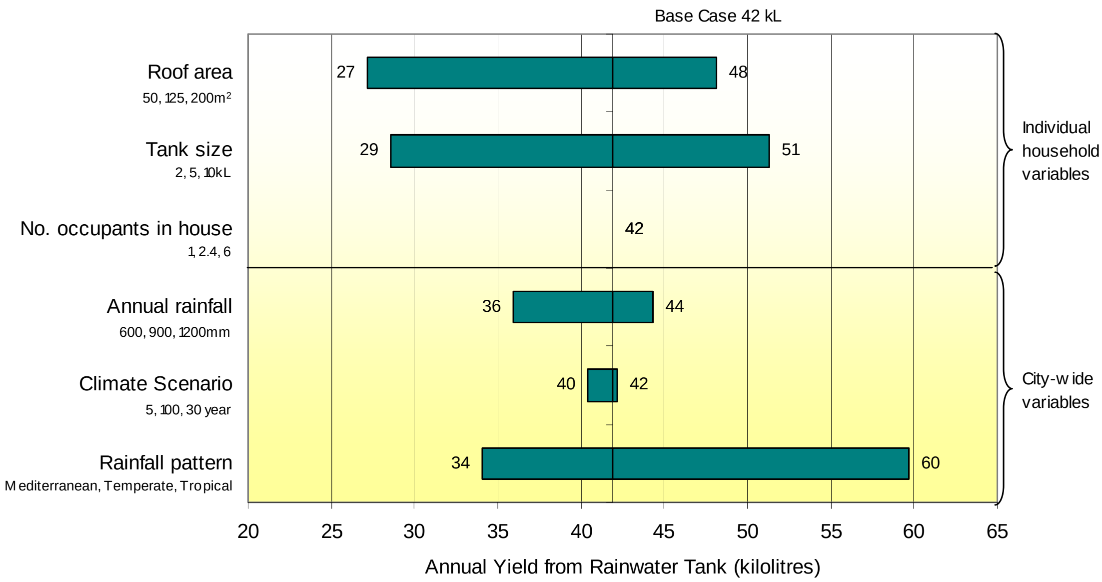
- the "base case" will return a yield of 71 kilolitres (kL) during an average year;
- the collection area (i.e. roof size) has the single greatest impact on the total yield available from a rainwater tank, potentially varying the yield from a low of 36 kL per year to a high of 90 kL per year (assuming a 5 kL tank and all other base case assumptions);
- the annual rainfall, tank size and number of occupants in the house (which determines indoor water use) also contribute significantly to the yield of the tank;
- interestingly, the climate scenario and the rainfall pattern make less difference to the tank yield than any of the other factors. The relatively small difference in tank yield under different rainfall patterns is due to the high level of indoor use. Assuming that water is not used on the garden for several days after a significant

rainfall event, the tank will tend to be depleted from indoor use by the time the water is required for the garden.

17. When the tank is used **outdoors only,** the yield and the sensitivity to individual variables changes significantly (Figure 3). The analysis shows that:

- the yield falls to around 42 kilolitres per year for the base case scenario. We note that this yield may be a high estimate if the home owner does not have a water pump to force water through sprinklers under pressure;
- roof are and tank size remain important determinants of yield; and
- the total quantity of annual rainfall becomes less important than the timing of that rainfall. The large yield in the tropical climates is due to the higher outdoor water use (and therefore higher draw on the tank) and in particular the year round garden watering that is required, including during the drier winter months. In Mediterranean and even temperate climates, comparatively little watering is required during winter due to the higher rainfall and significantly cooler temperatures.

Figure 3: Annual rainwater tank yield varied by key factors – tank plumbed for outdoor use only



Source: Marsden Jacob MART analysis

18. Further analysis was also conducted to understand the variance caused by the two most influential characteristics (other than location), and sensitivities were undertaken for both small and large roof sizes connected to 2kL, 5 kL and 10 kL tanks. The results of the yield analysis for various sites across the country are shown in Table 1. (Note that the results in Table 1 are representative of a single Bureau of Meteorology site only and do not necessarily represent the distribution across the whole city.)

Table 1: Rainwater tank yield by city

Tank Size	2 kL		5 kL		10 kL	
Roof Area	50m²	200m²	50m²	200m²	50m²	200m²
Annual Yield (kL) [1,2]						
Indoor and outdoor						
Brisbane	35	68	41	99	44	124
Sydney	40	77	47	105	50	128
Melbourne	24	68	24	86	24	98
Adelaide	22	57	22	73	22	82
Perth	29	58	30	74	30	84
Outdoor only						
Brisbane	28	49	37	79	42	100
Sydney	22	35	31	50	38	59
Melbourne	18	36	23	52	24	63
Adelaide	16	32	19	47	22	56
Perth	15	28	19	40	24	48

Notes:

1. Based on daily time step data from BoM sites (typically the airport). Substantial variation across cities may exist (for example, the old Brisbane regional office station shows total rainfall since 1976 to be within 1% of the total airport rainfall, however the rainfall at the Brisbane showgrounds was 10% lower for the same period). Yield modelling errs toward a high estimate of yield by assuming that daily usage is drawn from run-off before it is drawn from tank balance.
2. Yields for large families may be higher due to higher use; yields may be lower if toilet, laundry or hot water system are not connected to tank.

Source: Marsden Jacob analysis

19. Table 1 demonstrates that for the same equipment and expenditure outlay, tank yields are highest at the BoM sites in Sydney and Brisbane and lowest at the sites in Adelaide and Perth. In addition, Brisbane's high outdoor usage and summer rains provide by far the highest yield for tanks dedicated to outdoor water use only.

YIELD RELIABILITY

20. A pertinent consideration in determining the impact of rainwater tanks on public water supplies will be the level of reliability of a tank's yield compared with other water sources. Public water providers typically plan to provide sufficient water resources to ensure that water restrictions are required no more frequently than 1 in 25 years. If the low dam inflows over the past decade were to continue indefinitely, the level of water resources required to maintain a 1 in 25 year water restriction policy would increase substantially. Therefore many rainfall independent water sources, including water recycling and desalination, are currently being investigated by water authorities and government agencies across Australia.[1]

[1] See Marsden Jacob Associates (2006).

21. Rainwater tanks are reliant on rainfall, but their precise reliability compared with conventional dams is complex. Rainwater tanks have a number of features which tend to promote yield reliability compared with dams, including:
    - a small reduction in rainfall can cause a more than proportionate reduction in dam inflows, because catchments require significant rains to saturate the soil sufficiently to begin the run-off process. Catchment water is also lost through evaporation and absorption by vegetation. By contrast, roofs provide an impervious surface and therefore run-off is closely correlated with rainfall. The significant “step changes” in dam inflow that have been recorded in some capital cities are far less pronounced in water tanks yields;
    - rainwater tanks provide some degree of resource diversification. Large dams are slow to empty, but can equally be slow to fill. By comparison, rainwater tanks may fill during a single storm event and can empty over just a few days; and
    - dwellings in major urban areas are typically constructed closer to the coast than dams, often in areas receiving higher rainfall. This is demonstrated by the “green droughts” which have recently affected Sydney and Brisbane, in which the low rainfall over inland dam catchments is not reflected by the rainfall occurring at some coastal locations.

22. However, the reliability of rainwater tanks also suffers from a number of significant shortcomings compared with dams, including:
    - the catchment area of roofs is relatively small compared with dam catchment areas. The greater coverage of dam catchments implies that changes in the precise location of rainfall may impact tanks to a greater degree than it impacts dam catchments;
    - the yield from rainwater tanks is highly variable on a day to day basis and may be empty, partially full or overflowing on any given day. By contrast, dams are typically constructed to hold between one and six times a city’s annual water supply needs. Therefore, day to day variations in rainfall, and in some cases even multi-year variations, have less impact on supply reliability from a dam.

COST OF RAINWATER TANKS

23. To determine the actual cost of rainwater tanks, Marsden Jacob surveyed more than 20 rainwater tank suppliers across the country. On a confidential basis, suppliers were queried about the cost of a standard above ground tank, including the cost of installation and plumbing (if undertaken or known by the supplier), and the cost of a domestic pump for the garden and all internal water use applications (toilet, laundry and hot water system). The results were relatively consistent for the tank itself, but the estimates of installation and plumbing costs were far more variable. In some cases, indoor plumbing is inaccessible or encased within the concrete slab of the house, making plumbing to some areas of the house cost prohibitive.

24. The high variability of the total cost underscores the importance of individual circumstances in determining the cost efficiency to the individual property owner. The survey results are summarised in Table 2.

Table 2: Rainwater tank costs provided by suppliers ($)

	2 kL tank	5 kL tank	10 kL tank	20 kL tank	Pump	Plumbing (approx.)	Installation (approx.)
Range	641-922	935-1,349	1,621-1,899	2,618-2,835	240-1,045	300-3,000	300-800
Average	732	1,080	1,656	2,852	622	885	549
Median	721	1,091	1,630	2,835	650	727	548

	Average	Median	
Total Cost 2 kL	2,788	2,645	- May exclude other incidental costs - Costs may be lower for DIY
Total Cost 5 kL	3,137	3,016	
Total Cost 10 kL	3,713	3,554	
Total Cost 20 kL	4,909	4,760	

Source: Marsden Jacob survey of rainwater tank suppliers, December 2006

25. In addition, property owners will incur additional expenses (financial and non-financial) operating and maintaining the tank, including:
    - energy costs for pumping;
    - regular checking and cleaning of gutters, roof catchments and tank screens, including removing overhead branches where required;
    - potentially installing gutter screens or guards;
    - checking the tank for sludge every two to three years and having the tank cleaned if there is a thick layer of sludge at the bottom;
    - if the tank owner suspects the tank has been contaminated, the water stored in the tank may require chlorine disinfection; and
    - maintenance of the water pump as required.

26. In contrast to the installation and plumbing for a rainwater tank, the operating and maintenance of a tank can often be undertaken by the home owner and in some cases represents a cost that would have been incurred even without the tank (e.g. cleaning of gutters). For the purposes of this analysis, Marsden Jacob has assumed a nominal allowance of $20 per year ($200 over 10 years) for rainwater tank operating and maintenance.

27. Interestingly, the cost of the physical tank itself might account for as little as 30% of the whole of life cost if the tank is plumbed for both indoor and outdoor use. In a "typical" installation, the water pump (including replacement every 10 years) might account for around 35%, installation and plumbing 25% and ongoing operation and maintenance around 10%.

LEVELISED COST

28. For individual property owners, a key financial benefit of tank ownership will be a reduction in the usage charge from the public water provider. The reduction in water charges will vary depending on factors such as the size of the tank and the roof

collection area. To compare the cost of various tank options against the savings in the usage charge, the cost of tank ownership can be expressed as a "levelised" unit cost (a cost per kilolitre) over the life of the tank. From a broader community perspective, levelised cost also provides a basis to compare small scale solutions such as rainwater tanks against large options such as dams and desalination plants.

29. To understand the range of costs and benefits attributable to changes in key variables, a levelised cost analysis of rainwater tank options was undertaken for specific Bureau of Meteorology sites (typically the airport) in five major capital cities using a range of tank sizes and both small (50m^2) and large (200m^2) roof area connections.

30. The levelised cost of tank ownership to the property owner is shown in Table 3 and Table 4. Table 3 shows the cost of tank ownership if the tank is plumbed inside the house, while Table 4 shows the cost if the tank is used for outdoor watering only. Importantly, Table 4 assumes that no water pump or significant plumbing costs will be required for outdoor use.

Table 3: Levelised cost of rainwater tanks for property owners (indoor and outdoor use)

Tank Size	*2 kL*		*5 kL*		*10 kL*		*Price of mains water*
Roof Area	*50m^2*	*200m^2*	*50m^2*	*200m^2*	*50m^2*	*200m^2*	
Levelised Cost ($/kL)[1]							
Brisbane	5.80	2.99	5.47	2.29	5.86	2.09	0.91-1.20
Sydney	5.05	2.64	4.79	2.16	5.10	2.03	1.26-1.63
Melbourne	8.40	3.00	9.12	2.63	10.41	2.64	0.81-1.55+ [2]
Adelaide	9.23	3.57	10.14	3.06	11.59	3.13	0.47-1.09
Perth	6.98	3.51	7.32	3.04	8.34	3.07	0.49-1.59

Notes: 1. Levelised cost at Bureau of Meteorology stations (typically the airport). Actual results will vary across the city.
The levelised cost can be higher in individual circumstances, including:
- tank is not plumbed to all indoor areas (toilet, laundry and hot water system)
- underground or slimline tanks are required
- tank usage is lower (e.g. small families)
- reduced rainfall scenario
- additional incidental costs are incurred
- household contracts in all gutter and tank maintenance services

The levelised cost will be lower if:
- tank is also used for drinking water
- tank usage is higher (e.g. large families)
- property owner provides DIY installation or plumbing

Levelised cost based on a discount rate of 8% (nominal).

2. Melbourne water authorities also charge a wastewater usage charge ($0.93-$0.98/kL) which is estimated based on a fraction of total water consumption each season. If the fraction were 0.5 over the year, then a home owner with a rainwater tank might benefit from lower water use by an additional $0.47-$0.49/kL.

Source: Marsden Jacob analysis

Table 4: Levelised cost for outdoor watering only - no pump or major plumbing required

Tank Size	*2 kL*		*5 kL*		*10 kL*		*Price of mains water*
Roof Area	*50m²*	*200m²*	*50m²*	*200m²*	*50m²*	*200m²*	
Levelised Cost ($/kL) [1]							
Brisbane	2.70	1.55	2.59	1.25	3.06	1.31	0.91-1.20
Sydney	3.36	2.14	3.08	1.95	3.37	2.21	1.26-1.63
Melbourne	4.14	2.10	4.25	1.87	5.24	2.05	0.81-1.55+ [2]
Adelaide	4.71	2.30	5.02	2.05	5.94	2.31	0.47-1.09
Perth	5.07	2.68	5.02	2.40	5.33	2.66	0.49-1.59

Notes: 1. See Note 1, Table 3.
2. See Note 2, Table 3.

Source: Marsden Jacob analysis

31. The results of the levelised cost analysis show that, in all of the cases examined, the cost per kilolitre of tank water is greater than the price currently charged by water companies. However, for many households with large connected roof areas (particularly in Brisbane, Sydney and Melbourne), the unit cost falls within 20% of the top tier price of mains water.

32. The results do not support the conventional assumption that tanks are most cost effective if plumbed into the house. Provided the tank is sufficiently elevated compared with the garden, the tank may not require a water pump and a significant cost can be avoided. In addition, tanks dedicated to outdoor watering will not require in-house plumbing and will not require a device that automatically switches over to mains water when the tank is empty (unless watering via automatic reticulation). Finally, operating and maintenance costs will be lower if a pump is not required and the lower water quality requirements will make the level of gutter, screen and tank maintenance less onerous. However, it is likely that the above assumptions will only apply in a relatively small number of instances, as property owners without a water pump will have low pressure for garden watering and may therefore be required to hand water or move watering equipment regularly over a relatively long period of time.

33. The levelised cost results demonstrate that a "typical" property owner who installs a rainwater tank will, in most cases, face a net financial loss over time. To offset this loss, a rebate in the order of $1,600 to $4,000 would be required depending on tank size and roof size. Where the tank is used for garden watering only (without the need for a pump), lower rebates of around $500 to $1,900 per property might be required. Rebates at these levels assume that the property owner has no objective other than cost minimisation and has no cashflow constraints. In practice, property owners may have a number of intangible or other objectives when installing a rainwater tank. The rapid take up of tanks in recent years demonstrates that in many cases the other objectives of tank ownership must have a sufficiently high value to offset the associated financial shortfall.

34. It is important to emphasise that there are a significant number of variables that affect the cost and yield of a tank and only the most critical were modelled during this exercise. Other factors, including number of occupants in the house, garden requirements, other potential uses for the water (including drinking), ease of installation and the availability of cheaper products will all have a direct impact on the cost effectiveness of a tank for

any particular property owner. A number of specific case studies that were reviewed during this study were found to cost significantly more or significantly less than the base case results in this report. The results presented throughout this study should therefore by understood as an indicative guide for a "typical" household only.

PUBLIC COSTS AND BENEFITS

35. The primary financial benefit of rainwater tanks to the community (in contrast to the individual property owner) is the potential reduction in the cost of water and stormwater infrastructure. The ability of water authorities to reduce the cost of water and stormwater infrastructure will depend critically on local conditions and vary substantially.

36. Various economic regulators have determined the Long Run Marginal Cost (LRMC) of developing new water sources. These estimates represent the change in cost if new water sources are brought forward or delayed (including new dams, desalination and water recycling schemes). In Table 5 the estimated LRMC is compared against the levelised cost of installing a rainwater tank. As noted earlier, the reliability of rainwater tanks is different to the reliability of other water sources, and therefore direct comparisons should be treated with some caution.

Table 5: Levelised cost of rainwater tanks to community

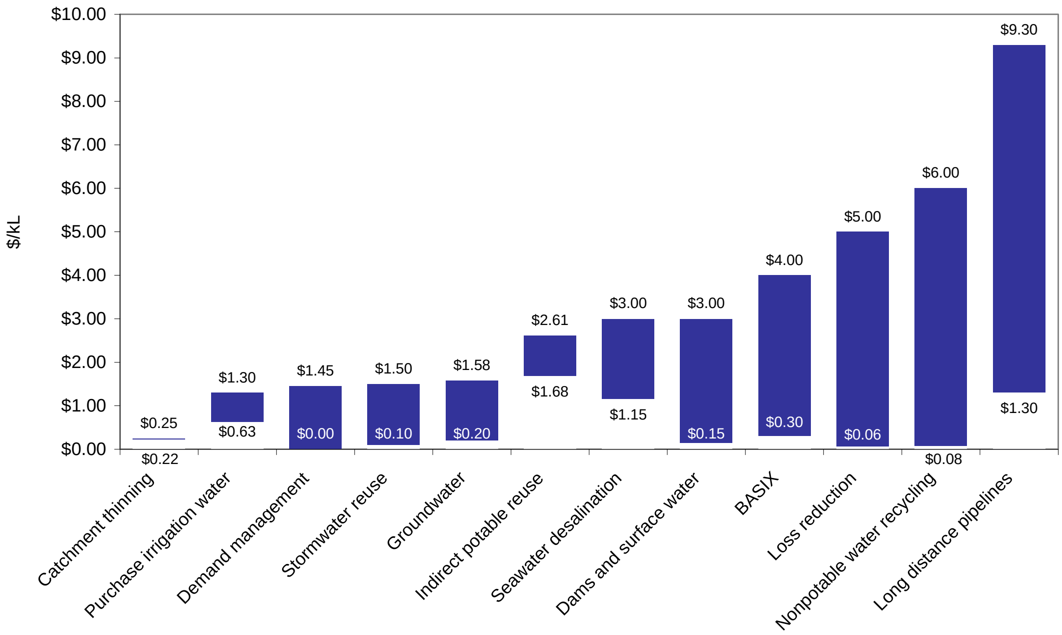
City	***Cost of tanks ($/kL)*** [1]		***Estimated LRMC ($/kL)***
	Indoor use, pump required	***Outdoor use only, no pump required***	
Brisbane	2.22 - 6.22	1.41 - 3.29	2.00 + ?
Sydney	2.15 - 5.41	2.31 - 3.63	1.20-1.50
Melbourne – Yarra Valley	2.67 - 10.92	2.00 - 5.51	0.50-0.54
Melbourne – City West	2.67 - 10.92	2.00 - 5.51	0.74
Adelaide	3.32 - 12.30	2.48 - 6.39	Approx 1.09
Perth	3.25 - 8.85	2.87 - 5.74	0.82-1.20

Note: 1. Based on a standard above ground tank only. Community cost differs slightly from property owner cost, as a social (rather than private) discount rate is applied and a cost offset has been included for reduced stormwater treatment due to nitrogen removal in Melbourne.

Source: Marsden Jacob analysis. LRMC (except Brisbane) from economic regulator price reviews (see Table 14 for references).

37. The estimate of LRMC is developed using a source development timetable in which a number of sources are assumed to be implemented over time, typically ranging from the least expensive options first to the higher cost options in the long term. Therefore it can be expected that the LRMC will increase over time as more expensive sources are brought on line. It is therefore instructive to consider where rainwater tanks fit compared with the estimated cost of other water sources (Figure 4).

Figure 4: Levelised cost of alternative water sources



Source: Marsden Jacob Analysis based on water supply plans for Sydney, Adelaide, Perth, Newcastle. Lower bound of indirect potable reuse estimate based on Toowoomba. Comparable costings for Melbourne are not available and no costings are available for Queensland.

38. For rainwater tanks connected to large roof areas, the unit costs ranged from $1.41/kL to $3.32/kL – which would fall within the range of costs indicated for many water source options being examined around the country. For moderate and small roof areas, the cost of rainwater tanks can be as high as $12.30/kL. The results indicate that for a typical household, rainwater tanks will be among the higher cost water supply options. It is important to note that rainwater tanks would have to be taken up on a very large scale to represent a viable alternative to the major supply options presented in Figure 4.

39. In addition to the benefit of deferring new water sources, rainwater tanks may also allow a reduction in the size of water mains or stormwater infrastructure costs. However significant savings will generally only be achievable in a greenfield environment, i.e. prior to the construction of the water and stormwater infrastructure. If the stormwater infrastructure savings indicated in Coombes and Kuzcera (2003) are achievable in other areas,[2] then the levelised cost of rainwater tanks could potentially be offset by stormwater savings in the order of $0.30/kL to $1.00/kL. In cases where the property owner is required to install expensive on-site stormwater detention (reportedly costing as much as $10,000 per allotment), households may save more than the total cost of tank installation.

40. Studies on potential stormwater savings are limited. Interviews with water authorities indicated that stormwater infrastructure savings may be minimal in most cases, particularly those households in areas with established infrastructure. However, the possible magnitude of the results may warrant further investigation on a case by case basis.

[2] $210-$959 per lot for a 10 kL rainwater tank, plus $10-23 per annum operating cost savings. Estimated from a dwelling in Newcastle and other sites in the Lower Hunter Region.

CONCLUSIONS

41. Cost efficiency is only one factor affecting an individual's decision to install a rainwater tank. Others include avoidance of water restrictions, concern for the environment, improved taste and community-mindedness.

42. The yield and cost efficiency of tanks varies substantially between individual properties and locations. In the five cities examined, the single most influential variable in determining the cost efficiency of a tank was the size of the connected roof area. Other variables that influence cost efficiency include the size of the tank, the areas into which the tank is plumbed, the local climatic conditions and the volume of household water use.

43. The results from the five city locations examined throughout this report indicate that costs for rainwater tanks could range from a low of $1.41/kL to a high of $12.30/kL, depending on individual circumstances. In most cases, the cost of rainwater tanks will be amongst the higher cost sources of public water supply.

44. For properties that can take advantage of high yields, in particular those in tropical or temperate climates with large connectable roof areas, the cost of a rainwater tank may be comparable with many of the water source options currently being examined across the country, including some desalination and water recycling schemes. In addition, the cost of the tank may also be offset by savings in the stormwater system, particularly if the home requires an on-site detention system.

45. The analysis in this report also calls into question a number of conventional assumptions about rainwater tanks by finding that:
    - the recent downturn in climate has little impact on the volume of run-off into tanks;
    - rainfall timing (e.g. summer/winter) has a relatively small impact on rainwater tank yield when the tank is plumbed for both indoor and outdoor use; and
    - rainwater tanks need not be plumbed inside the house to maximise cost efficiency if a pump is not required for garden watering.

22 February 2007

1. Introduction

The National Water Commission (NWC) has engaged Marsden Jacob Associates (MJA) to undertake an evaluation of the cost-effectiveness of urban domestic rainwater tanks, i.e. the efficiency and cost-effectiveness of rainwater tanks for domestic use as a means of augmenting urban water supply.

The comments and opinions expressed in this paper are those of MJA and do not necessarily reflect the opinions of the NWC.

1.1. The role of rainwater tanks in urban water supply

The severity of the current drought, which has affected all of Australia's most heavily populated centres, has focussed attention on a growing range of potential water supply solutions. Non-conventional water sources such as desalination and large scale wastewater recycling are either in place or being considered for many cities across Australia. These options are being considered as both emergency drought responses and as long term water supply solutions. Many water supply plans are being developed on the basis that the low inflows experienced over the last ten years (or less) might continue indefinitely.[3]

In addition to large scale water supply solutions, many researchers, state governments and water authorities have also begun to explore the potential use of rainwater tanks and other water conservation solutions to reduce the demand for water from dams and catchments. The importance of water conservation and collection at the household level has been increasingly recognised through the concept of Integrated Water Cycle Management (IWCM), which considers the costs and benefits of all possible water supply options, including both traditional large scale infrastructure such as dams and bore-fields, in addition to household water collection via grey-water reuse or rainwater tanks. The approach moves beyond the traditional focus on water agency costs alone and examines the full range of costs and benefits across the community - including infrastructure providers, government agencies, businesses and residents. IWCM is gradually being adopted across Australia and is reflected in the wide range of water sources examined in recent metropolitan water plans.

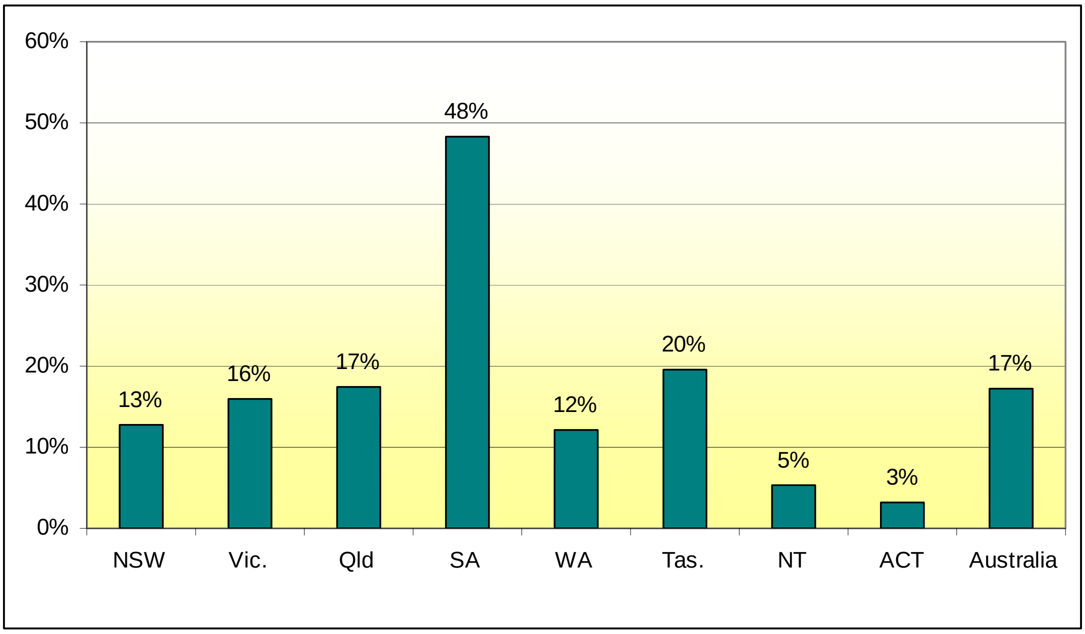
Rainwater tanks are already well established in Australia, with a rainwater tank currently installed in around 17% of Australian households.[4] The highest proportion of tanks are found in South Australia, where 48% of all households have a rainwater tank and 28% have the tank plumbed into their house (Figure 5). The relatively high proportion of tanks in South Australia has been attributed to the (historically) high dissatisfaction with the taste of tap-water.[5] Correspondingly, improvements in water treatment may therefore be responsible for the declining take up rate of new tanks in South Australia in recent years.

3 See Marsden Jacob Associates (2006).

4 Australian Bureau of Statistics (2006).

5 Australian Bureau of Statistics (2004).

Figure 5: Proportion of households with a rainwater tank (March 2004)



Source: ABS Water Account Australia 2004-05

1.2. Rainwater tank objectives

Rainwater tanks provide a number of benefits and therefore serve a number of objectives in the community. Objectives include:

- **cost efficiency:** water from rainwater tanks can be used to displace water supplied through the centralised water supply system ("mains water"). If the uptake of tanks is significant, then public infrastructure such as dams, desalination plants or water recycling schemes could be deferred. The public benefit will also be translated into lower water bills for those private households that have installed rainwater tanks. The cost efficiency of tanks – to either the property owner or the public water provider – will be determined by the lowest overall cost to provide the same volume of water;
- **environmental objectives:** where rainwater tanks reduce the draw on the public water supply, there can potentially be environmental benefits for stressed waterways and aquifers. In addition, the water from rainwater tanks could potentially defer the need for environmentally damaging new water sources. Other considerations must also be taken into account in a complete environmental analysis, including the energy used in the centralised water system compared with the energy used in household water pumps and the raw materials required to construct tanks compared with conventional water sources;
- **avoidance of water restrictions:** rainwater tanks may provide additional water supply security for property owners, particularly where public water supply schemes utilise water restrictions to balance water supply and demand. In particular, property owners who have invested significant time and resources into establishing their garden may consider reliability to have a very high value; and

- **other objectives:** rainwater tanks may also serve a number of other objectives, including:
  - in areas with poor quality water, some households may prefer the taste of rainwater;
  - rainwater tanks are a visible and high profile method of conserving water and can therefore reinforce and promote a government's general water conservation policy;
  - some households may install a rainwater tank to "do the right thing" and contribute to alleviating our current water shortages.

The purpose of this study is to review only the first of these objectives, i.e. the cost efficiency of installing rainwater tanks. A second key financial benefit of rainwater tanks, which is beyond the scope of this study, is the ability of households to mitigate or avoid the impact of water restrictions (for example, the death of non-drought resistant plants, a loss in property value or a reduction in the availability of home grown fruit and vegetables).

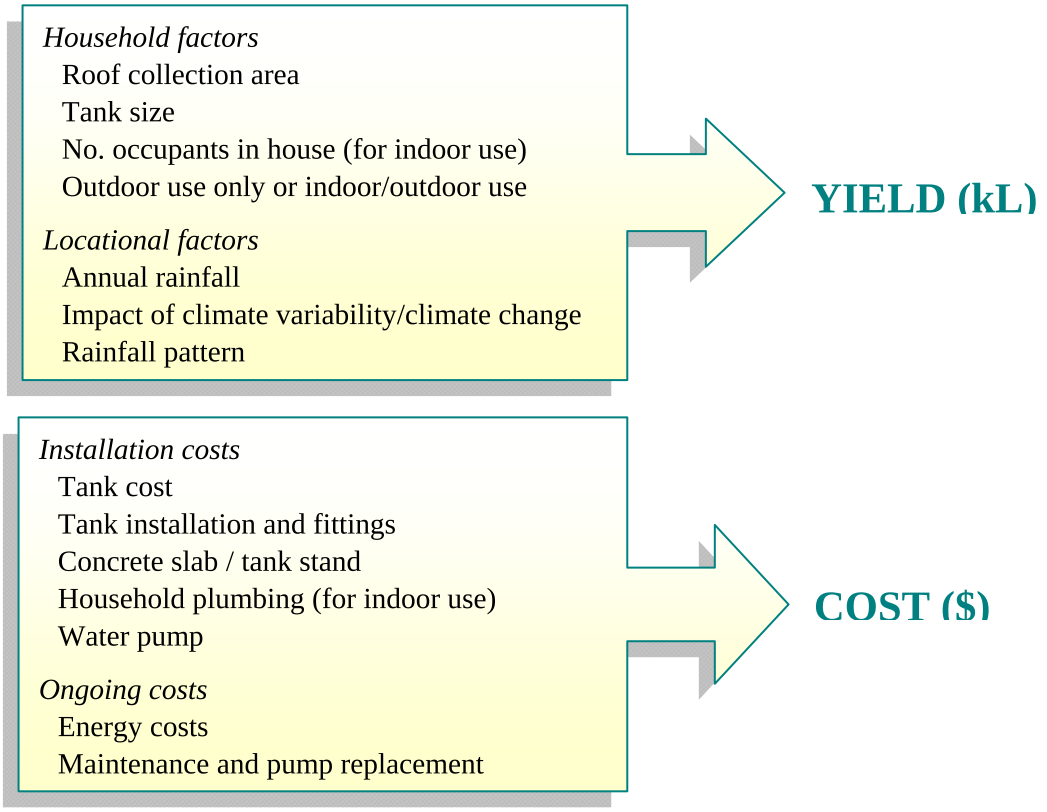
1.3. Factors affecting cost efficiency

Cost efficiency can be viewed from two perspectives – that of the individual property owner and that of the community as a whole. From the perspective of the property owner, a tank will be cost efficient if the cost of the tank is outweighed by savings to the household budget, including a reduction in the property owner's annual water bill.

From the broader community perspective, rainwater tanks will be cost efficient if the total cost of tanks is less than the total cost savings to the community, including savings to public water supply and stormwater infrastructure.

From both perspectives, the cost efficiency of a tank is directly related to the cost of the tank and the yield that can be drawn from the tank over time.

Figure 6: Factors affecting tank cost and yield



1.4. Yield reliability

A pertinent consideration in determining the impact of rainwater tanks on public water supplies will be the level of reliability of a tank's yield compared with other water sources. Public water providers typically plan to provide sufficient water resources to ensure that water restrictions are required no more frequently than 1 in 25 years. If the low dam inflows recorded in recent years were to continue indefinitely, the level of water resources required to maintain a 1 in 25 year water restriction policy would increase substantially. Therefore many rainfall independent water sources, such as water recycling and desalination are being investigated by water authorities and government agencies across Australia.

Rainwater tanks are reliant on rainfall, but their relative reliability compared with dams is complex.

Rainwater tanks have a number of features which tend to promote yield reliability, including:

- a small reduction in rainfall can cause a more than proportionate reduction in dam inflows, because catchments require significant rains to saturate the soil sufficiently to begin the run-off process. By contrast, roof run-off is closely correlated with rainfall;
- the amount of run-off from an impervious roof is much greater on square metre basis than the run-off from dam catchments, which can lose water to evaporation and absorption by vegetation; and

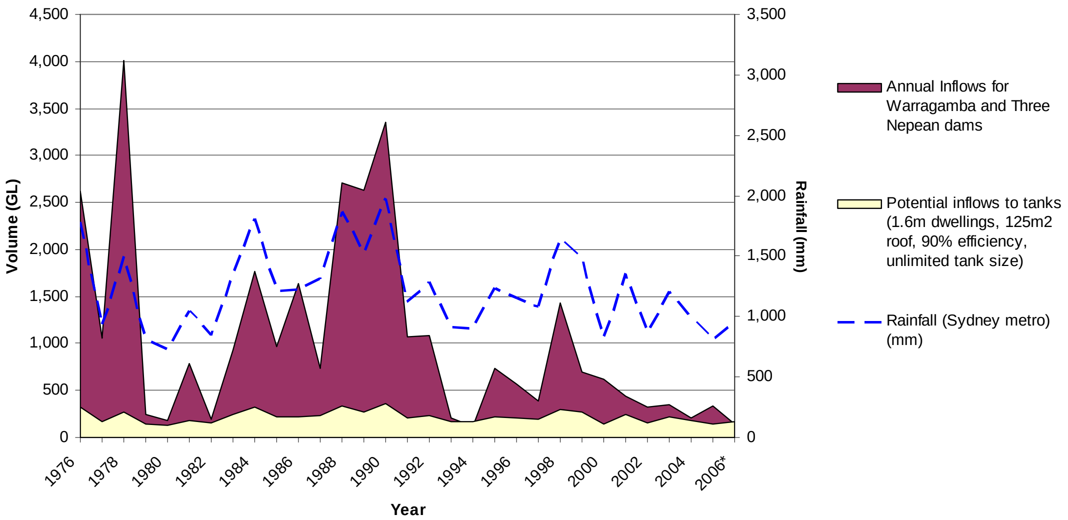
- dwellings in major urban areas are typically constructed closer to the coast than dams, often (but not always) in areas receiving higher rainfall.

However, the reliability of rainwater tanks also suffers from a number of significant shortcomings compared with dams, including:

- the catchment area of roofs is relatively small compared with dam catchment areas. The greater coverage of dam catchments implies that changes in rainfall location may have a higher impact on inflow into tanks compared with inflow into dams; and
- the yield from rainwater tanks is highly variable on a day to day basis and may be empty, partially full or overflowing on any given day. By contrast, dams are typically constructed to hold between one and six times a city's annual water supply needs. Therefore, day to day variations in rainfall, and in some cases even multi-year variations, have little impact on supply reliability from a dam.

Figure 7 demonstrates the variability of dam inflow levels compared with rainfall over the last 30 years. The figure also shows the potential volume of water that could be supplied if rainwater tanks were installed in all Sydney households (assuming a roof capture area of 100m^2 per dwelling, 90% rainwater capture and a rainwater tank of sufficient size to capture all run-off[6]). While the absolute volume of roof run-off is significantly less than the catchment run-off in most years,[7] the roof run-off is more stable and increases or decreases in proportion with the change in rainfall.

Figure 7: Sydney metropolitan rainfall data compared with inflow into primary dams and potential tank yield



Source: Marsden Jacob analysis based on data from Sydney Catchment Authority and Bureau of Meteorology

6 These assumptions are for illustrative purposes only. Further detailed analysis of assumptions is undertaken in later chapters.

7 Over the last 30 years, inflows into Sydney's dams has totalled around 32,500 gigalitres. By comparison, if sufficiently large rainwater tanks were fitted to every one of Sydney's 1.6 million dwellings, as much as 6,800 gigalitres might have been captured over the same period (ignoring the possibility of tank overflows).

The magnitude of run-off into dam catchments during wet years implies that dams are likely to remain a valuable source of water for our cities, but the shortfalls in dry years also highlights the potential role of rainwater tanks in providing security of supply during low rainfall years. Other sources that are even less dependent on rainfall, and against which rainwater tanks must also be evaluated, include other water conservation measures, water recycling and desalination.

1.5. Previous studies

Each city has a unique combination of issues and available resources that will make some water supply solutions more effective than others – as many commentators have noted, there appears to be no "silver bullet" solution to the current water supply crisis. A number of water businesses have calculated the cost of different water supply solutions. Costs included in water supply plans across Australia range from $0.15/kL-$3.00/kL for conventional dams, to $1.15/kL-$3.00/kL for seawater desalination, to as much as $9.30/kL for long distance pipelines from the North West of Australia.[8] Water authorities have estimated the cost of rainwater tanks as between $3.00/kL and $5.60/kL, suggesting that the cost of tanks is relatively high compared with many alternative options, but may be competitive against some of the higher cost options.

The results of the water authorities' analyses have been disputed by some researchers, including Dr Peter Coombes from the University of Newcastle, who suggests that the cost of water could be as low as $0.28/kL.[9] If the actual cost is as low as $0.28/kL, then rainwater would be less expensive than almost all alternative water supply options. This study seeks to independently verify the actual cost of rainwater tanks based on existing evidence and independent research.

1.6. Scope and conduct of research

The study reviews the cost-effectiveness of rainwater tanks at two levels:

- the net financial benefit accruing to individual property owners, determined primarily by the savings in the annual water bill less the cost of installing, operating and maintaining the tank; and
- the net financial benefit to the community relating to the broader system impacts on water and stormwater infrastructure.

To understand the key factors influencing the cost-effectiveness of rainwater tanks, the study team consulted widely across the industry, including researchers, water authorities, state government agencies and rainwater tank suppliers and installers. A significant body of research has been undertaken across Australia and a large number of articles, publications and presentations have been developed. In many cases, supporting background data – in particular tank yield models – were not publicly accessible and were therefore independently developed using original data from the Bureau of Meteorology.

8 Marsden Jacob analysis based on water supply plans for Sydney, Adelaide, Perth, Newcastle. For full comparison of water supply options see Marsden Jacob Associates (2006).

9 Coombes, *et. Al*. (2004)

The study first considers the physical benefits of rainwater tanks, i.e. the yield and use of tanks in the Australian context. The study then separately assesses the cost-effectiveness of rainwater tanks to the individual property owners and to the community as a whole. The assessment of property owner impacts clarifies the costs and benefits of installing a rainwater tanks for household use, while the community wide analysis also considers the impact of rainwater tanks on water and stormwater infrastructure constructed by water authorities and land developers.

1.7. Acknowledgements

Marsden Jacob would like to acknowledge the valuable assistance of the researchers, state government agencies and water authorities who provided data, insights and comment on the issues and the investigation. In particular, we would like to thank Dr Peter Coombes, who provided substantial research information and took time from his vacation to meet with us on this important project.

2. Water use benefits

Rainwater tanks are used extensively across Australia for uses including garden watering, toilet flushing and laundry use. In many households, particularly rural properties without access to mains water, rainwater tanks supply all household needs including drinking water and bathing. For properties without access to mains water, rainwater tanks are fundamental for essential health and hygiene. In urban areas, rainwater tanks provide water that substitutes for mains water. In some cases, tanks provide a superior product to mains water, including better tasting water and water that can be used during water restrictions. However the key financial benefit of rainwater tanks is the reduced demand for mains water, resulting in reduced water bills for the property owner and deferred infrastructure investment for water businesses. The initial task of this study was therefore to determine the total physical volume of water that can be obtained from a rainwater tank.

The total volume of water supplied by a rainwater tank for typical household use is a function of two factors:

- the volume and timing of water entering the tank; and
- the volume and timing of water required by the property owner (i.e. water leaving the tank).

The interaction between the water entering the tank and the water used by the property owner determines whether the tank will be empty, full or partially filled at any particular point in time. When the tank is empty, additional water must be sourced from the water authority’s central water supply system. When the tank is full, additional rainfall will overflow into the stormwater system and will not be captured by the tank. The ideal circumstances for rainwater tank use are consistent rainfall and consistent water usage or, preferably, higher usage during times of higher rainfall.

We examine water supply and demand in turn below.

2.1. Volume and timing of water inflows

The volume of water entering the tank is determined by a number of factors, including:

- the collection area (the roof size);
- the losses due to evaporation from the roof and overflow from gutters;
- the size of the tank (and therefore how often it overflows); and
- the total volume and timing of rainfall.

Collection area: Roof sizes across Australia vary based on factors such as land availability and income of the property owner. To complicate the issue further, not all roof area is available for use and will depend on the location of downpipes and tank location. Ideally, the tank location and plumbing will be configured to ensure that all (or most) roof run-off is captured, however considerations such as cost, site availability and aesthetic preference limit the actual roof area that can be used. Typically up to half of the roof area can be diverted into a rainwater tank.

A recent joint initiative between Newcastle City Council, Hunter Water Corporation, the Stormwater Trust, and the University of Newcastle gave 99 households in Kotara, New South Wales, the opportunity to have rainwater tanks installed free of charge. 16 households proceeded with installation (those who did not participate cited reasons including site constraints and concern over future maintenance). Of the 16 participating households, the average contributing roof area was $60m^2$ per house or around 40% of the total roof area. Other projects, reported by Coombes and others, have also reported connecting roof areas of up to $115m^2$.[10] In established dwellings, the location of downpipes will typically imply that around half of the total roof area of a house can be directed to a rainwater tank. In some cases, the tank can be stored under the house and therefore potentially capture 100% of roof run-off. The exact size of the roof and proportion that can be connected will vary based on individual circumstances.

It is anticipated that new residential dwellings subject to mandatory requirements to fit rainwater tanks will design roofs and downpipes more effectively to increase the potential capture of rainwater run-off. For example, regulations in South Australia require all new buildings to connect a *minimum* roof area of $50m^2$.[11]

For the purposes of this study, we have analysed roof capture areas of between $50m^2$ and $200m^2$.

Losses from roof and gutters: A light rainfall event may not produce enough saturation of the roof to flush water into the tank. On the opposite end of the spectrum, substantial rainfall events might result in overflow from the roof, particularly if debris has accumulated in gutters or screens. In addition, some rainwater tanks incorporate a "first flush" system that diverts the initial flush from a rainfall event in order to avoid the potential for contaminated or discoloured water entering the tank.

The proportion of total rainfall that is translated into run-off has been estimated by a number of government and non-government sources, and ranges from less than 60% to 90%.[12] Following advice from Dr Peter Coombes, Marsden Jacob has modelled run-off by subtracting the first 0.5mm of daily rainfall and assuming that 20 litres is diverted through a first flush system. In addition, many households fail to maintain a gutter that is free of debris throughout the year, which can cause a reduction in water run-off through overflows and blockages. Early estimates by Dr Coombes suggest that poorly maintained gutters may account for losses of around 10% of total rainfall. The MART model therefore applies a mid-point estimate of 5% for losses due to gutter debris.

10 Coombes, *et al* (2003) and Coombes, *et al* (2004b)

11 100% of roof area if smaller than $50m^2$. South Australian Government (2005).

12 For example:

- Gardner (2006) quotes one source that indicate that roof "yield" may be in the order of 80% of the total rainfall hitting the roof and another source that indicates that yield may be less than 60% of rainfall;
- a joint fact sheet issued by the South Australian Government, CSIRO, Water Care and others indicates an approximate run-off coefficient of 70% of rainfall;
- a runoff coefficient of 80% of rainfall has been assumed in publications by the Northern Territory Government; and
- the South Australian Water Corporation and Department for Environment, Heritage and Aboriginal Affairs indicate an approximate runoff coefficient of 90% (Department for Environment, Heritage and Aboriginal Affairs (1999)).

Size of tank: A number of tank sizes are available on the market, ranging from small 600 litre tanks, to industrial size concrete tanks of almost unlimited proportions. For residential properties, very large tanks are often cost prohibitive and difficult to locate on an average suburban block. Typically, research has therefore focussed on the more practical domestic tank sizes ranging from 2,000 litres (2 kL) to 10,000 litres (10 kL).

Volume and timing of rainfall: The volume of rainfall varies considerably across Australia. Table 6 shows average annual rainfall in selected Australian cities.

Table 6: Annual rainfall in selected Australian cities

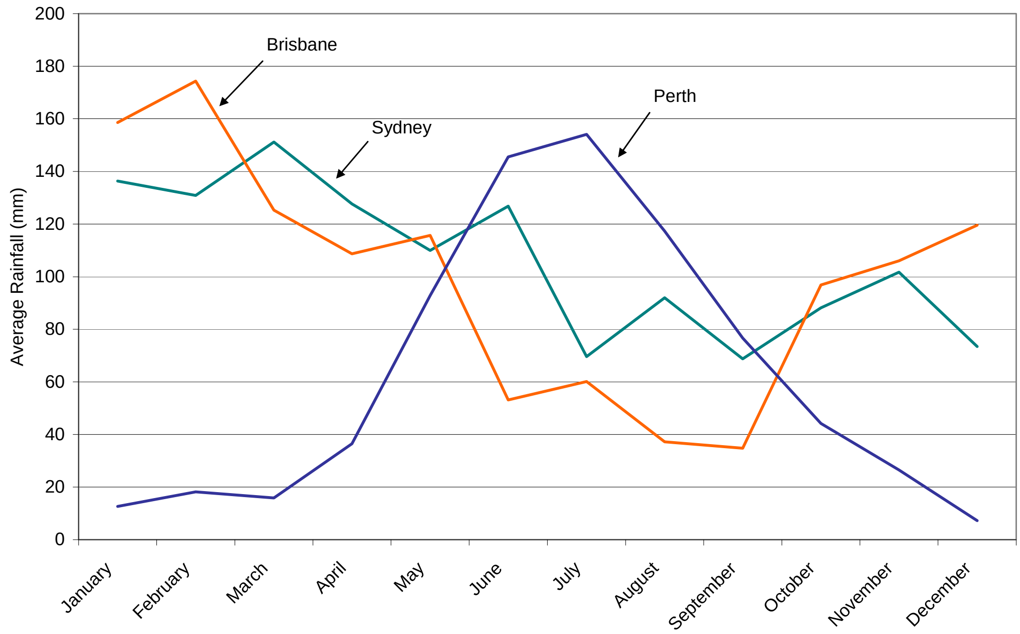
Capital City	*Annual Rainfall (mm)*
Brisbane	1,194
Sydney	1,276
Melbourne	654
Adelaide	563
Perth	745
Hobart	576
Darwin	1,847
Canberra	630
Alice Springs	326

Source: ABS Yearbook Australia 2006

In addition to the volume available for collection, the timing of rainfall is also important for determining the yield of a rainwater tank. The total yield will be improved in areas where consistent or high rainfall coincides with high water use. The chart below shows the monthly rainfall patterns of three typical Australian climates:

- the tropical summer rainfall of Brisbane;
- the more consistent year round rainfall of Sydney; and
- the Mediterranean climate of Perth, with significant rainfall during winter and relatively dry summers.

Figure 8: Monthly rainfall for Sydney, Brisbane and Perth 1971-2000



Source: ABS Yearbook Australia 2006

Both Sydney and Brisbane also receive more extreme single events (more than 50mm during a single day) than Perth, but otherwise have a relatively high number of moderate rain events during the wettest months (historically, both cities have around 40% rainy days during the peak wet season, of which 16%-17% receive more than 5mm). By comparison, Perth has relatively few events that exceed 50mm on a single day, but has more regular periods of heavy rain during winter (historically, 57% of wet season days have some rain, of which 30% receive more than 5mm).[13]

The pattern of rainfall influences not only the timing of rainfall entering the tank, but also the water use pattern. Gardens in Mediterranean climates will tend to require more regular watering during warmer months compared with temperate climates, while tropical weather will require more frequent watering during winter.

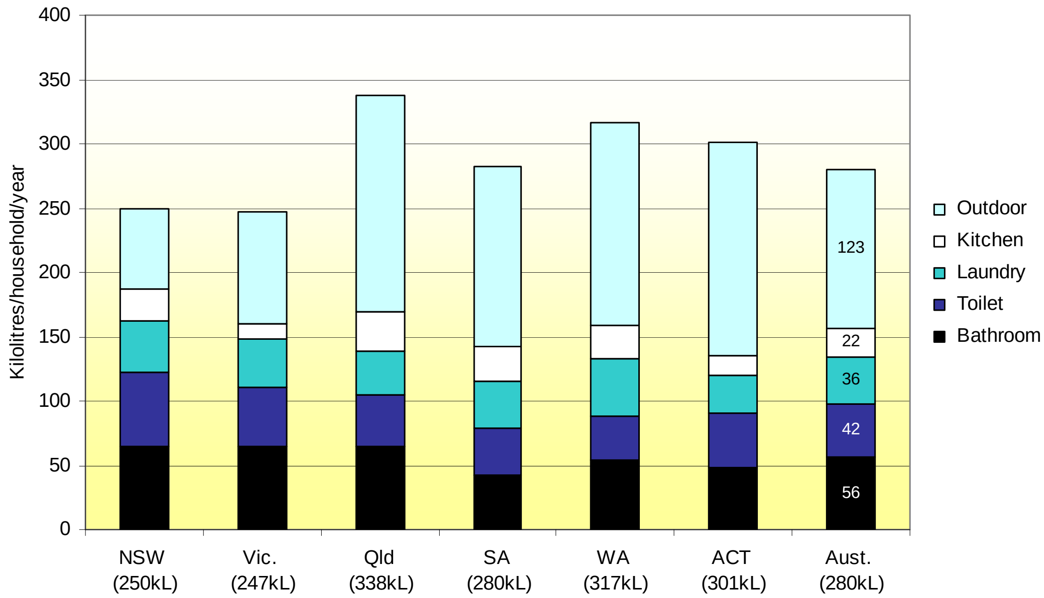
2.2. Volume and timing of water use

The second major determinant of the total yield of a rainwater tank is the volume and timing of use by the property owner. The volume of rain water used in a household depends on which areas of the house are supplied with rain water and the total volume of water used in those areas.

Rainwater tanks can be dedicated to outdoor use or can also be plumbed to accommodate indoor use. The relative water use in each area of the house – and therefore the potential benefit from rainwater tanks - is shown in Figure 9.

[13] Marsden Jacob analysis of daily rainfall data provided by Bureau of Meteorology.

Figure 9: Water use per household by location and State



Source: Marsden Jacob analysis based on ABS Water Account Australia 2000-2001

Almost half of all household water supply is used outdoors (44%), except in New South Wales and Victoria, where garden watering needs are lower due to the relatively temperate climate. With most of Australia's populated centres now on some form of outdoor water restriction, tanks are increasingly being installed for the purpose of watering lawns and gardens. Rainwater is also used to supply other areas of the house, particularly in rural areas where it is common for rain water tanks to supply all household water needs, including drinking water. As noted earlier, 28% of South Australians have rainwater tanks plumbed into their house, of which the majority appear to use the water for drinking.[14]

Some water authorities and health regulators have expressed concern at the wide spread use of rainwater tanks for drinking purposes. Poorly maintained tank systems have the potential to become contaminated and may pose a serious health risk (see Section 3.7 for more details). For this study, Marsden Jacob has assumed that all outdoor use would be supplied with rainwater, in addition to indoor water use for the toilet, laundry and hot water system. Therefore, the only water not supplied through the tank would be the cold water supply to the kitchen and bathroom (approximately 14% of total water use[15]). This assumption will tend to overestimate the yield if the property owner does not use the rainwater tank for all household applications. Some areas may not be connected to the rainwater system due to plumbing difficulties or personal preference (some property owners may be uncomfortable bathing or washing clothes in water that has run off from the roof).

[14] A South Australian Government website indicates that 33% of South Australians sourcing drinking water from a rainwater tank (www.environment.sa.gov.au/reporting/human/water/urban_sources.html), however this appears inconsistent with ABS reports that only 28% of households have a tank plumbed into their house.

[15] Based on results presented in Gardner (2006). Gardner's presentation reports that the "Healthy House" project monitored between 2000 and 2005 indicated that of the 58% of indoor water used for bathroom and kitchen purposes, approximately 25% was for cold water use. For the average Australian house using 156 kL indoors, this translates to approximately 39 kL or approximately 14% of total water use.

Alternatively, if rainwater is also used for drinking (i.e. cold water use in the kitchen and bathroom), then the total yield from the tank may be higher than the estimates produced by this study.

Regardless of the rainwater applications, households with tanks of 10 kL or less will also typically require a mains water connection to supply water during low rainfall periods. Switching devices can be installed that allow mains water to be supplied via a trickle top up of the tank or via a by-pass device that automatically switches to mains water when the tank is empty. When switching devices are installed water authorities will typically require the installation of a backflow prevention device to avoid potential contamination of the mains water supply. Finally as noted in Section 2.1, the use of rainwater tanks for indoor use may also require a “first flush” device to divert the first rainfall away from the tank to reduce the potential for contaminated or discoloured water entering the tank. These systems add to the cost of the tank, but allow indoor water use to be accommodated with relatively little inconvenience to the property owner.

2.3. Expected yield from rainwater tanks

Various studies have reached different conclusions about the total volume of water available from a rainwater tank.[16] Coombes and Kuczera (2003) found that depending on roof size and number of occupants in a household, the use of rainwater tanks could result in annual mains water savings ranging from 18 kL to 55 kL for 1 kL rainwater tanks to 25 kL to 144 kL for 10 kL rainwater tanks.

To verify the range of yield estimates, Marsden Jacob developed an independent model (the Multi-factor Analysis Rainwater Tank or MART model) to simulate the water balance in a rainwater tank based on historical daily rainfall data for Sydney, Melbourne, Brisbane, Adelaide and Perth (generally the main airport in each city). A number of cities have reported potential “step” changes in climate over the past 10 and 30 years, and even more severe changes over more recent years. Marsden Jacob therefore modelled the water balance based on four potential scenarios: rainfall modelled over the past 5 years, 10 years, 30 years and 100 years respectively.

[16] For example,:

- Gardner (2006) found that rainwater tanks at Pimpama (Gold Coast) would yield around 40 kilolitres for a 5 kL tank connected to a 50m2 roof area (marginally more for a 10 kL tank). If connected to a 200m2 roof, a 5kL and 10 kL tank would yield just over 90 and 110 kL per year respectively;
- Hunter Water estimate that a 4.5kL tank capturing runoff from the entire roof area on an average home connected to toilets, washing machine and garden will save around 70kL per house per year; and
- the ACT Government indicates that a 10 kL tank would yield about 60 kL per year (ACT Government, *Think Water, Act Water Factsheet – Rainwater Tanks* fact sheet).

The water available for collection was derived by the formula:

$Q = A \times R \times C$

Where:

Q = roof run-off in any one day (litres)

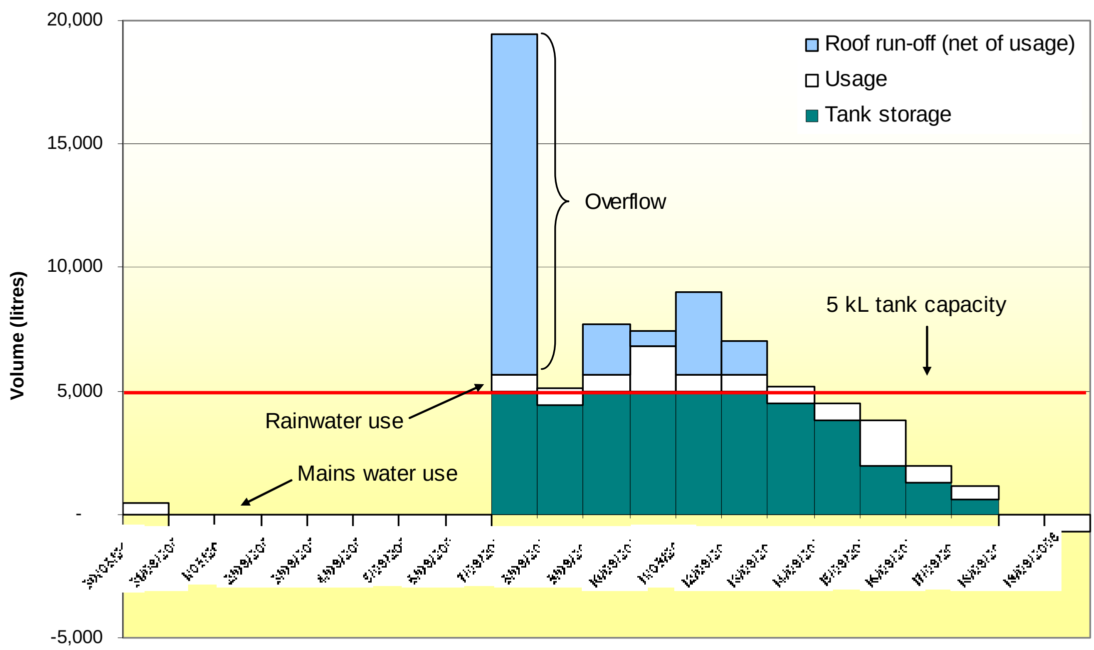
A = connected roof area (m^2)

R = daily rainfall (mm)

C = the coefficient of run-off of 90% (see Section 2.1)[17]

A typical daily water balance model is shown in Figure 10. As shown, the tank can be in one of three states – either empty (in which case mains water is required), above capacity (in which case water overflows from the tank) or somewhere between the two.

Figure 10: Typical water balance model (Sydney 30/8/06 to 19/9/06)



Source: Marsden Jacob MART model

The MART model assumes that daily water use is supplied from the day's rainfall first. After daily use is subtracted from the total run-off, either the additional run-off is added to the tank's water balance or the net usage is subtracted from the tank's balance. When the tank is full, the additional water overflows and when the tank is empty, water is assumed to be sourced from the mains water supply. This method will tend to overestimate water use slightly, as in practice a rainfall event in the early morning may overflow a full (or nearly

[17] We note that some variations of the formula also subtract a minimum quantity (eg 2mm) for absorption and wetting of surfaces.

full) tank before water use for the day can occur. Consequently the full daily rainfall would not actually be available for use during the day.

2.4. Water balance model results

A generic version of the MART model (i.e., not city specific) was constructed to test the difference in yield caused by the six key factors outlined in Table 7. The appropriate reference points for the base case, low and high estimates were identified during interviews with researchers, government agencies and industry groups.

Table 7: Key factors affecting rainwater tank yield

Factor	*Low*	*Base Case*	*High*
Tank Size	2 kL	5 kL	10 kL
Connected roof area	50m^2	125m^2	200m^2
Number occupants in house	1	2.4 (ABS average[18])	5
Climate scenario	Past 5 years	Past 30 years	Past 100 years
Annual rainfall	600mm	900mm	1200mm
Climate type	Mediterranean (based on Perth)	Temperate (based on Sydney)	Tropical (based on Brisbane)

The base case in Table 7 would deliver an average rainwater tank yield of **71 kL per year**. Each characteristic was then individually set to the corresponding low and high estimate to develop a "tornado chart", in which the sensitivity of the result to changes in each characteristics can be individually identified (Figure 11).

The sensitivity analysis shows that the roof area has the single greatest impact on the total yield available from a rainwater tank, potentially varying the yield from a 5 kL tank from a low of 36 kL per year to a high of 90 kL per year (assuming all other characteristics are held constant).

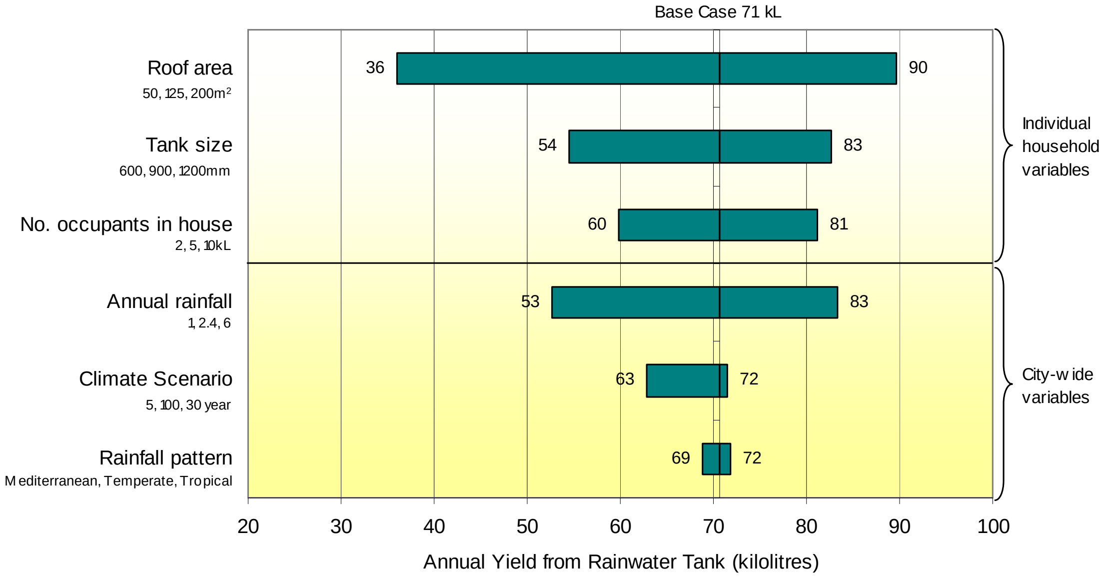
The annual rainfall, tank size and number of occupants in the house (which determines indoor water use) also contribute significantly to the yield of the tank. Interestingly, the climate scenario and the rainfall pattern make less difference to the tank yield than any of the other factors. While the change in climate and reduced rainfall across Australia has made a dramatic difference to dam catchment run-off, the impact on rainwater tanks is much lower, as outlined in Section 2.1.

With regard to the different rainfall patterns in each city, the relatively small difference in tank yield is due to the fact that the primary use of water is for indoor use. The modelling conducted by Marsden Jacob assumed that water would not be used for the garden for several days after a significant rainfall event. This has the implication that when the tank is

18 Average for water use statistics for 2000-01 as presented in ABS *Water Account Australia 2000-01* – calculated as Australian average water use divided by Australian average water use per capita.

recharged, water is not used on the garden for several days thereafter. If the household has significant indoor use, then the tank will tend to be depleted by the time the water is required for garden use.

Figure 11: Rainwater tank yield varied by key factors

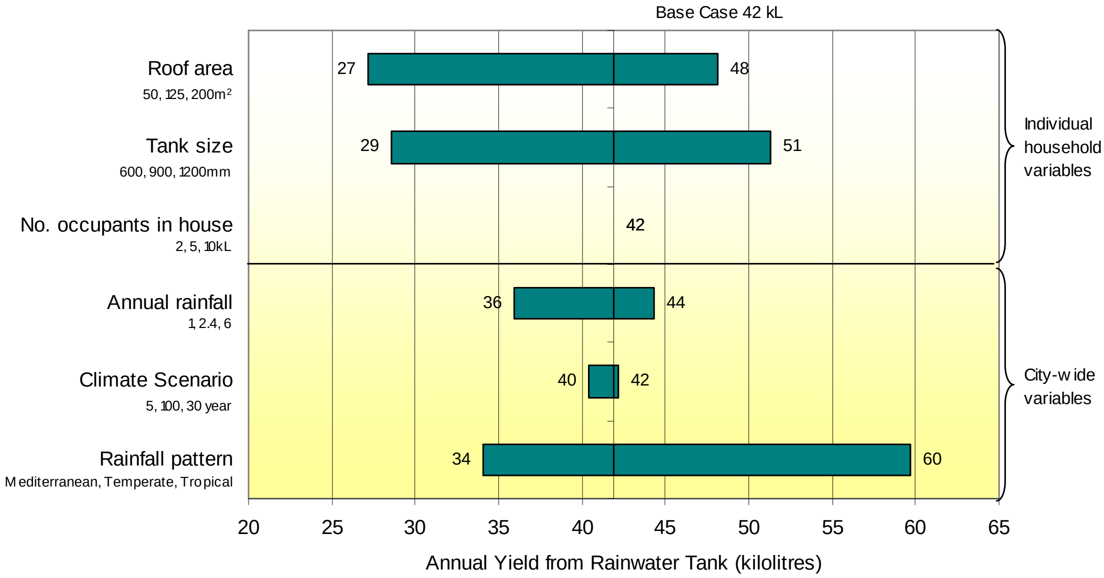


Source: Marsden Jacob analysis

A second case was also tested, in which the tank is only used for outdoor garden watering and is not connected for any indoor applications. With the base case assumptions shown in Table 7, the total yield from the rainwater tank falls to 42 **kL per year**.

Importantly, the sensitivity to individual variables changes dramatically when the tank is used for outdoor purposes only (Figure 12). In this scenario, the total quantity of annual rainfall is less important than the timing of that rainfall. The large yield in the tropical climates is due to the higher garden watering requirements and in particular the year round garden watering that is required, including the dry winter months. In Mediterranean and even temperate climates, comparatively little watering is required during winter due to the higher rainfall and significantly cooler temperatures.

Figure 12: Rainwater tank yield outdoor use only



Source: Marsden Jacob analysis

2.5. Tank yields by city

Using the MART model, an analysis of tank yields for each city was undertaken for the scenario in which the rainwater tanks are plumbed for both outdoor and indoor uses (including toilet, laundry and hot water system). To understand the variance caused by the two most influential characteristics (other than location), sensitivities were conducted for both small and large roof sizes connected to 2kL, 5KL and 10 kL tanks. The results of the yield analysis are shown in Table 8. Note that the results in Table 8 are representative of a single Bureau of Meteorology site in each city and do not necessarily represent the distribution across the whole city.

Table 8: Rainwater tank yield by city

Tank Size	*2 kL*		*5 kL*		*10 kL*	
Roof Area	*50m²*	*200m²*	*50m²*	*200m²*	*50m²*	*200m²*
Annual Yield (kL) [1,2]						
Indoor and outdoor						
Brisbane	35	68	41	99	44	124
Sydney	40	77	47	105	50	128
Melbourne	24	68	24	86	24	98
Adelaide	22	57	22	73	22	82
Perth	29	58	30	74	30	84
Outdoor only						
Brisbane	28	49	37	79	42	100
Sydney	22	35	31	50	38	59
Melbourne	18	36	23	52	24	63
Adelaide	16	32	19	47	22	56
Perth	15	28	19	40	24	48

Notes:
1. Based on daily time step data from BoM sites (typically the airport). Some variation across cities may exist (eg sites such as the Brisbane regional office and RPA hospital show long term rainfall between 1% and 9% lower than the Brisbane airport sites since 1976). Yield modelling errs toward a high estimate of yield by assuming that daily usage is drawn from run-off before it is drawn from tank balance.
2. Yields for large families may be higher due to higher use; yields may be lower if toilet, laundry or hot water system are not connected to tank.

Source: Marsden Jacob analysis

It should be noted that some cities experience extensive variation in rainfall across different suburbs. Yields shown in Table 8 are therefore unlikely to be representative of the yield achievable across the entire city. This is particularly the case of Brisbane where the rainfall data is from Brisbane airport and higher rainfall may be experienced due to its coastal location compared with other more inland suburbs.

Table 8 demonstrates that for the same equipment and expenditure outlay, tank yields are highest at the BoM sites in Sydney and Brisbane and lowest at the sites in Adelaide and Perth. In addition, Brisbane's high outdoor usage and summer rains provide by far the highest yield for tanks dedicated to outdoor water use only.

3. Property owner impacts

In order to consider whether a rainwater tank is an efficient solution for property owners, the cost of purchasing, installing and operating a tank must be compared against the value derived by the tank owner. For properties with access to mains water, the primary financial benefit of a rainwater tank will be a reduction in the annual water bill from the local water authority. In addition, property owners may attach some value to the taste of water from the tank or to the added insurance that a rainwater tank provides against the impact of water restrictions.

To determine the costs and benefits to the property owner, data was collected on:

- the cost and installation of a rainwater tank;
- ongoing costs of the rainwater tank, including pumping costs and general maintenance; and
- the price of mains water to the property owner.

Using this information the life cycle cost of a rainwater tank was estimated and compared against the avoided cost to the property owner over the same period of time. Where the life cycle cost of the rainwater tank is greater than the avoided cost, rainwater tanks are not be considered financially viable from the perspective of the property owner. In this case a rebate may be required if the property owner is to be encouraged to voluntarily install a rainwater tank.

3.1. Capital cost and installation

The cost of installing a rainwater tank includes the cost the tank itself, delivery and installation, household plumbing and the cost of incidentals such as concrete slabs, rainwater stands and mains water switching devices. A water pump will typically also be required to provide adequate pressure if the tank supplies showers or washing machines, or if the tank is not elevated sufficiently to provide water to the garden or toilet.

The cost of rainwater tanks has been estimated in a number of Australian studies. Estimates vary widely, ranging between $1,300 and $5,000 per tank for a moderately sized domestic rainwater tank (including installation).[19] The wide variation in costs is largely explained by the different cost items included in each estimate, including items such as pumps, concrete slabs, tank stands, mains water switching devices and plumbing costs.

Marsden Jacob surveyed more than 20 rainwater tank suppliers across the country. On a confidential basis, suppliers were queried about the cost of tanks, the cost of installation and plumbing (if undertaken or known by the supplier), and the cost of a domestic pump for the garden and all internal water use applications (toilet, laundry and hot water system). The individual results from the survey are shown in Appendix 1 and summarised in Table 9.

Table 9: Rainwater tank costs provided by suppliers ($)

State	*2 kL*	*5 kL*	*10 kL*	*20 kL*	*Pump*	*Plumbing (approx)*	*Installation (approx)*
Average	732	1,080	1,656	2,852	639	885	549
Median	721	1,091	1,630	2,835	675	727	548

	Average	Median	
Total Cost 2 kL	2,796	2,664	May exclude other incidental costs
Total Cost 5 kL	3,144	3,035	
Total Cost 10 kL	3,720	3,573	
Total Cost 20 kL	4,917	4,779	

Source: Marsden Jacob analysis

The costs in Table 9 are for a standard, above ground, round rainwater tank only – prices are typically higher for slimline or rectangular tanks or tanks housed underground. We also note that some refinement of these costs may be possible. Costs are likely to be underestimated as the cost of incidental expenditure, such as mains water switching devices, "first flush" diversion systems and concrete slabs, were not specifically requested when obtaining quotes for tank installation. Other incidental costs may also be incurred by the home owner. For

19 For example:
- Coombes and Kuczera (2003), Coombes et al (2004a) and Coombes et al (2004b) found that the cost of tanks installed on identified properties (2 x 2.2kL, 9kL and 10kL) ranged between $1,851 and $2,350 including installation, pumps and plumbing. Coombes (2004c) estimates a total installation cost of between $1,300 and $3,500;
- Hunter Water estimate that fully installed (retrofitted) tanks could cost $5,000 or more after all plumbing and installation costs are accounted for. In a trial exercise at Kotara, Hunter Water found that the cost of a rainwater tank is relatively small compared with total installation costs, which include site preparation, plumbing and installation of a pressure pump (*pers. comm*., Brendan Berghout, Hunter Water, 5/12/2006);
- the Water Corporation of WA estimate that the cost of installing a tank, including modifying the plumbing system, is approximately $1,500 for an above ground tank and $2,000 for an underground tank (pers. comms. Michael Loh and Rod Burton, Water Corporation, 8/12/2006);
- the Northern Territory Government estimates $3,300 for 9kL tank (installed) and pump connected to toilets or hot water system (Northern Territory Government, *Waterwise Alice Springs – Rainwater Tanks* information brochure); and
- an information fact sheet released by the South Australian Government and others indicates that the cost of a rainwater tank (including pumps and installation) may vary between $1,800 and $2,490 for tanks sized between 5 kL and 20 kL.

example, interviews with water utilities indicated that some hot water systems may not operate optimally using rainwater or rainwater/mains switching systems.

The installation and plumbing requirements will also vary substantially between households depending on the site layout and plumbing configuration. For the purposes of our analysis, we have used the median costs provided by manufacturers for the tank, pump, plumbing and installation. These costs are intended as an indicative estimate only and will vary on a site by site basis.

3.2. Ongoing costs

In addition to the initial cost of installation, a rainwater tank also requires ongoing operations and maintenance. If the tank requires a water pump (which we have assumed is required for indoor water supplies), the pump will consume electricity and will require regular maintenance and replacement. For the purposes of this analysis we have assumed an average pump life of 10 years. We note that some interviewees suggested that the average life of low priced pumps may be considerably less.

Other costs include the costs of regular maintenance and cleaning of tanks, gutters and screens. There appears to be significant disagreement between researchers regarding the ongoing operating and maintenance costs for a tank. In particular, Coombes and Kuzcera (2003) indicate that operating costs for a rainwater tank are minimal, and conservatively apply a value of $0.05/kL for ongoing operating and maintenance costs (i.e. between $1 and $7 per year depending on yield). By contrast, estimates by Melbourne Water and Hunter Water indicate that the annual cost of operation and maintenance of a rainwater tank could be around $90 and $50-$100 per year respectively.

The operating cost variation is significant and resolution of the actual cost would require monitoring and surveying of a number of residential properties with rainwater tanks. The primary disagreement between researchers appears to be regarding the cost of maintaining the rainwater tank and its associated components. Specifically, tank maintenance includes tasks such as:

- regular checking and cleaning of gutters, roof catchments and tank screens;
- removing overhead branches;
- potentially installing gutter screens or guards;
- checking the tank for sludge every two to three years and having the tank cleaned if there is a thick layer of sludge at the bottom;
- if the tank owner suspects the tank has been contaminated, the water stored in the tank may require chlorine disinfection;
- replacing water filters (if fitted); and
- maintenance of the water pump as required.

Some of these tasks would be undertaken by a home owner regardless of rainwater tank ownership (for example cleaning of gutters), although the tasks may be initiated more regularly to ensure the tank water does not become contaminated and provides the maximum yield. Several other costs – such as removing branches, desludging the tank and cleaning screens – might be undertaken by some home owners with no financial outlay. The value of the home owners' time is difficult to quantify, but is certainly greater than zero. Studies have shown that home labour is typically valued at around 25-40% of an individual's gross hourly wage rate.[20] Furthermore, some home owners will not be capable of undertaking any maintenance on their own and will need to purchase outside labour.

Recognising all maintenance costs at the full cost of hired labour will tend to overstate the true cost to most individuals. Equally, including no allowance for maintenance costs would fail to recognise the fact that when these services are required and that they are often time consuming or expensive. We have therefore included a nominal estimate of $20 per year ($200 over the course of ten years) for one or more of the following services: tree-lopping, tank desludging, pump servicing (excluding pump replacement), additional gutter maintenance, gutter guards and/or chlorine for disinfection.

3.3. Avoided cost

The primary financial benefit of a rainwater tank to the property owner will be a reduction in the annual water bill paid to the local water utility. Water supply prices in 2006/07 for selected Australian water utilities are shown in Table 10.

Table 10: Water utility usage prices 2006/07

City	Water Usage	Volumetric Price ($/kL)
Brisbane	<200 kL/yr	0.91
	201-300 kL/yr	0.94
	>300 kL/yr	1.20
Sydney	<1,096 l/day	1.264
	>1,096 l/day	1.634
Melbourne	0-440 l/day	0.81-0.82
(3 retailers)	440-880 l/day	0.96
	>880 l/day	1.41-1.55
Adelaide	<125 kL/yr	0.470
	>125 kL/yr	1.090
Perth	0-150 kL/yr	0.493
	151-350 kL/yr	0.732
	351-550 kL/yr	0.950
	551-950 kL/yr	1.268
	>950 kL/yr	1.588

Source: Water company websites

[20] Office of Best Practice Regulation, *Best Practice Regulation Handbook,* Appendix C: Cost benefit Analysis

Table 10 shows that many water businesses now charge a multiple part tariff, in which the price of water becomes more expensive as consumption increases (a rising block tariff). Water used from a tank will reduce the water bill in accordance with the highest tier paid by the household. Although water use varies across households, we have assumed for this study that the price of water saved by a typical customer will be the highest volumetric price paid by a household using 250 kilolitres. This assumption will tend to understate the financial savings for large water users and overstate the savings for low water users.

3.4. Calculation of lifecycle costs and rebates

To calculate the lifecycle costs and benefits to the property owner, Marsden Jacob developed a spreadsheet model that sets out the cost estimates, yields, avoided costs (etc.) by city. A discounted cashflow analysis (Net Present Value analysis) was undertaken to compare the financial cost of rainwater tanks with the benefits to the property owner over time.[21]

Discounted cashflow analysis requires a rate at which costs and benefits are reduced over time, known as the discount rate. There is significant uncertainty about the discount rate applicable to personal investments, because individuals have different opportunity costs, access to different forms of funds and are typically inconsistent in placing a value on different types of future cost and benefit. One of the most common forms of opportunity cost for private investment is the repayment or extension of the household mortgage. Therefore, for the analysis in this report, we have assumed a discount rate equal to the current standard home loan variable rate, i.e. approximately 8% per annum.

If the present value of benefits does not exceed the present value of costs, then a potential purchaser of a tank may require financial incentives such as rebates if he or she does not value the tank for other reasons (e.g. improved taste or avoidance of water restrictions). The level of rebate required by the property owner flows directly from the Net Present Value calculation, as the rebate would need to cover the shortfall of costs (if any) created by the investment in the tank.

3.5. Levelised cost of tank ownership

To understand the range of costs and benefits attributable to changes in key variables, a discounted cashflow analysis was undertaken for five major capital cities using a range of tank sizes and both small ($50m^2$) and large ($200m^2$) roof area connections. An example calculation is attached as Appendix 2.

The levelised cost of private tank ownership compared with the cost of mains water is shown in Table 11 below. The actual cost will vary based on individual circumstances (see Note 1 of Table 11). Note that the yield (and therefore the levelised cost) may differ even across a single city depending on localised rainfall conditions.

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[21] Cashflows analysis is typically limited to 20-50 years for water projects. However, due to the low discount rate applied in this analysis, cashflows beyond 50 years remain relevant. The cashflow model was therefore extended to perpetuity for the levelised cost analysis. Net Present Value benefits to the current property owner are shown for a 50 year period only.

Key assumptions common to all scenarios include:

- that the tank is plumbed for all outdoor and indoor use other than cold kitchen and bathroom water;
- 2.4 occupants per house (in accordance with Australian Bureau of Statistics averages for water use statistics); and
- daily rainfall (volume and timing) is based on actual historical data over the past 30 years.

Table 11: Levelised cost of rainwater tanks for property owners (indoor and outdoor use)

Tank Size	*2 kL*		*5 kL*		*10 kL*		*Price of mains water*
Roof Area	*50m²*	*200m²*	*50m²*	*200m²*	*50m²*	*200m²*	
Levelised Cost ($/kL)[1]							
Brisbane	5.80	2.99	5.47	2.29	5.86	2.09	0.91-1.20
Sydney	5.05	2.64	4.79	2.16	5.10	2.03	1.26-1.63
Melbourne	8.40	3.00	9.12	2.63	10.41	2.64	0.81-1.55+ [2]
Adelaide	9.23	3.57	10.14	3.06	11.59	3.13	0.47-1.09
Perth	6.98	3.51	7.32	3.04	8.34	3.07	0.49-1.59

Notes: 1. Levelised cost at selected Bureau of Meteorology sites (typically the airport). Based on variable home loan rate of 8% p.a.
The levelised cost can be higher in individual circumstances, including:
- tank is not plumbed to all indoor areas (toilet, laundry and hot water system),
- underground or slimline tanks are required,
- tank usage is lower (e.g. small families),
- reduced rainfall scenario,
- additional incidental costs are incurred, and
- household purchases all gutter and tank maintenance services.

The levelised cost will be lower if:
- tank is also used for drinking water, and
- tank usage is higher (eg large families).

2. Melbourne water authorities also charge a wastewater usage charge ($0.93-$0.98/kL) which is estimated based on a fraction of total water consumption each season. If the fraction were 0.5 over the year, then a home owner with a rainwater tank might benefit from lower water use by an additional $0.47-$0.49/kL.

Source: Marsden Jacob analysis

As shown in Table 11, the levelised cost of installing a tank for indoor and outdoor usage ranges from a low of $2.03/kL for a house with a large connected roof area in Sydney to a high of $11.59/kL for a house with a small connected roof area in Adelaide. In all of the cases examined, the levelised cost of tank ownership was found to be greater than the price paid for mains water, even for the largest tank and rook sizes.

Importantly, the costs and benefits of rainwater tanks will be different on a case by case basis. Therefore, there will be many individual cases in which rainwater tank ownership is financially viable without a subsidy.

Interestingly, the conventional assumption that tanks are most cost effective if plumbed into the house is not borne out by the levelised cost modelling. If the tank is used for outdoor watering only, there can be significant cost advantages. Firstly, if the tank is elevated compared with the garden, the tank may not require a water pump. By comparison, showers and washing machines require greater water pressure and would therefore require a water pump, even if the tank is elevated.[22] Pumps account can account for around for just over 20% of the cost of installing a tank and, if the pump requires replacement every 10 years, it accounts for around 35% of the total lifecycle cost.[23] In addition, tanks dedicated to outdoor watering will not require in-house plumbing and may not require a mains switching device (except when an automatic reticulation system is used). The cost of plumbing alone represents around 25% of the total installation cost of a tank that is plumbed into the house.[24] Finally, operating and maintenance costs will be lower if no pump is required and the lower water quality requirements will make the level of gutter, screen and tank maintenance less onerous. The levelised cost of rainwater tanks for outdoor use only (assuming neither a pump nor significant plumbing is required) is shown in Table 12.

Table 12: Levelised cost for outdoor watering only - no pump or major plumbing required

Tank Size	*2 kL*		*5 kL*		*10 kL*		*Price of mains water*
Roof Area	*50m²*	*200m²*	*50m²*	*200m²*	*50m²*	*200m²*	
Levelised Cost ($/kL) [1]							
Brisbane	2.70	1.55	2.59	1.25	3.06	1.31	0.91-1.20
Sydney	3.36	2.14	3.08	1.95	3.37	2.21	1.26-1.63
Melbourne	4.14	2.10	4.25	1.87	5.24	2.05	0.81-1.55+ [2]
Adelaide	4.71	2.30	5.02	2.05	5.94	2.31	0.47-1.09
Perth	5.07	2.68	5.02	2.40	5.33	2.66	0.49-1.59

Notes: 1. See Note 1, Table 11.
2. See Note 2, Table 11.

Source: Marsden Jacob analysis

Table 12 shows that in most cases, rainwater tanks without a pump that are used for garden watering only can have a lower levelised cost than rainwater tanks used for indoor applications (provided a water pump and significant plumbing are avoided). In particular, households in Brisbane with a large roof area connected to the tank may receive water at a rate only marginally above the top tier water price charged by Brisbane Water. However, it is likely that only a relatively small number of property owners will be able to take full advantage of rainwater tanks without a pump, as the water will be supplied under low pressure and property owners may therefore be required to hand water or move watering equipment regularly over a relatively long period of time.

It is important to emphasise that there are a significant number of variables that affect the cost and yield of a tank and only the most critical were modelled during this exercise. Other factors, including number of occupants in the house, garden requirements, other potential uses for the water (including drinking), ease of installation and the availability of cheaper products will all have a direct impact on the cost effectiveness of a tank for any particular property owner. A number of specific case studies that were reviewed during this study were found to cost significantly more or significantly less than the base case results in this report.

22 Rainwater used for toilet flushing may also not require a water pump.

23 Assumes the median value of $650 for a pump, plus $4 per year in pumping costs. Annualised cost of a 5 kL tank fully installed and plumbed is $3,010, with annual operating costs of $24 per year.

24 Median plumbing cost of $727 compared with a total installation cost of $3,010 for a 5 kL tank.

The results presented throughout this study should therefore by understood as an indicative guide for a “typical” household only.

3.6. Rebates required by property owners

The rebate required by a property owner will vary based on individual circumstances. Many home owners have installed rainwater tanks without the need for a rebate – potentially to improve the taste of drinking water, avoid water restrictions or for general water conservation reasons.

Table 13 shows the rebate that would be required to encourage a property owner to take up a water tank for both outdoor and indoor uses (and therefore maximise water conservation). The calculation of the rebate assumes that the property owner receives no non-financial benefits from the tank and aims only to ensure that the investment does not result in a net financial loss over time. The rebate is calculated as the present value difference between the lifecycle cost of tank ownership and the net savings to the home owner’s water bill.

Table 13: Rebate required for rainwater tank plumbed for all internal applications

Tank Size	*2 kL*		*5 kL*		*10 kL*		
Roof Area	*50m2*	*200m2*	*50m2*	*200m2*	*50m2*	*200m2*	
Annual savings from water bill[1]	*$23-$54*	*$24-$66*	*$24-$62*	*$58-$140*	*$48-$108*	*$65-$167*	
Rebate required ($)[2]							***Actual State rebate***[3]
Brisbane	2,851	2,351	3,128	2,252	3,626	2,413	Up to $1,000
Sydney	2,553	1,790	2,783	1,589	3,252	1,651	Up to $800
Melbourne	3,005	2,331	3,367	2,421	3,905	2,776	Up to $1,000
Adelaide	2,990	2,375	3,356	2,450	3,895	2,834	Up to $400
Perth	3,041	2,708	3,391	2,889	3,929	3,313	Up to $500

Note: 1. Assumes marginal price from water authority at 250 kL usage level.
2. Assumes personal discount rate equal to a variable home loan rate of 8% p.a. (nominal).
3. Other rebate schemes include: ACT up to $800; Hobart City Council up to $220; Northern Territory currently offer no rebates.

Source: Marsden Jacob analysis. Rebate from water company and State Government websites

Table 13 demonstrates that the rebate required to use water for both outdoor and indoor applications would be between around $1,600 and $4,000, depending on location, tank size and roof area connected. Rebates at these levels assume that the property owner has no objective other than cost minimisation and has no cashflow constraints. In most cases the rebate required to ensure a zero net cost to the property owner would be greater than the full cost of installing a tank because the ongoing costs, particularly replacement of the water pump, can be greater than the annual savings from the water bill.

Where the tank is used for garden watering only (without the need for a pump), lower rebates of around $500 to $1,900 per property might be required.

Table 13 also shows that the rebate currently falls short of meeting the full shortfall. The fact that many households are actually installing tanks regardless of the rebate, demonstrates either that tanks are still economic under specific circumstances or that property owners value the tank more highly than the financial loss they will sustain.

3.7. Health risks

In addition to the financial costs and benefits, property owners may also consider the health risk of installing a rainwater tank. The quality of rainwater stored in tanks can be degraded by poor maintenance of the rainwater tank and can in some cases result in the transmittal of pathogens from human, animal or birds via faecal contamination. As such it is not uncommon for there to be local health regulations concerning rainwater that puts restrictions on possible indoor uses.

As noted earlier, the highest proportion of tanks in Australia are found in South Australia, where some 28% of households have the tank plumbed into their house. The relatively high proportion of tanks in South Australia has been attributed to the (historically) high dissatisfaction with the taste of tap-water.[25]

In some States, government regulations expressly forbid the connection of rainwater tanks to the drinking water supply if mains water is available, but do allow connection for other indoor uses.[26] In other States, where the use of rainwater for drinking is not forbidden, some water authorities have indicated that large scale retrofitting of rainwater tanks for drinking purposes would not be supported by health regulators due to health concerns. There is also some concern that water supplied for use in the bathroom (shower, bath and basins) could pose a potential health risk if ingested. If the water is supplied to the bathroom or kitchen through the hot water system only, then these concerns may be ameliorated because most pathogenic bacteria can be eliminated at high temperatures.

State government agencies and national standards committees have provided conflicting advice regarding the connection of rainwater tanks to the hot water system. For example, officers of the Queensland Department of Natural Resources have explicitly recommended against connecting rainwater tanks to the hot water system,[27] while the South Australian Government requires all new dwellings to install a rainwater tank that is connected to one or more specified areas of the house – one of which is the hot water system.[28]

For this study, Marsden Jacob has assumed that all indoor use could be supplied with rainwater, other than the cold water supply to the kitchen and bathroom. As noted earlier, cold water used in the kitchen and bathroom accounts for only 14% of total household water use.

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25 Australian Bureau of Statistics (2004).

26 See for example, Northern Territory Plumbing Code AS3500.

27 Due to possible voiding of hot water system warranty plus potential health implications. See Gardner (2006). Gardner also suggests that the Australian Standards committee decided that connecting rainwater tanks to the hot water system was “too risky”.

28 Tanks must be connected to either – 1) at least one toilet, 2) all laundry cold water outlets, or 3) the hot water supply. See South Australian Government (2005). Coombes et. al. (2004), also provides evidence that pathogenic bacteria are rapidly removed if water temperatures are maintained at greater than 60ºC.

4. Community costs and benefits

Installation of rainwater tanks provides benefits to both the property owner and to the wider community, particularly if water or stormwater infrastructure requirements are reduced. Rainwater tanks play an integral part in Water Sensitive Urban Design (WSUD). WSUD refers to the integration of water cycle management into urban planning and design. Benefits include reductions in mains water consumption (and therefore the need to expand its supply), reduced stormwater infrastructure and improved environmental outcomes for surrounding rivers and streams. Due to the nature and type of water and stormwater infrastructure in each city, the benefits of WSUD will vary substantially across each State.

The study examines the benefit from the point of view of the community as a whole rather than from the point of view of water authorities or governments. This distinction is important because, while rainwater tanks free up water that utilities could sell to other customers or use to defer new water sources, the water authority will also lose revenue from each household that installs a tank. From a whole of community perspective, the revenue lost to the water authority is the corollary of savings in water bills for property owners. Therefore, we have considered only the net resource cost to the community rather than the costs and revenues to individual sectors within the community.

In comparison with a financial analysis for private investment, an analysis of the broader community costs and benefits is distinguished by a number of features, including:

- the net impact on all members of the community must be accounted for. For rainwater tanks, not only must the impacts on the property owner be accounted for, but also the impacts on the broader water and stormwater systems and, where applicable, costs faced by the land development industry;
- as indicated above, the analysis should only account for the *net resource costs* – that is, the cost of resources, regardless of who bears the cost, including materials and labour. Where actual resource costs are known and accounted for, transactions between customers and suppliers should be excluded from the analysis as these transactions represent a cost to one party and an income (or benefit) to the other. Therefore, provided the true cost of water supply infrastructure and operations are included in the analysis, payments from the property owner to water businesses should be excluded from the analysis as should rebate payments from the government to customers. In some cases an analysis of the redistribution of wealth is also warranted, but such an analysis is beyond the scope of the current study;[29]
- the discount rate applied for private investment is usually different to that applied for public cost-benefit analysis. Public analysis is often conducted at discount rates lower than those required by private investment to reflect the social time value of money rather than the investment value. The difficulty in assessing this value has led to a range of recommendations from various government departments. For example, state and federal

[29] Expenditure on rainwater tanks may have flow-on benefits for rainwater tank manufacturers, plumbers and other parts of the economy. However if rainwater tanks are not installed, alternative water sources such as dams, desalination plants and recycled water schemes may be required, which will also have flow-on effects for the economy. For the purposes of this analysis, only the first order costs and benefits have been analysed.

government studies variously recommend rates between 5% and 8%.[30] These rates are commonly set, in part, with reference to prevailing interest rates. The fall in interest rates over the last decade suggests that the lower rates within the range are more applicable to current evaluations. Therefore a base case real pre-tax discount rate of 6% has been adopted for this analysis. Importantly, this discount rate also approximates the rates used by water regulators and water utilities for determining the marginal cost of new water sources (see section 4.2). Any analysis of public costs and benefits must be careful to ensure that the same discount rate is used across all aspects of the analysis; and

- for both private and public cost-benefit analysis it is important to consider marginal costs only. Marginal costs are those costs (actual costs or opportunity costs) that change in response to the proposal being examined. Therefore sunk costs, fixed costs that would remain unchanged whether the proposal proceeds or not, and non-cash costs such as depreciation should not be included in the cost-benefit analysis.

4.1. Methodology and overview

The costs of rainwater tank ownership were reviewed in detail in Section 3. The primary financial benefit of rainwater tanks to the community is the potential reduction in the cost of water and stormwater infrastructure. As noted above, the monetary savings to individual property owners are excluded from a community wide cost benefit analysis as the saving to the property owner represents a reduction in revenue to the water utility and ultimately the state government (who would otherwise have employed that revenue for other purposes).

The ability of water authorities to reduce the cost of water and stormwater infrastructure will vary substantially based on local conditions. An important distinction in determining the total benefit to the community will be whether the rainwater tank is to be installed on an existing property or on a new (greenfield) site. On new sites, the deployment of water tanks may influence design and dimensioning of water supply headworks and distribution infrastructure. The distinction between new and exiting sites is often overlooked, but is critical because the distribution and reticulation network typically accounts for more than 70% of total water supply infrastructure costs.

The use of rainwater tanks to supplement the existing water supply can also reduce localised urban flooding, improve stormwater quality and minimise the influx of stormwater into the drainage system. These may provide benefits to the stormwater system in greenfield sites or areas where major augmentations of established systems are expected in the future.

In the following we review the evidence for water and stormwater cost savings to determine an indicative benefit per kilolitre of water saved by a rainwater tank.

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30 See, for example, Commonwealth Department of Finance (1991), *Handbook of Cost Benefit Analysis*; NSW Treasury (1997), *NSW Government Guidelines for Economic Appraisal*; Queensland Treasury (1997) *Project Evaluation Guidelines*; Community Department of Health, Housing, Local Government and Community Services (1993) *Background document on the use of economic analysis as a basis of inclusion of pharmaceutical products on the Pharmaceutical Benefits Scheme*.

4.2. Water source infrastructure

The financial impact of reducing demand on the mains water system has been considered by a number of water businesses and economic regulators across the country. While a reduction in demand from just one rainwater tank will be negligible, the impact of wide spread take up of tanks may have a significant impact on potable water demand and therefore on the need to develop new water sources. The growing demand for water from natural population growth means that the construction of new sources is typically only delayed rather than eliminated altogether.

Structural water conservation measures such as rainwater tanks will mean that demand for mains water is permanently reduced and therefore that water sources planned for both the short and long term can effectively be delayed. The total system impact can therefore be calculated as the difference between the present value cost of water sources with "business as usual" demand and the present value cost of the delayed water sources. This calculation is commonly referred to as the Long Run Marginal Cost (LRMC) of new water sources. LRMC includes changes in both capital and operating cost for a water utility.

Depending on the next planned augmentation, LRMC will vary considerably between regions. The LRMC has been estimated by regulators across Australia with varying degrees of confidence and precision. The estimations of LRMC are shown in Table 14.

Table 14: Estimated Long Run Marginal Cost by City

City	Estimated LRMC ($/kL)
Sydney	1.20-1.50 [1]
Melbourne – Yarra Valley	0.50-0.54 [4]
Melbourne – City West	0.74 [5]
Adelaide	Approx 1.09 [3]
Perth	0.82-1.20 [2]

Notes:
1. IPART (2005) *Sydney Water Corporation, Hunter Water Corporation, Sydney Catchment Authority - Prices of Water Supply, Wastewater and Stormwater Services.*
2. Economic Regulation Authority (2005), *Final Report on the Inquiry on Urban Water and Wastewater Pricing.*
3. "[The] second tier water price reflects current estimates of LRMC": ESCoSA, *Transparency Statement Water and Wastewater Prices In Metropolitan And Regional South Australia 2006-07*, p.32.
4. Yarra Valley Water, Water Plan $0.02 transport opex, $0.33 LRMC, plus Melbourne Water LRMC for supplying Yarra Valley $0.15-$0.19.
5. City West Water Plan 2005-06 to 2007-08. It is unknown if this estimate incorporates Melbourne Water's estimate of LRMC.

The Long Run Marginal Cost of water sources for Brisbane has not been published. New water sources for South East Queensland will include the Western Corridor Scheme, which will pipe recycled water to power plants and other water users to free up potable water supply, and potentially dams at Traveston and Wyaralong. In addition, Brisbane may require other sources of water in the near future if the current low level of inflow into Wivenhoe dam continues. It is likely that the cost of future water sources for Brisbane will be equal to or greater than the cost of desalination, which in Australia has been estimated to range from

$1.20/kL to more than $2.00/kL. Desalination in Brisbane faces particularly serious difficulties with regard to site location and therefore any desalination plant may need to be sited a considerable distance from the city, incurring high transportation costs. As a preliminary estimate we have therefore assumed that the LRMC of new water sources for Brisbane will be $2.00/kL or more.

The LRMC estimates above have been applied as the potential for water source savings if rainwater tanks are adopted on a large scale. We note that several economic regulators have not made the details of the LRMC calculation available to the public and therefore it is unclear what assumptions have been adopted and whether those assumptions are consistent across all States. Further work may be warranted to understand the basis of LRMC estimates across Australia and to ensure a consistency of approach.

4.3. Local water mains

Local water mains (reticulation and distribution mains) and pump stations are typically not included in the calculation of LRMC, which relates primarily to new water sources. Some local water mains (reticulation mains) are funded and installed by land developers. Water mains and pump stations are typically sized to supply peak water demand. Therefore, in greenfield sites, there may be some scope to reduce the size of water mains if rainwater tanks are widely installed and will be utilised during peak water usage periods. There has been little work conducted on the impact of rainwater tanks on peak water usage, however it is likely that peak usage will occur at times of high garden watering, when rainfall is lowest. If rainfall is low, then it can be expected that rainwater tanks will also be drawn down at times of peak usage.

Furthermore, the reduction in the cost of water mains is not proportional to the reduction in peak usage. There are significant fixed costs associated with laying new water mains. At least one study has found that the cost of the top 10% of peak usage is around 4% of the total whole of life cost for a greenfield scheme.[31]

This study assumes that the impact of rainwater tanks on the size of local water mains will be limited, however the potential for cost savings should be considered on a case by case basis.

4.4. Stormwater infrastructure

There have been few studies on the impact of reduced demand on the size of stormwater infrastructure. Typically, the capital cost of established sites will not change if rainwater tanks are introduced. Some replacement costs may be impacted, but most stormwater assets are long lived assets that are constructed prior to development of the land.

For greenfields sites or established areas that require augmentation of infrastructure, it is possible that the size of stormwater infrastructure might be reduced if run-off from roofs is diverted by rainwater tanks rather than being discharged into stormwater drains. In discussions with water utilities it was noted that stormwater infrastructure was designed for

[31] See Pickering and Werner (2002), Appendix 3.

probable peak events. The size of stormwater infrastructure may therefore need to be maintained if the peak run-off period occurs when rainwater tanks are already full.

Consider, for example, the volume of water that would have been in tanks and the amount of water that would have been diverted for the top ten rainfall events in Sydney over the past 100 years.

Table 15: Water diverted by rainwater tanks during top 10 rainfall events

	2,000 litre (2 kL) tank				10,000 litre (10 kL) tank			
	50m² roof area		200m² roof area		50m² roof area		200m² roof area	
Rainfall (mm)	Volume in tank[1]	Volume diverted[2]	Volume in tank[1]	Volume diverted[2]	Volume in tank[1]	Volume diverted[2]	Volume in tank[1]	Volume diverted[2]
328	2,000	1%	2,000	1%	3,587	23%	10,000	1%
281	2,000	1%	2,000	1%	4,211	24%	10,000	1%
244	0	11%	1,346	2%	0	47%	1,346	21%
235	2,000	2%	2,000	1%	7,305	15%	10,000	1%
198	1,783	3%	2,000	1%	1,783	48%	10,000	1%
198	2,000	2%	2,000	1%	3,434	39%	10,000	1%
192	0	14%	1,557	2%	0	50%	5,394	14%
191	0	14%	0	7%	0	50%	0	30%
190	0	14%	1,389	3%	0	50%	2,314	24%
188	1,067	8%	2,000	1%	1,067	50%	10,000	1%

Notes:
1. Volume in tank prior to rainfall event.
2. Maximum run-off diverted by a rainwater tank. Calculated as the total volume used during the day, plus spare capacity of tank, divided by total roof run-off. Assumes half the roof connected for $50m^2$ and full roof connected for $200m^2$.

Source: Marsden Jacob analysis

The pattern highlighted in Table 15 demonstrates that tanks with smaller roof areas connected are likely to divert a greater proportion of roof run-off than large roof areas during peak events. This is partly because the tank is less likely to be full when the storm event hits and partly because there is less total run-off to be diverted from a smaller roof.

For Sydney, the volume of rainfall that would have been diverted during peak events is relatively small for smaller tanks, but is as high as 20-50% of peak flow for large tanks connected to smaller roof areas. Modelling for other cities shows varied results. For example, a 10 kL tank connected to a $200m^2$ roof area in Perth would have diverted an average of 25% of household roof run-off during the top ten rainfall events (ranging from a minimum of 3% to a maximum of 62%).

If significant volumes of rainfall could be diverted from the stormwater system, then local drains in greenfields sites could potentially be reduced in size. Larger drains and drains that capture significant road or other run-off would be affected to a lesser degree. Costs associated with detention and treatment of stormwater (for example for nitrogen removal) could also potentially be reduced.

The potential impact on the stormwater system will be greatest in greenfield sites and will vary significantly between cities. A marginal impact analysis would require a detailed engineering analysis of stormwater costs in each location and is beyond the scope of this study. A review of the literature also showed a lack of published information on the marginal cost of stormwater systems. One paper by Coombes and Kuzcera (2003a), suggested that for a particular development in Newcastle, stormwater savings could be in the order of $959 per lot with ongoing savings of $10-23 per year. In a second development, estimated savings ranged from $210 to $511 per lot. It is unclear from the paper how these figures were derived or whether they related to reductions in probable peak events as indicated above. However the potential magnitude indicates that stormwater savings may contribute significantly to the economic benefit of installing tanks in some areas.

Another impact on stormwater infrastructure will be the reduction of nutrients in the stormwater system. These reductions will be particularly important when stormwater infrastructure drains into environmentally sensitive waterways. Melbourne Water have explicitly recognised that rainwater tanks reduce the flow of rainwater into drainage outlets and therefore reduce the naturally occurring nitrogen entering waterways by around 0.2 kg per year for a 150m^2 roof. A one off offset charge of $800/kg of nitrogen is currently levied on developers, who can therefore receive a reduction of around $160/house by enforcing the installation of rainwater tanks. For the purposes of this analysis we have assumed that the nitrogen offset charge is cost reflective and applied the cost saving to developers as a broader infrastructure saving for Melbourne residents.

4.5. Community Levelised Cost Results

The levelised cost of rainwater tanks was calculated using the same assumptions as those used for the impact on property owners. The assumptions include:

- the tank is plumbed for all outdoor and indoor use other than cold kitchen and bathroom water;
- 2.4 occupants per house in accordance with Australian Bureau of Statistics averages; and
- daily rainfall (volume and timing) based on actual historical data over the past 30 years.

Additional assumptions for calculating broader system impacts include:

- a 6% real discount rate; and
- no impact on the cost of local water mains or stormwater infrastructure, other than the impact of reduced nitrogen in Melbourne.

Table 16: Levelised cost of rainwater tanks to community

Tank Size	2 kL		10 kL		LRMC of other water sources
Roof Area	$50m^2$	$200m^2$	$50m^2$	$200m^2$	
Levelised Cost ($/kL) [1]					
Indoor and outdoor use					
Brisbane	6.14	3.16	6.22	2.22	2.00+ ?
Sydney	5.34	2.79	5.41	2.15	1.20 - 1.50
Melbourne	8.75	2.98	10.92	2.67	0.50 - 0.74
Adelaide	9.76	3.77	12.30	3.32	1.09
Perth	7.39	3.71	8.85	3.25	0.82 - 1.20
Outdoor use only (no pump required)					
Brisbane	2.91	1.67	3.29	1.41	2.00+ ?
Sydney	3.63	2.31	3.62	2.38	1.20 - 1.50
Melbourne	4.29	1.90	5.51	2.00	0.50 - 0.74
Adelaide	5.09	2.48	6.39	2.49	1.09
Perth	5.47	2.89	5.74	2.87	0.82 - 1.20

Notes: 1. The levelised cost can be higher in individual circumstances, including:
- tank is not plumbed to all indoor areas (toilet, laundry and hot water system),
- underground or slimline tanks are required,
- tank usage is lower (eg. small families),
- reduced rainfall scenario,
- additional incidental costs are incurred, and
- households purchase all gutter and tank maintenance services.

The levelised cost will be lower if:
- tank is also used for drinking water,
- tank usage is higher (eg large families),
- water mains or stormwater savings are achievable, and
- tank costs can be lowered by wide-spread roll out.

Source: Marsden Jacob analysis

The levelised cost of rainwater tanks is subject to significant variation, depending on roof and tank size. The cost will also vary by location and is subject to individual circumstances (outlined in Note 1 of Table 16).

In many cases, the actual cost of rainwater tanks will be higher than the levelised cost shown in Table 16, as the tank may not be plumbed into all indoor areas or – particularly for large tanks – site conditions may require more expensive underground or slimline tanks to be installed.

The levelised cost may also be lower if the cost of the tank is offset by smaller water mains or stormwater infrastructure costs. Significant savings may in certain circumstances be achievable in a greenfield environment. If the stormwater infrastructure savings indicated in Coombes and Kuzcera (2003) are achievable in other areas,[32] then the levelised cost of rainwater tanks could potentially be offset by stormwater savings in the order of $0.30/kL to

[32] $210-$959 per lot for a 10 kL rainwater tank, plus $10-23 per annum operating cost savings. Estimated from a dwelling in Newcastle and other sites in the Lower Hunter Region.

$1.00/kL. In cases where the property owner is required to install expensive on-site stormwater detention (reportedly costing as much as $10,000 per allotment), households may save more than the total cost of tank installation.

Studies on potential stormwater savings are limited. Interviews with water authorities indicated that stormwater infrastructure savings may be minimal in most cases, particularly those households in areas with established infrastructure. However, the possible magnitude of the results may warrant further investigation on a case by case basis.

Based on the yields and costs derived for the calculation of levelised cost, the total Net Present Value of rainwater tanks is shown in Table 17. The Net Present Value deducts the total costs of tanks ownership and maintenance (the total resource cost) from the water supply savings (the total resource benefit), assuming the mid-point of regulators estimated range of Long Run Marginal Cost for water supply infrastructure.

Table 17: Net Present Value per household based on mid-point LRMC

Tank Size	*2 kL*		*10 kL*	
Roof Area	*50m²*	*200m²*	*50m²*	*200m²*
Net Present Value ($/household) [1,2]				
Brisbane	-2,258 (?)	-1,239 (?)	-2,893 (?)	-421 (?)
Sydney	-2,505	-1,744	-3,205	-1,608
Melbourne	-3,057	-2,512	-3,961	-3,151
Adelaide	-2,966	-2,393	-3,872	-2,884
Perth	-2,887	-2,451	-3,769	-2,962

Notes: 1. NPV may be higher or lower under certain circumstances - see Note 1, Table 16.
2. Cost of alternative water sources in Brisbane was unavailable. NPV based on $2/kL for alternative water sources.

Source: Marsden Jacob analysis

In all cases, the Net Present Value result is negative, indicating that the financial benefits do not outweigh the financial costs. The result will vary in individual circumstances (as outlined in Note 1 of Table 16) and may reduce substantially if significant stormwater infrastructure savings can be achieved. The downward trend in costs for Brisbane in particular indicates that larger tanks may be beneficial in many cases if sufficient roof area is connected. The low NPV in Brisbane is due in part to the high outdoor water use and in part to the high cost of alternative water sources compared with other capital cities.

Appendix 1: Rainwater tank supplier survey results

Marsden Jacob surveyed more than 20 rainwater tank suppliers across the country. On a confidential basis, suppliers were queried about the cost of tanks, the cost of installation and plumbing (if undertaken or known by the supplier), and the cost of a domestic pump for internal water use applications. The individual results from the survey are shown in Table 18.

Table 18: Rainwater tank costs provided by suppliers ($)

State	*2 kL*	*5 kL*	*10 kL*	*20 kL*	*Pump*	*Plumbing (approx)*	*Installation (approx)*
ACT	779	1,210	1,783		700	400-800	800
		1,349	1,899		600		
NSW	669	1,048	1,628	2,731	318		
	721	1,100	1,621	2,835	727		
	732	1,184		3,357	395		
	800	1,100			600		
	779						
QLD	681	995	1,635	2,731	315	727	495
	708	1,062	1,621	2,835	772	800	600
	721	1,091	1,632		467-909		
	733	1,184					
		1,100					
VIC	641	909	1,686	2,618	743		
	922		1,577	2,859	545		
					1,000		
SA	705	1,000	1,755		650		
					240		
WA	693	935	1,518		742	300-500	300
					1,045	800-3000	
					500		
Average	732	1,080	1,656	2,852	622	885	549
Median	721	1,091	1,630	2,835	650	727	548

	Average	Median	
Total Cost 2 kL	2,788	2,645	May exclude other incidental costs
Total Cost 5 kL	3,137	3,016	
Total Cost 10 kL	3,713	3,554	
Total Cost 20 kL	4,909	4,760	

Source: Marsden Jacob analysis

Marsden Jacob Associates

Appendix 2: Levelised cost analysis for Sydney property owner with 200m² roof

Rainwater Tank Cost Benefit Model - 200m2 roof size

	Tank size	2kL	5kL	10kL				
1 General								
Discount Rate (Real)	%	5.5%	5.5%	5.5%				
Annual Yield	kL	77.0	104.8	128.0				
Climate scenario	30.00	years						
2 Costs		**Initial Cost**			**Present value to perpetuity***			**Comments**
Costs					**2kL**	**5kL**	**10kL**	
Tank Cost	$	721	1,091	1,630	774	1,172	1,750	Replacement every 50 years
Installation Cost	$	548	548	548	552	552	552	Reinstallation and disposal @ 10% every 50 years
Pump Cost	$	650	650	650	1,568	1,568	1,568	Replacement every 10 years
Internal Plumbing Cost	$	727	727	727	727	727	727	No replacement
Tank O&M	$ / kL	0.05	0.05	0.05	70	95	116	
Additional O&M	$ / year	20.00	20.00	20.00	364	364	364	
Total					3,691	4,114	4,714	
3 Results								
Present Value Cost	$	3,691	4,114	4,714				
PV Volume	kL	1,400	1,905	2,327				
Levelised cost of tank water	$ / kL	2.64	2.16	2.03				

* Present value to perpetuity = Initial capital cost + Replacement cost / ((1 + Discount rate) ^ Asset life - 1)

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